PICES-2016

25 Year of PICES:
Celebrating the Past, Imagining the Future

North Pacific Marine Science Organization

November 2-13, 2016
San Diego, CA, USA

Table of Contents

Abstracts for oral presentations are sorted first by presentation day and then by presentation time.
Abstracts for posters are sorted by session and then by paper ID number.
Presenter name is in bold-face type and underlined.
Some abstracts in this collection are not edited and are printed in the condition they were received.

Notes for Guidance

The North Pacific Marine Science Organization (PICES) announces its 2016 Annual Meeting to be held November 2-13, 2016, at OMNI Hotel. The meeting is hosted by the National Oceanographic and Atmospheric Administration (NOAA), in coordination with the PICES Secretariat. Local arrangements are made by the Southwest Fisheries Science Center of NOAA.

Presentations

In order to allow the sessions to run smoothly, and in fairness to other speakers, please note that all presentations are expected to adhere strictly to the time allocated. All authors should designate at least 5 minutes for questions. Authors can download their presentations directly to the computers where the session/workshops will be held.

Important: Please rename your files - time-name.ppt (*e.g.* 0900-Smith.ppt, 1530-Kim.ppt).

If complications occur due to incompatibilities between PCs and Macs, Macintosh owners may use their own computers to make presentations.

Posters

Posters will be on display from November 7 (a.m.) until the end of the "Wine and Cheese" Poster Session on the evening of November 10.

Two Poster Sessions for all posters (workshop and sessions) will be held on November 8 and November 10. Poster presenters are expected to be available to answer questions from 19:00-20:00 during at least one Poster Session.

Internet access

Internet access via wireless LAN will be available. A few desktop computers will also be available for participants.

Social activities

November 7 (18:30-21:00)
OMNI Hotel, Palm/Sail Terrace (6th Floor)

Welcome Reception

The Welcome Reception for all participants (and registered guests)

November 9 (18:30-21:00)
TBA at the Meeting

Sport Event

Please sign up for participation at the Registration Desk

November 8 and November 10 (18:30-21:00)
OMNI Hotel, Gallery (Ground Level)

Wine & Cheese Poster Session Reception

The wine & cheese Poster Sessions at the meeting venue will allow participants to roam around the poster displays and chat with presenters while sipping beer or wine and nibbling on hot and cold hor d'oevres.

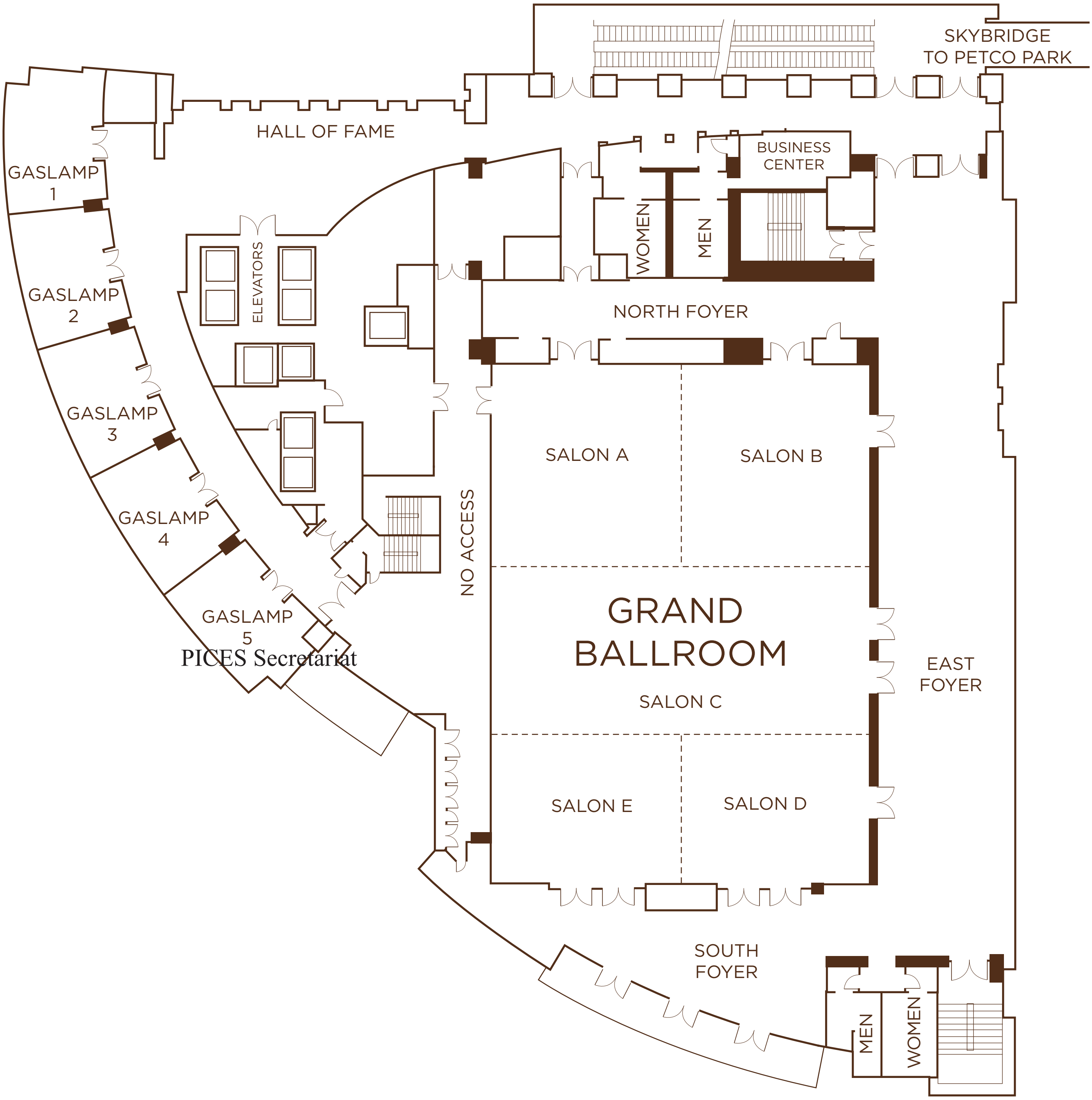
Floor of the Hotel for each of the room types:

Ground Level: Gallery
4th Floor: Grand Ballroom; Salon; Gaslamp; East Foyer; South Foyer
5th Floor: Balboa
6th Floor: Boardroom; Palm/Sail Terrace

PICES Secretariat is located in Gaslamp-5 Room (4th Floor)
Local Organizing Committee is located in Board Room 1 (6th Floor)

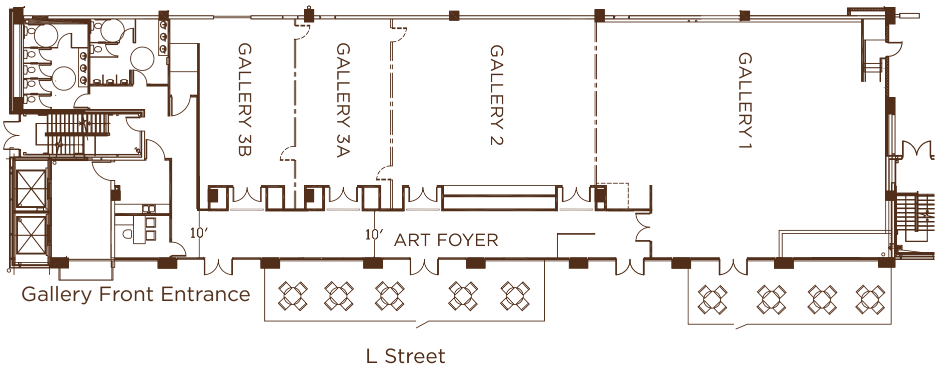
Floor Plan

San Diego 4th Floor



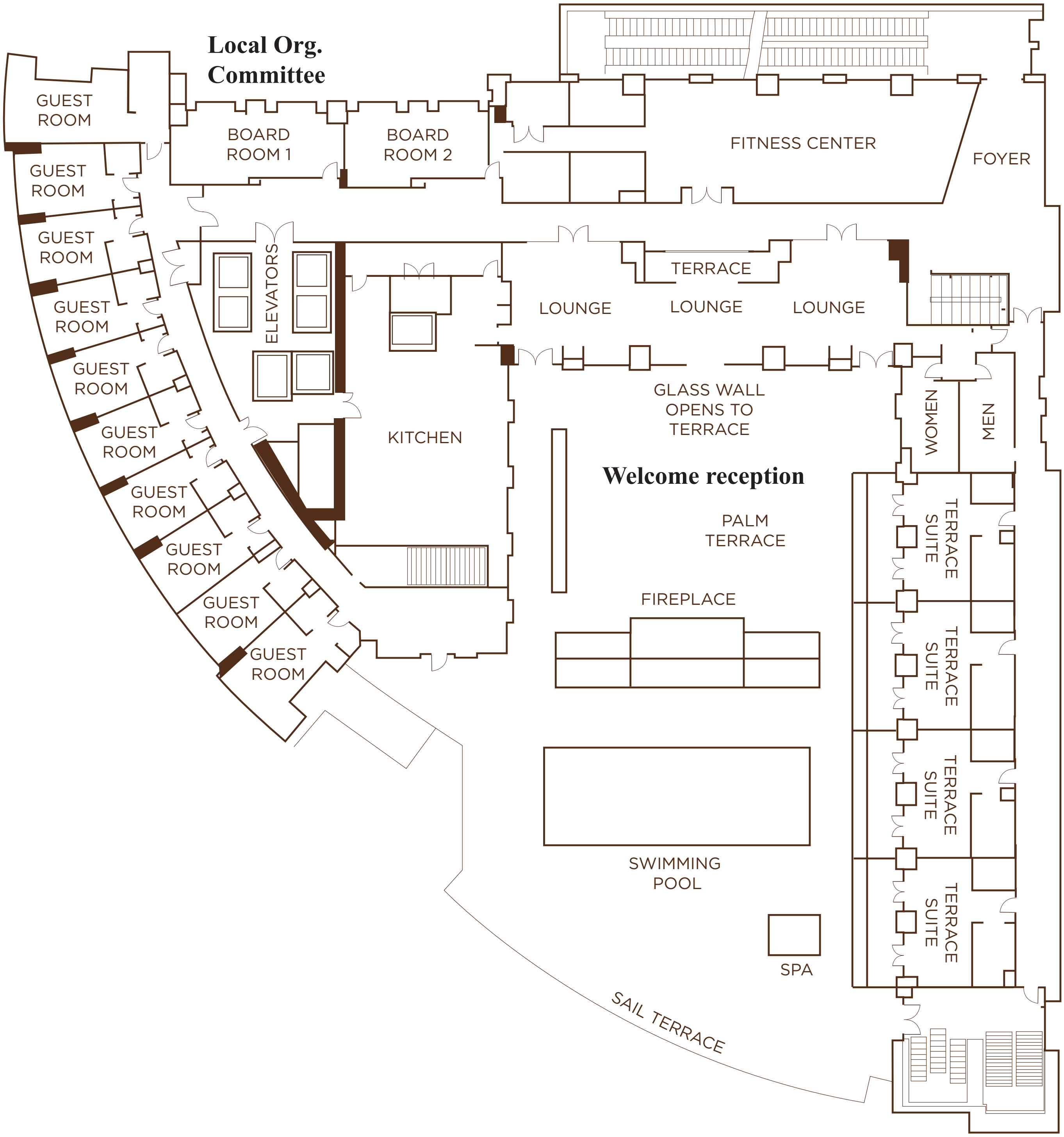
San Diego 5th Floor

San Diego Gallery Meeting Space



POSTER SESSION
Ground level

San Diego 6th Floor



List of Sessions and Workshops

S1	Nov. 7	25 Years of PICES: Celebrating the Past, Imagining the Future
S2	Nov. 10	Early life history stages as indicators and predictors of climate variability and ecosystem change
S3	Nov. 10	Source, Transport and Fate of Hydrocarbons in the Marine Environment
S4	Nov. 10	Climate Variability, Climate Change and the Reproductive Ecology of Marine Populations
S5	Nov. 8	Understanding our Changing Oceans through Species Distributions and Habitat Models based on Remotely Sensed Data
S6	Nov. 8	What Factors make or break Trophic Linkages?
S7	Nov. 8	New Stage of Ocean Acidification Studies: Responses of Oceanic Ecosystem including Fisheries Resources
S8	Nov. 8, 9	The Effect of Marine Debris caused by the Great Tsunami of 2011
S9	Nov. 9, 10	Resilience, Transitions and Adaptation in Marine Ecosystems under a Changing Climate
S10	Nov. 10, 11	The Response of Marine Ecosystems to Natural and Anthropogenic Forcing: Past, Present and Future
S11	Nov. 8, 9	Advances in Understanding and Modeling of Physical Processes in the North Pacific in the Past 25 Years of PICES and Future Directions
S12	Nov. 10	Causes and Consequences of 25 Years of Variability in Ocean Conditions on the Ecosystems of the North Pacific
S13	Nov. 9	Understanding the Changing Coastal Ocean: Advances and Challenges in Multi-parameter Observations
BIO-P1	Nov. 7-10	BIO-1 Contributed Poster Session Recent Progress in Deep-Sea Research and Conservation: Lessons from Various Parts of the Globe
BIO-P2	Nov. 7-10	BIO-2 Contributed Poster Session
FIS-P	Nov. 7-10	FIS Contributed Poster Session
MEQ-P	Nov. 7-10	MEQ Contributed Poster Session
POC-P	Nov. 7-10	POC Contributed Poster Session
MON-P	Nov. 7-10	MONITOR Contributed Poster Session
S-HD	Nov. 7-10	S-HD Contributed Poster Session
W1	Nov. 3	Acidification of the North Pacific Ocean: A Basin-Wide Assessment
W2	Nov. 3	Conditions promoting extreme Pseudo-nitzschia events in the eastern Pacific but not the western Pacific
W3	Nov. 2, 3	Distributions of habitat-forming coral and sponge assemblages in the North Pacific Ocean and factors influencing their distributions
W4	Nov. 3	Methods relating oceanographic conditions to the distribution of highly migratory species
W5	Nov. 4	Modeling effects of climate change on fish and fisheries
W6	Nov. 3	Consumption of North Pacific forage species by marine birds and mammals
W7	Nov. 3	Delivering quality multi-parameter data from the coastal ocean
W8	Nov. 4	Mesoscale and submesoscale processes in the North Pacific: history and new challenges
W9	Nov. 3	The role of the northern Bering Sea in modulating Arctic environments: Towards international interdisciplinary efforts
W10	Nov. 3	Distribution and risk analysis of radionuclides in the North Pacific

Meeting Timetable

Ground Level:
Gallery

4th Floor:
Sal = Salon
GL = Gaslamp
Grand Ballroom

5th Floor:
Bal = Balboa

6th Floor:
BR = Boardroom
Palm/Sail Terrace

Wednesday, November 2

Time	Gaslamp-2	Gaslamp-3		Gaslamp-1
09:00 18:00	**MAFF** Meeting	**W3** (corals) Day 1	**WG-33** Meeting (cancelled)	**SG-CEP** Meeting

Thursday, November 3

Time	Bal-3	Bal-1	GL-3	GL-2	Sal-A	Sal-B	Sal-D	Bal-2	GL-4	Bal-4	
09:00 12:30 14:00 18:00	**W1** (OA)	**W2** (HABS)	**W3** (corals) Day 2	**W4** (HMS)	**W6** (MBM) forage)	**W7** NPCOOS	**W9** (Bering Sea)	**W10** (Radionu clides)	**SG-CERP** Meeting	**WG-31** Meeting	**WG-33** Meeting (cancelled)

Friday, November 4

Time	Sal-A	Sal-B	Bal-2	GL-3	GL-2	Bal-3	Bal-1	GL-4	GL-1	Bal-4	Sal-D
09:00 12:30	**W5** (Mod-CCME)	**W8** (Meso Proc)	**WG-30** Meeting	**WG-32** Meeting	**WG-34** Meeting	**S-CC** Meeting	**S-HAB** Meeting	**S-MBM** Meeting	**AP-NPCOOS** Meeting	**SG-NPESR3** Meeting	**MoE** Meeting
14:00 18:00					**AP-CREAMS** Meeting						

Time		
18:00 20:00/ 21:00	GL-2 **AP-CREAMS** Meeting	Sal-A **S-CCME** Meeting

Saturday, November 5

Time	
09:00 18:00	Sal-D, Sal-E **FUTURE SSC Meeting**

Sunday, November 6 [set clocks back 1 hour to Pacific Standard Time]

Time	
09:00 12:30	Sal-A, Sal-B **FUTURE Mini-Symposium**
12:30 17:00	GL-1 **Science Board Meeting** (closed)

Time	Sal-A	Sal-E	Sal-B	Sal-D	GL-3	GL-4	GL-2
18:00 20:00	**BIO** Meeting Day 1	**FIS** Meeting Day 1	**MEQ** Meeting Day 1	**MONITOR** Meeting Day 1	**POC** Meeting Day 1	**TCODE** Meeting Day 1	**S-HD** Meeting Day 1

Monday, November 7

Time	
08:30 10:15	Grand Ballroom **Opening Session**
10:30 18:20	Grand Ballroom **Science Board Symposium (S1)**
18:30 21:00	Palm/Sail Terrace **Welcome Reception** (for all participants and registered guests)

Tuesday, November 8

Time	
09:00 10:30	Grand Ballroom **Plenary Session (S1, S5, S8)**

Time	Sal-C	Sal-D, Sal-E	Sal-B	Sal-A	GL-1
10:50	**S11 -** Day 1 (Model Phys. Process)	**S5** (Changing Oceans)	**S6** (Trophic Links)	**S7** (Ocean Acidification)	
16:20 18:00	**S8 -** Day 1 (Marine Debris)				[14:00] **F&A Meeting** (closed)

Time	
18:30 21:00	Gallery **Poster Session*** (begins at noon) **"Wine and Cheese"** (18:30-21:00)

Meeting Timetable (continued)

Ground Level:
Gallery

4th Floor:
Sal = Salon
GL = Gaslamp
Grand Ballroom

5th Floor:
Bal = Balboa

6th Floor:
BR = Boardroom

Wednesday, November 9

	Sal-D, Sal-E	Sal-B	Sal-A	Sal-C	GL-1
09:00 12:30	**S8** (Marine Debris) Day 2	**S9** (Resilience) Day 1	**S11** (Model Physical Process) Day 2	**S13** (Changing Coastal Ocean)	**F&A Meeting** (closed)

	GL-3	GL-4	GL-2	Bal-1	Bal-2	Bal-3	GL-1
14:00 19:00	**BIO** Meeting Day 2	**FIS** Meeting Day 2	**MEQ** Meeting Day 2	**MONITOR** Meeting Day 2	**POC** Meeting Day 2	**TCODE** Meeting Day 2	**S-HD** Meeting Day 2

18:30 21:00	**Sport Event**

Thursday, November 10

09:00 10:20	Grand Ballroom **Plenary Session (S10)**

	Sal-B	Sal-D, Sal-E	Sal-A	Sal-C
10:40 11:40	**S10** (FUTURE)	**S2** (Early Life History Stages)	**S4** (Climate Variability/ Reproductive Ecology)	**S12** (Causes/Consequences)
11:50 15:00	**S9** (Resilience)			
15:10	**S3** (Hydrocarbons)			

18:30 21:00	Gallery **Poster Session*** (all day) **"Wine and Cheese"** (18:30-21:00)

Friday, November 11

09:00 12:20	Grand Ballroom **FUTURE (Plenary) Session (S10)**
12:30 13:15	Grand Ballroom **Closing Session****
13:30 18:00	GL-1 **Science Board Meeting** (closed)
18:30 21:00	**Chairman's Reception*** [by invitation only]

Saturday, November 12

	GL-1	GL-3
09:00 18:00	**Science Board Meeting** (closed)	**Governing Council Meeting** (closed)

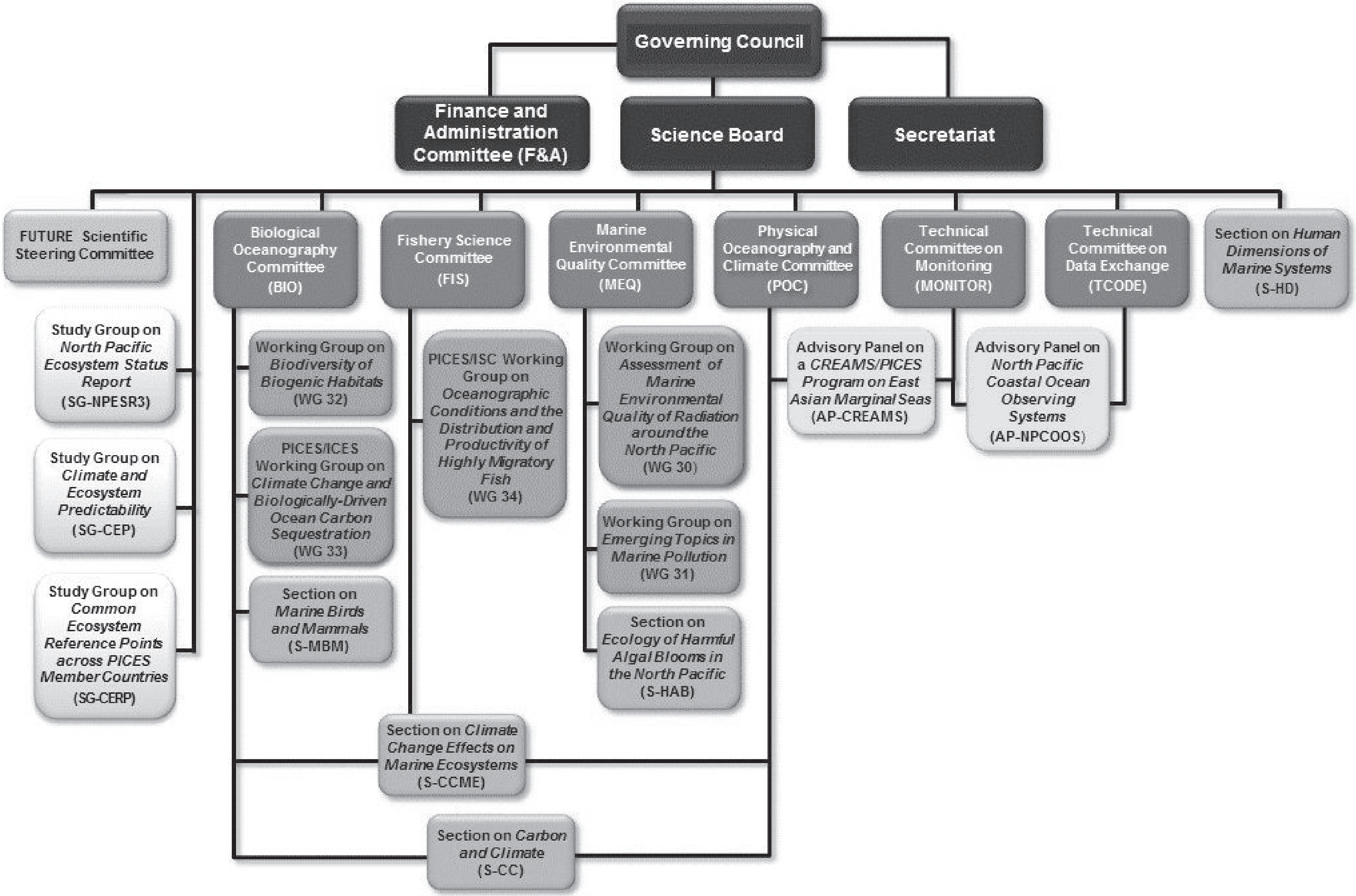
Sunday, November 13

09:00 18:00	GL-3 **Governing Council Meeting** (closed)

* Poster presenters are expected to be available to answer questions for at least one hour (19:00-20:00: Tuesday, Nov. 8 and Thursday, Nov. 10)
** Award recipients for Best Oral/Poster presentations will be announced during the Closing Session

10:30-10:50 Coffee Break (Except for Nov. 10, 10:20-10:40)
12:30-14:00 Lunch
16:00-16:20 Coffee Break

North Pacific Marine Science Organization (PICES) structure for 2015-2016



PICES Acronyms

Committees

BIO	Biological Oceanography Committee
FIS	Fishery Science Committee
MEQ	Marine Environmental Quality Committee
MONITOR	Technical Committee on Monitoring
POC	Physical Oceanography and Climate Committee
TCODE	Technical Committee on Data Exchange

Advisory Panels

AP-CREAMS	Advisory Panel for a CREAMS/PICES Program in East Asian Marginal Seas (*reports to MONITOR and POC Committees*)
AP-NPCOOS	Advisory Panel on North Pacific Coastal Ocean Observing Systems (*reports to MONITOR and TCODE Committees*)

Sections

S-CC	Section on Carbon and Climate (*reports to BIO and POC Committees*)
S-CCME	Joint PICES/ICES Section on Climate Change Effects on Marine Ecosystems (*reports to BIO, FIS and POC Committees*)
S-HAB	Section on Ecology of Harmful Algal Blooms in the North Pacific (*reports to MEQ Committee*)
S-HD	Section on Human Dimensions of Marine Systems (*reports to Science Board*)
S-MBM	Section on Marine Birds and Mammals (*reports to BIO Committee*)

Study Groups

SG-CEP	Study Group on Climate and Ecosystem Predictability (*reports to Science Board*)
SG-CERP	Study Group on Common Ecosystem Reference Points across PICES Member Countries (*reports to Science Board*)
SG-NPESR3	Study Group on North Pacific Ecosystem Status Report (*reports to Science Board*)

Working Groups

WG-30	Working Group on Assessment of Marine Environmental Quality of Radiation around the North Pacific (*reports to MEQ Committee*)
WG-31	Working Group on Emerging Topics in Marine Pollution (*reports to MEQ Committee*)
WG-32	Working Group on Biodiversity of Biogenic Habitats (*reports to BIO Committee*)
WG-34	Joint PICES/ISC Working Group on Ocean Conditions and the Distribution and Productivity of Highly Migratory Fish (*reports to FIS Committee*)

Scientific Program

FUTURE-SSC	Forecasting and Understanding Trends, Uncertainty and Responses of North Pacific Marine Ecosystems - Scientific Steering Committee

Session/Workshop Schedules at a Glance

Wednesday, November 2 [Gaslamp-3 Room, 4th Floor], W3 (Day 1)

Distributions of habitat-forming coral and sponge assemblages in the North Pacific Ocean and factors influencing their distributions

Convenors:
Kwang-Sik Choi (Korea)
Masashi Kiyota (Japan)
Chris Rooper (USA)

9:15 ***Introduction by Workshop Convenors***

Session 1: Multiple factors affecting the dynamics of shallow-water corals and other organisms (Facilitator: Kwang-Sik Choi)

9:25 **Hiroya Yamano (Invited)**
Environmental factors affecting the distribution of habitat-forming shallow-water corals

10:05 **Jin-Soo Park**
First report on the annual gametogenesis of high-latitude corals *Alveopora japonica* (Eguchi, 1968) and *Oulastrea crispata* (Lamarck, 1816) on Jeju Island, Korea

10:30 ***Coffee Break***

Session 2: Factors and processes affecting corals and sponges in mesophotic and deep water zones (Facilitator: Les Watling)

10:50 **Les Watling**
Biogeographic patterns and hypotheses relating deep-sea coral distributions to water masses

11:30 **Christopher Rooper**
Factors affecting the large scale distribution of deep sea corals and sponges in the Alaskan ecosystems of the North Pacific Ocean

11:55 **Stephanie K. Archer**
Seascape ecology of glass sponge reefs: Fine scale measurements of habitat heterogeneity and its relationship to community structure

12:20 ***Lunch***

Session 3: SDM approach: Data collection, modeling, and evaluation (Facilitator: Samuel Georgian)

14:00 **Samuel E. Georgian**
Resolving biogeographic patterns in the deep sea using species distribution modeling

14:40 **Anders Knudby**
Data-driven bioregions for local ecosystem context in species distribution models

15:05 **Mai Miyamoto**
Selection of the proper spatial resolution for habitat modeling of cold-water corals

15:30 **Dana Haggarty**
Testing the transferability of species distribution models between shallow seamounts in the North Pacific Ocean

15:55 ***Coffee Break***

Session 4: Workshop on distribution modeling of data-limited species: Corals and sponges as an example (Facilitator: C. Rooper and S. Georgian)

16:20 ***Introduction by Session Convenors***

16:25 **Scoping discussion**
Presentation of biotic and abiotic data; Choice of target area; Taxonomic resolution; Available model types

17:20 **Data compilation and formatting**

18:00 ***End***

Thursday,

W1 [Balboa 3]		W2 [Balboa 1]		W3 (Day 2)[Gaslamp 3]		W4 [Gaslamp 2]	
Acidification of the North Pacific Ocean: a basin-wide assessment		Conditions promoting extreme *Pseudo-nitzschia* events in the eastern Pacific but not the western Pacific		Distributions of habitat-forming coral and sponge assemblages in the North Pacific Ocean and factors influencing their distributions		Methods relating oceano-graphic conditions to the distribution of highly migratory species	
Convenors: James Christian (Canada) Tsuneo Ono (Japan)		**Convenors:** Vera Trainer (USA) Polina A. Kameneva (Russia)		**Convenors:** Kwang-Sik Choi (Korea) Janelle Curtis (Canada) Masashi Kiyota (Japan) Chris Rooper (USA)		**Convenors:** Gerard DiNardo (USA) Chi-lu Sun (Chinese Taipei)	
		8:55	***Introduction by Workshop Convenors***	8:55	***Introduction by*** C. Rooper and S. Georgian		
9:00	***Introduction by Workshop Convenors***	9:00	**Inna V. Stonik (Invited)** *Pseudo-nitzschia* diversity, bloom events and their impacts in the North Pacific: An East-West comparison	9:00	Modeling: Interpretation of model outputs; Model validation; Multimodel comparison/ensemble	9:00	**Barbara A. Muhling (Invited)** Ecology and management of Atlantic bluefin tuna under climate variability and change
9:10	**Karen E. Kohfeld (Invited)** Assessing vulnerability to ocean acidification in the Strait of Georgia along the Canadian Pacific Coast	9:40	**Nicola Haigh** *Pseudo-nitzschia* species and domoic acid on the west coast of Vancouver Island, British Columbia, in 2015			9:40	**Xianshi Jin** Population dynamics of fish species in marine ecosystem: A case study in the Bohai Sea, China
9:50	Discussion	10:05	**Yuichi Kotaki** Amnesic shellfish poisoning (ASP) potential in Japan			10:10	**Rosa Runcie** The impact of climate change on Pacific Bluefin (*Thunnus orientalis*) tuna distribution in the Eastern Pacific Ocean
10:30	***Coffee Break***	10:30	***Coffee Break***	10:30	***Coffee Break***	10:40	***Coffee Break***

November 3

	W6 [Salon A]	W7 [Salon B]	W9 [Salon D]	W10 [Balboa 2]
Title	Consumption of North Pacific forage species by marine birds and mammals	Delivering quality multi-parameter data from the coastal ocean	The role of the northern Bering Sea in modulating Arctic environments: Towards international interdisciplinary efforts	Distribution and risk analysis of radionuclides in the North Pacific
Convenors	**Convenors:** Andrew Trites (Canada) Elliott Hazen (USA) Tsutomu Tamura (Japan) Yutaka Watanuki (Japan)	**Convenors:** Akash Sastri (Canada) Chuanxi Xing (China)	**Convenors:** Lisa Eisner (USA) Matthew Baker (USA) Kirill Kivva (Russia)	**Convenors:** Yusheng Zhang (China) Kathryn A. Higley (USA)
8:55		***Introduction by Workshop Convenors***		***Introduction by Workshop Convenors***
9:00	***Introduction by Workshop Convenors***	**Zhifeng Zhang (Invited)** Delivering quality multi-parameter data from on-line monitoring network in estuaries and bays: A case study in Bohai Sea	***Introduction by Workshop Convenors*** Overview of data collection efforts/data sharing	**Núria Casacuberta (Invited)** Assessment of the distribution of radionuclides (^{137}Cs, ^{134}Cs, ^{90}Sr, ^{129}I, ^{236}U and Pu-isotopes) in the coast off Japan derived from the Fukushima Dai-ichi nuclear accident
9:10	**Pete Warzybok** Consumption of forage fishes by marine birds in the Gulf of the Farallones, California		**Seth Danielson (Invited)** Currents and water mass structure in and near the Gulf of Anadyr	
9:30	**Yutaka Watanuki** Consumption of salmon fingerlings by Rhinoceros Auklets breeding in Hokkaido, Japan			
9:40			**Alexander Zavolokin (Invited)** Impact of oceanographic fluctuations on the northwestern Bering Sea ecosystem	**John N. Smith** Transport of the Fukushima radioactivity plume to the eastern North Pacific
9:45		**Hidekatsu Yamazaki** Joint Environmental Data Integration System: JEDI System in 2016		
9:50	**Motohiro Ito** The records of Chum salmon fingerling predation by avian predators at the coastal area of Otsuchi, Japan			
10:05		**Genki Terauchi** Identification of potential eutrophic zones in the Northwest Pacific region		**Hideki Kaeriyama** Five years monitoring activity on radioactive cesium in seawater after the Fukushima Dai-ichi Nuclear Power Plant accident
10:10	**Yu Kanaji** Spatio-temporal variations in the stable carbon and nitrogen isotopic compositions of Delphinidae species in the western North Pacific		**Ellen M. Yasumiishi** Climate related changes in abundance and range shifts of pelagic fishes and jellyfish in the eastern Bering Sea during late summer, 2002-2015	
10:25		***Coffee Break***		
10:30	***Coffee Break***		**Yury Zuenko** Environmentally driven variability of zooplankton composition in the northwestern Bering Sea and its influence on the pollock fishery	***Coffee Break***

W1 [Balboa 3]	
Acidification of the North Pacific Ocean: a basin-wide assessment	
Convenors: James Christian (Canada) Tsuneo Ono (Japan)	
10:50	Individual national delegation presenta-tions
12:20	***Lunch***

W2 [Balboa 1]	
Conditions promoting extreme *Pseudo-nitzschia* events in the eastern Pacific but not the western Pacific	
Convenors: Vera Trainer (USA) Polina A. Kameneva (Russia)	
10:50	**Vera L. Trainer** *Pseudo-nitzschia* and domoic acid on the US west coast: State of our knowledge and impli-cations for the future
11:25	**Meredith L. Elliott** *Pseudo-nitzschia* occurrence in the central California Current
12:00	**William P. Cochlan** The effects of tempera-ture and ocean acidi-fication on the growth and toxicity of *Pseudo-nitzschia australis* from the California Current upwelling system
12:35	***Lunch***

W3 (Day 2)[Gaslamp 3]	
Distributions of habitat-forming coral and sponge assemblages in the North Pacific Ocean and factors influencing their distributions	
Convenors: Kwang-Sik Choi (Korea) Janelle Curtis (Canada) Masashi Kiyota (Japan) Chris Rooper (USA)	
10:50	Model transfer; Future projection
12:30	***Lunch***

W4 [Gaslamp 2]	
Methods relating oceano-graphic conditions to the distribution of highly migratory species	
Convenors: Gerard DiNardo (USA) Chi-lu Sun (Chinese Taipei)	
11:00	**Stephanie Snyder** Crossing the line: Albacore actively exploit submesoscale fronts to enhance foraging success
11:30	Discussion
12:30	***Lunch***

W6 [Salon A]

Consumption of North Pacific forage species by marine birds and mammals

Convenors:
Andrew Trites (Canada)
Elliott Hazen (USA)
Tsutomu Tamura (Japan)
Yutaka Watanuki (Japan)

Time	
11:00	**Julie A. Thayer (Invited)** Predator consumption of forage species in the California Current
11:30	**Hiroko Sasaki** Spatial estimation of prey consumption by common minke, Bryde's and sei whales in the western North Pacific: A preliminary attempt
11:50	**Andrew W. Trites** Simple models to predict daily energy requirements may not yield accurate estimates of prey consumption by marine mammals in the North Pacific
12:10	**George L Hunt, Jr** Prey consumption by marine birds in the eastern Bering Sea: Variability over time
12:30	***Lunch***
13:45	Introduction - goal of afternoon workshop

W7 [Salon B]

Delivering quality multi-parameter data from the coastal ocean

Convenors:
Akash Sastri (Canada)
Chuanxi Xing (China)

Time	
10:50	**Naoki Yoshie** Monitoring of coastal ocean in the Western Seto Inland Sea, Japan
11:10	**Chuanxi Xing** Analysis on the patterns and formation dynamics of the summertime coastal circulation system in the western Bohai Sea
11:30	Discussion
12:30	***Lunch***

W9 [Salon D]

The role of the northern Bering Sea in modulating Arctic environments: Towards international interdisciplinary efforts

Convenors:
Lisa Eisner (USA)
Matthew Baker (USA)
Kirill Kivva (Russia)

Time	
10:50	***Coffee Break***
11:20	**Lisa Eisner** Spatial and temporal variations in late summer chlorophyll a and zooplankton distributions in the northeastern Bering Sea
11:40	Discussion
12:30	***Lunch***

W10 [Balboa 2]

Distribution and risk analysis of radionuclides in the North Pacific

Convenors:
Yusheng Zhang (China)
Kathryn A. Higley (USA)

Time	
10:50	**Takami Morita** Radioactive cesium in marine biota off Fukushima
11:15	**Shizuho Miki** Concentrations of strontium-90 in marine fishes after the Fukushima Dai-ichi Nuclear Power Plant accident
11:40	**Daisuke Ambe** Spatio-temporal variation of radiocesium in sea sediment around off Fukushima
12:05	**Jinqiu Du** Distribution of radionuclides in sediment and sedimentation rates in Dalian Bay
12:30	***Lunch***

W1 [Balboa 3]

Acidification of the North Pacific Ocean: a basin-wide assessment

Convenors:
James Christian (Canada)
Tsuneo Ono (Japan)

14:00	**Zhongyong Gao** Variations of carbon uptake and ocean acidification in the Bering Sea and Western Arctic Ocean from 1999 to 2014
14:20	**Simone Alin** Reconstructing ocean acidification in deep coastal and estuarine waters of the northeastern Pacific Ocean (Cascadia Margin): A crab's eye view
14:40	Breakout sessions
15:20	Discussion

W2 [Balboa 1]

Conditions promoting extreme *Pseudo-nitzschia* events in the eastern Pacific but not the western Pacific

Convenors:
Vera Trainer (USA)
Polina A. Kameneva (Russia)

14:00	**Lin Yang** *Pseudo-nitzschia* harmful algal blooms (HAB) in the coast of China
14:25	**Weol-Ae Lim** Temporal changes and toxicity of *Pseudo-nitzschia* species in Korean coastal waters
14:50	**Tamara Russell** *Pseudo-nitzschia* spp. and domoic acid in the waters of Haida Gwaii, British Columbia: A summary of occurrences and details on anthropogenic and environmental considerations
15:15	**Devan Johnson** *Pseudo-nitzschia* species and domoic acid in southeast Vancouver Island, November 2015 to July 2016
15:40	**Anthony Odell** Washington State Pacific coast *Pseudo-nitzschia* bloom of 2016

W3 (Day 2)[Gaslamp 3]

Distributions of habitat-forming coral and sponge assemblages in the North Pacific Ocean and factors influencing their distributions

Convenors:
Kwang-Sik Choi (Korea)
Janelle Curtis (Canada)
Masashi Kiyota (Japan)
Chris Rooper (USA)

14:00	Application of the SDM technique to other species (e.g., shalllow-water corals)

W4 [Gaslamp 2]

Methods relating oceanographic conditions to the distribution of highly migratory species

Convenors:
Gerard DiNardo (USA)
Chi-lu Sun (Chinese Taipei)

14:00	Discussion

W6 [Salon A]

Consumption of North Pacific forage species by marine birds and mammals

Convenors:
Andrew Trites (Canada)
Elliott Hazen (USA)
Tsutomu Tamura (Japan)
Yutaka Watanuki (Japan)

14:00	How to estimate food consumption (birds - Julie Thayer)
14:15	How to estimate food consumption (mammals - Andrew Trites)
14:30	Dietary information & methodological biases (birds - Yutaka Watanuki)
14:45	Dietary information & methodological biases (mammals - Andrew Trites)
15:00	Desired spatial resolution (Elliot Hazen)
15:15	Seasonality & decadal changes (Tsutomu Tamura)
15:30	Population abundances and distributions (birds - TBA)
15:45	Population abundances and distributions (mammals - TBA)

W7 [Salon B]

Delivering quality multi-parameter data from the coastal ocean

Convenors:
Akash Sastri (Canada)
Chuanxi Xing (China)

14:00	**Rich Pawlowicz (Invited)** What do we do with observatory data? A user's perspective
14:45	**Marlene Jeffries** Data quality assurance/quality control approaches for coastal ocean multi-parameter data from a cabled observatory in the NE subarctic Pacific
15:05	**Wiley Evans** Tracking ocean acidification in coastal settings using land-based Burke-O-Lator pCO_2/TCO_2 Analyzers
15:25	Discussion

W9 [Salon D]

The role of the northern Bering Sea in modulating Arctic environments: Towards international interdisciplinary efforts

Convenors:
Lisa Eisner (USA)
Matthew Baker (USA)
Kirill Kivva (Russia)

14:00	**Kirill Kivva (Invited)** Summer water masses and fish communities in the north-western Bering and western Chukchi Seas in 2003-2010
14:30	**Jared Weems** Crab larvae in the northeastern Bering Sea and southern Chukchi Sea: Abundance relative to water masses in 2012
14:50	**Edward Farley** Defining critical periods for Yukon River Chinook salmon
15:10	**Albert J. Hermann** Statistical downscaling of global projections to the Bering Sea, based on an ensemble of regional model output
15:30	**Matthew Baker** Opportunities for data sharing in the northern Bering Sea – Research and data to support international and interdisciplinary analyses

W10 [Balboa 2]

Distribution and risk analysis of radionuclides in the North Pacific

Convenors:
Yusheng Zhang (China)
Kathryn A. Higley (USA)

14:00	**Jianhua He** Effect of settle time on absorption of AMP to ^{137}Cs in co-precipitation method
14:25	**Kyung Tae Jung** Preliminary results from modeling of radionuclide transfer through marine food web using a multi-organ fish model
14:50	**Wu Men** Marine radioactive environmental quality assessment method of China
15:15	**Jinzhao Zhang** The *in-situ* measurement of ocean radioactive base on HPGe detector
15:40	**Allen H. Andrews** Nuclear bombs and coral: Guam coral core reveals operation-specific radiocarbon signals from the Pacific Proving Grounds

W1 [Balboa 3]	**W2 [Balboa 1]**	**W3 (Day 2)[Gaslamp 3]**	**W4 [Gaslamp 2]**
Acidification of the North Pacific Ocean: a basin-wide assessment	Conditions promoting extreme *Pseudo-nitzschia* events in the eastern Pacific but not the western Pacific	Distributions of habitat-forming coral and sponge assemblages in the North Pacific Ocean and factors influencing their distributions	Methods relating oceano-graphic conditions to the distribution of highly migratory species
Convenors: James Christian (Canada) Tsuneo Ono (Japan)	**Convenors:** Vera Trainer (USA) Polina A. Kameneva (Russia)	**Convenors:** Kwang-Sik Choi (Korea) Janelle Curtis (Canada) Masashi Kiyota (Japan) Chris Rooper (USA)	**Convenors:** Gerard DiNardo (USA) Chi-lu Sun (Chinese Taipei)
16:00 ***Coffee Break***	16:05 ***Coffee Break***	16:00 ***Coffee Break***	Discussion (cont)
16:20 Breakout sessions	16:25 Discussion about publication on *Pseudo-nitzschia*	16:20 Synthesis	
16:50 Presentation of results of breakout sessions, final discus-sion and next steps			
17:30 ***End***	18:00 ***End***	18:00 ***End***	18:00 ***End***

	W6 [Salon A]	**W7** [Salon B]	**W9** [Salon D]	**W10** [Balboa 2]
	Consumption of North Pacific forage species by marine birds and mammals	Delivering quality multi-parameter data from the coastal ocean	The role of the northern Bering Sea in modulating Arctic environments: Towards international interdisciplinary efforts	Distribution and risk analysis of radionuclides in the North Pacific
	Convenors: Andrew Trites (Canada), Elliott Hazen (USA), Tsutomu Tamura (Japan), Yutaka Watanuki (Japan)	**Convenors:** Akash Sastri (Canada), Chuanxi Xing (China)	**Convenors:** Lisa Eisner (USA), Matthew Baker (USA), Kirill Kivva (Russia)	**Convenors:** Yusheng Zhang (China), Kathryn A. Higley (USA)
15:50			***Coffee Break***	
16:00	***Coffee Break***	***Coffee Break***		
16:05				***Coffee Break***
16:20	Indentifying available data; 2 groups (birds & mammals) to fill in spreadsheet; data sought: diets, population numbers, distributions	**Yeseul Kim** Optical discrimination of *Cochlodinium polykrikoides* blooms from non-harmful blooms in Korean coastal waters	Open discussion and ask audience to show slides of other datasets	
16:25				Discussion
16:40		**Akash Sastri** Real-time sea-surface measurements of coloured dissolved organic matter (CDOM) in the Strait of Georgia, Canada: Developing techniques to account for sensor fouling		
17:00	Groups report back	Discussion		
17:15	Consensus on how to proceed with estimating food consumption by birds and mammals in the N Pacific			
17:30	Proposal for PICES-2017 meeting		***End***	
18:00	***End***	***End***		***End***

S-HAB [Balboa 1]

Meeting of the Section on *Ecology of Harmful Algal Blooms in the North Pacific*

Convenors:
Douding Lu (China)
Vera Trainer (USA)

9:00	***Introduction by Section Convenors***
9:15	**Weo-Ae Lim** Korea Country Report
9:30	**Vera Trainer** USA Country Report
9:45	**Setsuko Sakamoto, Ryuji Kuwahara, Ichiro Imai** Japan Country Report
10:00	**Hao Guo** China Country Report
10:15	**Nikky Haigh** Canada Country Report
10:30	***Coffee Break***
11:00	Russia Country Report
11:15	**Joo-Hwan Kim** First record of the genus *Azadinium* (Dinophyceae) from the Puget Sound, western Washington State

W5 [Salon A]

Modeling effects of climate change on fish and fisheries

Convenors:
Anne B. Hollowed (USA)
Shin-ichi Ito (Japan)

8:55	***Introduction by Workshop Convenors***
9:05	**Michio Kawamiya (Invited)** Earth system and climate modeling activities toward CMIP6 in Japan: A review
9:30	**John Keith Pinnegar (Invited)** CERES (Climate change and European aquatic RESources): Socio-political scenarios for use alongside climate change projections
9:55	**Phoebe A. Woodworth-Jefcoats** Climate change is projected to reduce carrying capacity in North Pacific pelagic marine ecosystems
10:15	**Kirstin Holsman** The Alaska Climate-change Integrated Modeling project (ACLIM): Identifying impacts and management solutions for Eastern Bering Sea fisheries
10:35	***Coffee Break***
10:50	**Sukgeun Jung** Climate-change driven range shifts of exploitable chub mackerel (*Scomber japonicus*) projected by bio-physical coupling individual based model in the western North Pacific
11:10	**Shin-ichi Ito** Updated plan for modeling effects of climate change on fish and fisheries in the western North Pacific Ocean
Lightning talks: Reports from S-CCME members (8 min each with 2 min for questions)	
11:30	Canada, Jacquelynne King

November 4

W8	**[Salon B]**
Mesoscale and submesoscale processes in the North Pacific: History and new challenges	
Convenors: Kyung-Il Chang (Korea), Hiromichi Ueno (Japan), Annalisa Bracco (USA)	
8:55	***Introduction by Workshop Convenors***
9:00	**Sachihiko Itoh (Invited)** Finescale variability of isopycnal salinity in the southern California Current System
9:30	**Yasuhide Kobayashi** Eddy trajectory in a closed rectangular oceanic basin
9:50	**Young-Gyu Park** Mesoscale and submesoscale wavenumber spectra from the Geostationary Ocean Color Imager (GOCI)
10:10	**Hiromichi Ueno** Mesoscale eddies in the western subarctic North Pacific
10:30	***Coffee Break***
10:50	Discussion

S-HAB [Balboa 1]

Meeting of the Section on *Ecology of Harmful Algal Blooms in the North Pacific*

Convenors:
Douding Lu (China)
Vera Trainer (USA)

11:40	**Svetlana Esenkulova** A review of unusual phytoplankton dynamics and oceanographic conditions favoring diatom growth in the Strait of Georgia, Canada 2015
12:05	**Clarissa Anderson** Harmful algal bloom warning system for fisheries and marine mammal management
12:30	***Lunch***
14:00	**Charles Trick and Vera Trainer** Update on MAFF project, Marine Ecosystem Health and Human Well Being
14:20	**Mark Wells** Joint ICES/PICES/GEOHAB symposium on HABs and Climate Change, update
14:40	**Henrik Enevoldsen and Vera Trainer** The joint Harmful Algal Bloom Programme and International Oceanographic Data and Information Exchange Harmful Algae Information System: An update and country maps
15:00	**Vera Trainer** Global HAB
15:20	**Takufumi Yoshida** NOWPAP
15:40	**Toyomitsu Horii** FUTURE
16:00	***Coffee Break***
16:20	**Masahito Hirota** New MAFF project
18:00	***End***

W5 [Salon A]

Modeling effects of climate change on fish and fisheries

Convenors:
Anne B. Hollowed (USA)
Shin-ichi Ito (Japan)

Lightning talks: Reports from S-CCME members
(8 min each with 2 min for questions) (cont)

11:40	China
11:50	Japan
12:00	Korea, Suam Kim
12:10	Russia, Yury Zuenko
12:20	California Current USA
12:30	***Lunch***
14:00	Reports from other S-CCME members and discussion
14:20	**Jonathan Hare** A review of species distribution modeling in the Northeast U.S. Shelf Large Marine Ecosystem
14:40	**Alan C. Haynie** Report on the 2016 ICES/PICES Workshop on Economic Modelling of the Effects of Climate Change on Fish and Fisheries
15:00	Discussion selecting representative fishing pathways
15:30	Discussion techniques for cold or warm bias corrections and incorporating ESM data into projection models
16:00	***Coffee Break***
16:20	Discussion on future plans
18:00	***End***

W8	**[Salon B]**
Mesoscale and submesoscale processes in the North Pacific: History and new challenges	
Convenors: Kyung-Il Chang (Korea) Hiromichi Ueno (Japan) Annalisa Bracco (USA)	
12:30	***Lunch***
14:00	**Naomi M. Levine (Invited)** Competition in a patchy world: Submesoscale dynamics, phytoplankton growth, and carbon export in the oligotrophic North Pacific
14:30	**Elena I. Ustinova** Mesoscale structures and Pacific saury fishing grounds in the Northwestern Pacific
14:50	**Dongfeng Xu** The cross-shelf transport by the eddy-pair in the Northern South China Sea in June 2015
15:10	Discussion
16:00	***Coffee Break***
16:20	Discussion
18:00	***End***

Monday, November 7 [Grand Ballroom, 4th Floor]

Session 1: Science Board Symposium
25 Years of PICES: Celebrating the Past, Imagining the Future

Convenors:
Thomas Therriault (SB), Angelica Peña (BIO), Elizabeth Logerwell (FIS)
Chuanlin Huo (MEQ), Jennifer Boldt (MONITOR), Kyung-Il Chang (POC)
Toru Suzuki (TCODE), Steven Bograd (FUTURE), Hiroaki Saito (FUTURE)
Igor Shevchenko (Russia)

Ryan R. Rykaczewski (Keynote)
Projecting ecosystem consequences of climate variability and change: Aspirations for the next 25 years of PICES

University of South Carolina, Columbia, SC, USA

Research associated with the goals of PICES has transformed scientific perceptions of ecosystem variability. The vibrant forums of PICES meetings and coordinated efforts by scientists from participating regions have stimulated understanding of the relationships between large-scale atmospheric processes, oceanographic conditions, and marine ecosystems--notably at decadal scales. Even while the mechanisms of decadal scale variability continue to be investigated, the PICES community must also devote attention to changes associated with increasing greenhouse gas emissions. Our improving understanding of low-frequency, climate-ecosystem interactions may inform understanding of ecosystem responses to anthropogenic climate change. However, responses to climate change will be unlike responses to natural variability. Recognized patterns of natural climate variability have been characterized as oscillatory in space, with signs of change that differ regionally. Anthropogenic change, in contrast, is expected to result in large-scale physical forcing of a similar sign throughout ocean basins; as concentrations of carbon dioxide rise, surface temperatures, water-column stratification, and ocean acidity will increase in nearly all regions. Projecting the consequences of such forcing on other physical characteristics, biogeochemical properties (namely subsurface dissolved oxygen content, carbonate speciation, nutrient supply, and primary production) is possible. However, understanding ecosystem responses at scales relevant to individual populations, community structure, fisheries, and human society remains extremely challenging, particularly as conditions cross thresholds not experienced in the recent past. Physical, chemical, and biological anomalies in the Northeast Pacific over the last several years have demonstrated the insufficiency of describing of conditions using a combination of well recognized atmosphere-ocean modes.

During the next 25 years, marine scientists will face the challenge of distinguishing the effects of anthropogenic climate change from those of natural variability, fisheries exploitation, and other anthropogenic stressors. Investigations of the frequency, intensity, and spatial patterns of natural variability, their sensitivities to climate change, and their ecological consequences are necessary. Developing technologies and increasing computational power provide research opportunities that were nearly inconceivable two decades ago, but maintaining and expanding long-term ocean observing systems capable of concurrent physical, chemical, and biological measurements remains essential for resolving changes relevant to biogeochemical cycles and ecosystem structure. Creating conceptual and operational models that can relate physical variability to human society, represent ecological mechanisms that are robust to climate change, and convey appropriate levels of uncertainty will be critical. Developing "objective advice on scientific questions with great practical implications" was one of the primary justifications for the creation of PICES. We continue to make progress toward this goal, but effectively applying new oceanographic understanding to improve management of marine resources remains difficult. Achieving this goal requires consideration of both short-term model forecasts with practical utility as well as long-term model projections with more strategic emphasis. Continued multinational collaboration among PICES members and partnerships with other marine science organizations are crucial to addressing these challenges.

11:15 **Philip Munday (Invited)**
Predicting evolutionary responses to climate change in the sea: Progress and challenges

11:45 **Alan C. Haynie (Invited)**
Why people matter: Past and future analysis of the role of humans in marine ecosystems

12:15 **Robert Blasiak (*)**
Applying fractionalization indices to transboundary fish stocks to forecast future conflict hotspots

12:35 ***Lunch***

14:00 **Cornelius Hammer (Invited)**
PICES-ICES Cooperation: Where we are and where to go?

14:30 **Guido Marinone (Invited)**
Oceanography of the Mexican Pacific Ocean: An interactive region between north and south

15:00 **Luis Valdés**
The UN role in for ocean science and ocean governance

15:20 **Jeffrey Polovina**
Recent advances, ongoing challenges, and future directions in ecosystem approaches to fisheries management in the central North Pacific

15:40 **Sanae Chiba**
Can we use zooplankton diversity to fill the global indicator gap of the Aichi Biodiversity Target 10?

16:00 ***Coffee Break***

16:20 **Essam Yassin Mohammed (Invited)**
Harnessing blue capital for blue growth: Why invest?

16:50 **Shang Chen**
Marine Ecological Capital: Assessment, management and investment

17:10 **Naomi Harada (Invited)**
Potential environmental changes in the western Arctic and the western North Pacific: Their impacts on lower trophic level organisms

17:40 **Maciej Telszewski**
Future Global Ocean Observing System – Built on requirements, promoting alignment, delivering relevant information

18:00 **William J. Sydeman**
Marine birds, mammals and PICES: History and roadmap for the future

18:20 ***End***

Plenary

9:00 **Phillip R. Mundy (S1)**
A reference frame of environmental time series observations for detecting change in North Pacific Ecosystems; the North Pacific Ecosystem Status Report

9:30 **James T. Carlton (S8)**
Life rafts on the open sea: Successful long-term transoceanic transport of coastal marine organisms by marine debris

10:00 **Robert M. Suryan (S5)**
Making the most of satellite-derived oceanographic data and habitat use models to understand species distributions

10:30 ***Coffee Break***

S5	**[Salon D, E]**	**S6**	**[Salon B]**
Understanding our Changing Oceans through Species Distributions and Habitat Models based on Remotely Sensed Data		What Factors make or break Trophic Linkages?	
Convenors: Patrick O'Hara (Canada) Elliott L. Hazen (USA) Sei-Ichi Saitoh (Japan) Yutaka Watanuki (Japan)		**Convenors:** Elliott L. Hazen (USA) Jameal Samhouri (USA) Shin-ichi Ito (Japan) Jennifer Boldt (Canada)	
10:50	**Elizabeth A. Becker** Moving towards dynamic ocean management: How well do modeled ocean products predict species distributions?	10:50	**Masashi Kiyota (Invited)** Response of commercial fisheries and a top predator to long-term ecosystem fluctuations in the western North Pacific Ocean off northeastern Japan
11:10	**Sei-Ichi Saitoh** Spatio-temporal patterns of potential fishing zones for Pacific saury in a warming climate	11:10	**Charles Stock** Trophodynamic drivers of global fisheries catch
11:30	**Daniel M. Palacios** Modeling blue whale movement behavior in relation to environmental conditions in the California Current from satellite tracking and remote sensing	11:30	**Jennifer Boldt** Juvenile Pacific Herring (*Clupea pallasi*) trophic linkages in the Strait of Georgia, British Columbia
11:50	**Daniela Y. Munguía-Cajigas (*)** Foraging patterns of Laysan Albatross from Guadalupe Island, Mexico and their relation to oceanographic variables from the California Current System	11:50	**Lianggen Wang (*)** Role of small copepod in four genera (*Calocalanus*, *Clausocalanus*, *Farranula* and *Oithona*) in South China Sea fisheries resources conservation
12:10	**Jarrod Santora** Submarine canyons and essential krill habitat: Implications for modeling distribution patterns under climate change	12:10	**Sonia Batten** A comparison of trophic linkages across the PICES region, based on Continuous Plankton Recorder data
12:30	***Lunch***	12:30	***Lunch***

November 8

(*) Flags an Early Career Scientist

S7 **[Salon A]**		**S11 (Day 1)** **[Salon C]**	
New Stage of Ocean Acidification Studies: Responses of Oceanic Ecosystem including Fisheries Resources		Advances in Understanding and Modeling of Physical Processes in the North Pacific in the Past 25 Years of PICES and Future Directions	
Convenors: Tsuneo Ono (Japan) Jun Kita (Japan) Debby Ianson (Canada) John Pinnegar (ICES / UK)		**Convenors:** Shin-ichi Ito (Japan) Kyung-Il Chang (Korea) Steven Bograd (USA)	
10:50	**Tsuneo Ono** *Introduction by Convenor*	10:50	**Ichiro Yasuda (Invited)** Ocean mixing processes: Impact on biogeochemistry, climate and ecosystems
10:55	**Steve Widdicombe (Invited)** Ocean acidification: What can species responses tell us about ecosystem consequences?		
		11:15	**M. Debora Iglesias-Rodriguez** Oceanographic conditions facilitating the formation and propagation of a novel coccolithophore bloom in the Santa Barbara Channel
11:25	**George G. Waldbusser (Invited)** Coastal zone acidification and bivalves: Carbonate chemistry complexity, high frequency variability, and organism interactions, oh my!	11:35	**Olga Trusenkova** Long-term sea level variation in the Japan/East Sea from two decades of altimetry data
11:55	**Carrie A. Holt** Effects of ocean acidification on temperate coastal marine ecosystems and fisheries in the Northeast Pacific	11:55	**Sayaka Yasunaka** Long-term variability of surface nutrient concentrations in the North Pacific
12:15	Short introductions of posters	12:15	**Makoto Kashiwai** Mechanism of warming the Okhotsk Sea Intermediate Water, from consideration on the seasonal cycle
12:30	***Lunch***	12:35	***Lunch***

S5 [Salon D, E]		S6 [Salon B]	
Understanding our Changing Oceans through Species Distributions and Habitat Models based on Remotely Sensed Data		What Factors make or break Trophic Linkages?	
Convenors: Patrick O'Hara (Canada) Elliott L. Hazen (USA) Sei-Ichi Saitoh (Japan) Yutaka Watanuki (Japan)		**Convenors:** Elliott L. Hazen (USA) Jameal Samhouri (USA) Shin-ichi Ito (Japan) Jennifer Boldt (Canada)	
14:00	**Elliott L. Hazen** Forecasting bycatch and ship strike risk for dynamic ocean management in the California Current	14:00	**Kenneth A. Rose (Invited)** Linear and non-linear responses of marine and coastal fish populations to physics and habitat: A view from the virtual world
14:20	**Bungo Nishizawa (*)** Seasonal distribution of short-tailed shearwaters and their prey in the Bering and Chukchi seas	14:20	**Konstantin Rogachev** Effects of freshwater discharge and tidal currents on zooplankton aggregations in the coastal Sea of Okhotsk
14:40	**Trevor W. Joyce (*)** Relationships between seabird, tuna, and dolphin foraging aggregations and El Niño-Southern Oscillation in the oceanic eastern tropical Pacific	14:40	**Julie E. Keister** Cryptic trophic connections to juvenile salmon survival are revealed by a zooplankton time series
15:00	**Vladimir V. Kulik (*)** Climate change impacts on distribution patterns of boreopacific gonate squid (*Boreoteuthis borealis*) in the Northwest Pacific	15:00	**C. Anela Choy (*)** New insights on the trophic diversity of pelagic "forage species" in the central North Pacific and northern California Current ecosystems
15:20	**Brian Wells** Salmon prey assemblages and oceanographic conditions along the California Current shelf ecosystem	15:20	**Hitomi Oyaizu (*)** Modeling recruitment variability of Pacific saury (*Cololabis saira*) using an individual-based model
15:40	**George L. Hunt, Jr.** Eastern Bering Sea seabirds shift distributions in response to timing of sea-ice retreat	15:40	**Kelly Kearney (*)** A comparison of Bering Sea ecosystem energy pathways in warm versus cold years

S7 [Salon A]

New Stage of Ocean Acidification Studies: Responses of Oceanic Ecosystem including Fisheries Resources

Convenors:
Tsuneo Ono (Japan)
Jun Kita (Japan)
Debby Ianson (Canada)
John Pinnegar (ICES / UK)

14:00	**Richard A. Feely** The 2016 NOAA west coast ocean acidification cruise
14:20	**Jinwen Liu (*)** Respiration and enhanced ocean acidification in the hypoxic zone off the Changjiang estuary
14:40	**Katherine M. Swiney** Ocean acidification and increased temperatures reduce young-of-the-year red king crab (*Paralithodes camtschaticus*) survival, but not growth or morphology
15:00	**Cristina Villalobos (*)** Interactive effects of ocean acidification and ocean warming on Pacific herring (*Clupea pallasi*) early life stages
15:20	**Thomas P. Hurst** Nutritional and ocean acidification effects on larval growth of a North Pacific flatfish
15:40	**Jonathan Reum (*)** Identifying potential ecosystem effects of ocean acidification using size structured food web models

S11 (Day 1) [Salon C]

Advances in Understanding and Modeling of Physical Processes in the North Pacific in the Past 25 Years of PICES and Future Directions

Convenors:
Shin-ichi Ito (Japan)
Kyung-Il Chang (Korea)
Steven Bograd (USA)

14:00	**Vyacheslav B. Lobanov (Invited)** Recent advances and future perspectives in the understanding of mesoscale water dynamics in the Japan/East Sea
14:25	**Hanna Na (*)** Mesoscale-eddy-induced variability of flow through the Kerama Gap between the East China Sea and the western North Pacific
14:45	**Hiromichi Ueno** Studies on mesoscale eddies in the subarctic North Pacific
15:05	**William Crawford** Mesoscale eddies of the Northeast Pacific Ocean
15:25	**Cheryl Harrison (*)** The effect of mesoscale circulation on biological production and carbon export in the North Pacific
15:45	**Hally B. Stone** Reconciling perspectives of upwelling system dynamics and basin-scale drivers on shelf water variability in the Pacific Northwest coastal ocean

16:00	***Coffee Break***	16:00	***Coffee Break***
S5	**[Salon D, E]**	**S6**	**[Salon B]**
Understanding our Changing Oceans through Species Distributions and Habitat Models based on Remotely Sensed Data		What Factors make or break Trophic Linkages?	
Convenors: Patrick O'Hara (Canada) Elliott L. Hazen (USA) Sei-Ichi Saitoh (Japan) Yutaka Watanuki (Japan)		**Convenors:** Elliott L. Hazen (USA) Jameal Samhouri (USA) Shin-ichi Ito (Japan) Jennifer Boldt (Canada)	
16:20	**Irene D. Alabia (*)** Bioclimatic velocity for walleye pollock in the Bering Sea	16:20	**Brian Wells** Caught in the middle: Top-down impact of seabirds on Chinook salmon (*Oncorhynchus tshawytscha*) is dependent on bottom-up mechanisms
16:40	**Dorothy M. Dick (*)** Forecasting the flock: Using species distribution models to evaluate the effects of climate change on future seabird foraging aggregations in the California Current System	16:40	**Yoichi Miyake** Shoreward intrusions of Kuroshio waters may influence the recruitment of a top predator in river ecosystems
17:00	**Hiromichi Igarashi** Adaptive improvement of habitat suitability index (HSI) model for neon flying squid in central North Pacific by using ocean forecasts and real-time fishery reports	17:00	**Adam J. Schlenger (*)** Temporal variability of net primary production drives global patterns of structure and function across multiple marine ecosystems
17:20	**Juan P. Zwolinski** Use of a potential habitat model to reduce uncertainty in surveys of Pacific sardine	17:20	**Kirstin Holsman** Suboptimal thermal conditions and spatial mismatch between predators and prey and may limit walleye pollock growth under climate change
17:40	**Matthew Baker** Integrating species environmental thresholds to explore species interactions and parameterize multi-species models	17:40	**James J. Ruzicka** Comparing the roles of physical context and food web structure among continental shelf ecosystems using intermediate complexity end-to-end models
18:00	***End***	18:00	***End***
18:30 21:00	**Poster Session**		

16:00	***Coffee Break***	16:05	***End of S11, Day 1***
S7	**[Salon A]**	**S8 (Day 1)**	**[Salon C]**
New Stage of Ocean Acidification Studies: Responses of Oceanic Ecosystem including Fisheries Resources		The Effect of Marine Debris caused by the Great Tsunami of 2011	
Convenors: Tsuneo Ono (Japan) Jun Kita (Japan) Debby Ianson (Canada) John Pinnegar (ICES / UK)		**Convenors:** Cathryn Clarke Murray (Canada) Nancy Wallace (USA) Hideaki Maki (Japan) Thomas Therriault (Canada)	
16:20	**John Keith Pinnegar (Invited)** Ocean acidification research in the United Kingdom: Scaling from chemistry to commercial fisheries	16:20	***Introduction by Convenors*** Maki/Wallace/Therriault
		16:25	**Nancy Wallace** Responding to the debris generated by the Great Tsunami of 2011
16:50	**Masahiro Hayashi** Effects of ocean acidification on growth of juvenile Japanese surf clam *Pseudocardium sachalinense*	16:40	**Masafumi Kamachi** Drift simulation of Japan Tsunami Marine Debris (JTMD) as an application of data assimilation
17:10	**Robert J. Foy** Sustainability of crab fisheries with ocean acidification uncertainty in Alaska	17:00	**Nikolai Maximenko** Modeling the drift of marine debris generated by the 2011 tsunami in Japan
17:30	**Masahiko Fujii** Anticipated impacts of ocean acidification on local societies in Japan	17:20	**Sherry Lippiatt (*)** The NOAA Marine Debris Monitoring and Assessment Project: Four years of effort in the U.S. Pacific States
17:50	**Tsuneo Ono** Wrap up	17:40	**Cathryn Clarke Murray (*)** The influx of marine debris to North American shorelines after the Great Tsunami of 2011
18:00	***End***	18:00	***End***

S8 (Day 2) [Salon D, E]

The Effect of Marine Debris caused by the Great Tsunami of 2011

Convenors:
Cathryn Clarke Murray (Canada)
Nancy Wallace (USA)
Hideaki Maki (Japan)
Thomas Therriault (Canada)

9:00	*Introduction by Convenors*
9:05	**Shin'ichiro Kako** Sequential monitoring of marine debris washed ashore on a western US beach using a webcam system
9:25	**Tomoya Kataoka (*)** Accumulation of beach litter in Vancouver Island, Canada
9:45	**Atsuhiko Isobe** An estimate of the tsunami-debris quantity washed ashore on the US and Canadian beaches, based on a webcam monitoring and a particle tracking model experiment
10:05	**John W. Chapman** Crustaceans adrift: Multiyear observations of Asian marine amphipods, isopods, and tanaids arriving in North American shores on open ocean drift objects generated by the 2011 Japanese Tsunami
10:25	*Coffee Break*
10:50	**Hiroshi Kawai** Genetic diversity and biogeography of the macroalgal species associated with the Japanese tsunami marine debris
11:10	**Nancy Treneman** The fate of wood at sea: shipworms (Bivalvia: Teredinidae) in woody debris from the 2011 Japanese tsunami

S9 (Day 1) [Salon B]

Resilience, Transitions and Adaptation in Marine Ecosystems under a Changing Climate

Convenors:
Franz Mueter (USA)
Ken Drinkwater (Norway)
Sei-Ichi Saitoh (Japan)
Emanuele Di Lorenzo (USA)

9:00	**Benjamin Planque (Invited)** Marine ecosystem resilience, what is it and how can we measure it?
9:30	**Mary E. Hunsicker** Early warning signals of declining resilience and abrupt transitions in ocean ecosystems
9:50	**Yongjun Tian** Status and trend of four commercially important coastal cephalopods in China Seas: An overview with implications for climate change
10:10	**Koji Sugie (*)** Effects of high-CO_2 and temperature on the dynamics of plankton communities in the subarctic Pacific
10:30	*Coffee Break*
10:50	**Kenneth L. Denman** A model simulation of the adaptive evolution through mutation of the coccolithophore *Emiliania huxleyi* based on a published laboratory study
11:10	**Salvador E. Lluch-Cota** Detection of a geographically fixed center of high abundance of macroinvertebrates along the west coast of Baja California

November 9

S11 (Day 2) [Salon A]

Advances in Understanding and Modeling of Physical Processes in the North Pacific in the Past 25 Years of PICES and Future Directions

Convenors:
Shin-ichi Ito (Japan)
Kyung-Il Chang (Korea)
Steven Bograd (USA)

9:00	**Michael Foreman (Invited)** Linking technological and POC advances over the past 25 years
9:25	**Fangli Qiao** Wave turbulence interaction induced vertical mixing and its effects in ocean and climate models
9:45	**Chanhyung Jeon (*)** Distribution of near-inertial waves in the mixed and deep layers of the East/Japan Sea using a high-resolution wind-forced ocean model
10:05	**Daji Huang** Synoptic variability of wintertime wind-driven circulation in the Bohai, Yellow and East China seas
10:25	*Coffee Break*
10:50	**Jerome Fiechter (Invited)** Regional and climate forcing on forage fish and apex predators in the California Current: New insights from a fully coupled ecosystem model
11:15	**Romeo Saldívar-Lucio (*)** Macro-scale patterns in upwelling/downwelling activity along the North American west coast

S13 [Salon C]

Understanding the Changing Coastal Ocean: Advances and Challenges in Multi-parameter Observations

Convenors:
Vyacheslav B. Lobanov (Russia)
Matthew Baker (USA)
Sung Yong Kim (Korea)
John Barth, USA (USA)
Daisuke Ambe (Japan)

9:00	***Introduction by Convenors***
9:05	**Hidekatsu Yamazaki (Invited)** Coastal observation systems to monitor physical, chemical and biological parameters
9:30	**Jinyong Jeong** Introduction to the Ocean Research Stations (ORSs) in Korea and application activities
9:50	**David M. Anderson** Recording extreme events in the multi-parameter Central and Northern California Ocean Observing System (CeNCOOS)
10:10	**Sung Yong Kim** Probing multi-scale oceanic signals from the coast
10:30	*Coffee Break*
10:50	**Richard Dewey** Using multiple platforms to assess a potential link between the North Pacific warm anomaly (the 'Blob') and anomalous conditions in the Salish Sea during 2015
11:10	**Brian P. V. Hunt** From marine terrestrial interactions to the "warm blob": Integrating land-ocean-atmospheric research in a coastal observatory framework

S8 (Day 2)	**[Salon D, E]**	**S9 (Day 1)**	**[Salon B]**
The Effect of Marine Debris caused by the Great Tsunami of 2011		Resilience, Transitions and Adaptation in Marine Ecosystems under a Changing Climate	
Convenors: Cathryn Clarke Murray (Canada) Nancy Wallace (USA) Hideaki Maki (Japan) Thomas Therriault (Canada)		**Convenors:** Franz Mueter (USA) Ken Drinkwater (Norway) Sei-Ichi Saitoh (Japan) Emanuele Di Lorenzo (USA)	
11:30	**Jonathan Geller** DNA barcoding of potential Japanese tsunami marine debris-associated invaders of U.S. and Canadian waters	11:30	**Caren Barceló (*)** Identifying climatically resilient or sensitive locations in the Northern California Current using partitioned beta-diversity
11:50	**Jocelyn C. Nelson (*)** The invasion risk of invertebrate species associated with Japanese tsunami marine debris in North America and Hawaii	11:50	**Paul Spencer** Climate vulnerability analysis of eastern Bering Sea fish and invertebrate stocks
12:10	**Gregory M. Ruiz** Detection of non-native species in North America: Effects of the large-scale arrival of biota on Japanese tsunami marine debris (JTMD)?	12:10	**Ekaterina P. Kurilova (*)** Resilience and adaptation of marine ecosystems in Vanina Bay, Sea of Japan: Past, present and scenarios for the future
12:30	***End***	12:30	***End***

S11 (Day 2) [Salon A]

Advances in Understanding and Modeling of Physical Processes in the North Pacific in the Past 25 Years of PICES and Future Directions

Convenors:
Shin-ichi Ito (Japan)
Kyung-Il Chang (Korea)
Steven Bograd (USA)

11:35	**Andrey G. Andreev** The seasonal and interannual variability of circulation in the eastern and western Okhotsk Sea and its impact on plankton biomass
11:55	**Nicholas A. Bond** The response of Northeast Pacific Ocean circulation to recent atmospheric forcing
12:15	**Alexander Kurapov** Anomalous oceanic conditions along the US West Coast in 2014: Inferences from a high resolution regional ocean model
12:35	***End***

S13 [Salon C]

Understanding the Changing Coastal Ocean: Advances and Challenges in Multi-parameter Observations

Convenors:
Vyacheslav B. Lobanov (Russia)
Matthew Baker (USA)
Sung Yong Kim (Korea)
John Barth, USA (USA)
Daisuke Ambe (Japan)

11:30	**Yang Luo** Water quality comparison and ecological environment assessment during major and minor tides in near sea area of Fujian Province
11:50	**Tetjana Ross** Multi-parameter observations of whales, zooplankton and hydrography on the west coast of Vancouver Island using ocean gliders
12:10	**David W. Welch** Advances in the science and technology underlying measurement of survival of juvenile fish in the ocean
12:30	***End***

Thursday,

Plenary (S10) [Grand Ballroom]

9:00 **Richard B. Rivkin**
Influence of phytoplankton-bacterial coupling on the export of biogenic carbon in the ocean: Insights from iron enrichment experiments

9:20 **Colleen Petrik (*)**
The response of fisheries production to natural and anthropogenic forcing: Past, present and future

9:40 **Michael Litzow**
Non-analogue ecosystem states in the Gulf of Alaska

10:00 **Ivonne Ortiz**
Applications of downscaled regional ocean biophysical models: Forecasting indicators and fish habitat

10:20 ***Coffee Break***

S2 [Salon D, E]		**S4** [Salon A]	
Early Life History Stages as Indicators and Predictors of Climate Variability and Ecosystem Change		Climate Variability, Climate Change and the Reproductive Ecology of Marine Populations	
Convenors: Richard Brodeur (USA) Tony Koslow (USA) Ian Perry (Canada) Moto Takahashi (Japan)		**Convenors:** John Field (USA) Sandi Neidetcher (USA) Michio Yoneda (Japan) Sukgeun Jung (Korea)	
10:50	**Jonathan Hare (Invited)** Climate change, stock identification, and the distribution of early life stages	10:50	**Olav Sigurd Kjesbu (Invited)** Crucial factors affecting reproductive investment of marine fishes in a changing climate
11:15	**Benjamin Laurel** Climate-driven growth potential affects recruitment signals in coastal age-0 cod surveys from the Atlantic and Pacific	11:20	**Richard S. McBride (Invited)** Fish responses to climate variation along a capital-income breeding continuum
11:35	**Lu Guan (*)** Decadal-scale changes in larval fish abundance and composition in the Strait of Georgia (British Columbia, Canada)		

November 10

(*) Flags an Early Career Scientist

S10 [Salon B]

The Response of Marine Ecosystems to Natural and Anthropogenic Forcing: Past, Present and Future

Convenors:
Steven Bograd (USA)
Hiroaki Saito (Japan)
Jacquelynne King (Canada)
Sukyung Kang (Korea)

10:40	**Yuliang Li (*)** An ecological compensation mechanism for marine protection area in China, based on the ecosystem services valuation
11:00	**Youngji Joh (*)** Extreme ocean temperature events in the North Pacific under greenhouse forcing
11:20	**Henry Lee II** The Icarus challenge - Predicting vulnerability to climate change using an algorithm-based species' trait approach
11:40	10-min break to switch from S10 to S9 Session

S12 [Salon C]

Causes and Consequences of 25 Years of Variability in Ocean Conditions on the Ecosystems of the North Pacific

Convenors:
William Peterson (USA)
Jack Barth (USA)
Sanae Chiba (Japan)
Yury Zuenko (Russia)

10:50	**Arthur J. Miller (Invited)** Changes in climate and changes in concepts: Physical-biological interplay in the Pacific Ocean over the PICES years
11:20	**Emanuele Di Lorenzo (Invited)** Increasing variance and synchrony in North Pacific climate and ecosystems

S2 [Salon D, E]

Early Life History Stages as Indicators and Predictors of Climate Variability and Ecosystem Change

Convenors:
Richard Brodeur (USA)
Tony Koslow (USA)
Ian Perry (Canada)
Moto Takahashi (Japan)

11:55	**José A. Valencia (*)** The spring spawning habitats of small pelagic fish in northwestern Mexico
12:15	**Sam McClatchie** Variability, collapse, and recovery of forage fish populations
12:35	***Lunch***
13:55	**Akinori Takasuka (Invited)** Decadal changes in abundance and distribution of early life stages of fish in the Kuroshio Current system
14:20	**Tetsuichiro Funamoto** Two walleye pollock stocks around Japan under different recruitment control mechanism
14:40	**Hwahyun Lee (*)** Specific gravity measurements on mackerel eggs and larvae and implications for interannual variability in recruitment
15:00	**Chiyuki Sassa** Comparative larval growth and mortality of mesopelagic fishes and their predatory impact on zooplankton in the Kuroshio waters

S4 [Salon A]

Climate Variability, Climate Change and the Reproductive Ecology of Marine Populations

Convenors:
John Field (USA)
Sandi Neidetcher (USA)
Michio Yoneda (Japan)
Sukgeun Jung (Korea)

11:50	**Hiroshige Tanaka** Temperature-related variability in the resource allocation to egg production in Japanese anchovy *Engraulis japonicus* as revealed by stable isotope approach
12:10	**Laura M. Slater** Female reproductive potential of eastern Bering Sea snow crab (*Chionoecetes opilio*)
12:30	***Lunch***
14:00	**Michio Yoneda** Size dependent energy allocation to reproductive output of short-lived multiple-batch-spawning Japanese anchovy *Engraulis japonicus*
14:20	**Christina L. Conrath** Variability in spawning omission and the productivity of deepwater rockfish in the North Pacific Ocean
14:40	**Yutzil Lora-Cabrera** Impacts of recent environmental anomalies on seabirds of the Baja California Pacific Islands, Mexico
15:00	**Melissa A. Head (*)** Challenges associated with assessing maturity, skipped spawning, and abortive maturation rates for fisheries managers: A case study of *Sebastes pinniger*

S9 (Day 2) [Salon B]		**S12** [Salon C]	
Resilience, Transitions and Adaptation in Marine Ecosystems under a Changing Climate		Causes and Consequences of 25 Years of Variability in Ocean Conditions on the Ecosystems of the North Pacific	
Convenors: Franz Mueter (USA) Ken Drinkwater (Norway) Sei-Ichi Saitoh (Japan) Emanuele Di Lorenzo (USA)		**Convenors:** William Peterson (USA) Jack Barth (USA) Sanae Chiba (Japan) Yury Zuenko (Russia)	
11:50	**Anne B. Hollowed** Are Arctic and sub-arctic fish stocks more prepared for a changing climate?	11:50	**Phoebe A. Woodworth-Jefcoats** Relationships between climate variability and fisheries catch in the central North Pacific
12:10	**Jorge García Molinos** Going with the flow: Ocean currents modify the coupling between climate change and biogeographical shifts	12:10	**Elena I. Ustinova** Climate variability and changes in the marginal Far-Eastern Seas
12:30	***Lunch***	12:30	***Lunch***
14:00	**Lorenzo Ciannelli** Life history spatial constraints and species adaptability to climate change	14:00	**Paul Fiedler** Warm and cool years in the California Current: Relation to ENSO
14:20	**Chang Seung** Assessment of management strategies for eastern Bering Sea walleye pollock fishery with climate change	14:20	**Mark S. Lowry** California sea lions: Historical diet patterns in relation to environmental changes in the California Current
14:40	**Chaewon Yoo (*)** Fisheries collapse and social changes in a fishing-dependent community: The case of Goseong	14:40	**Jaime Jahncke** Mid- and upper trophic level responses to variability in ocean conditions off central California
15:00	10-min break to switch from S9 to S3 Session	15:00	**John A. Barth** The subsurface and inner-shelf structure of 25 years of variability in the Northern California Current

S2	[Salon D, E]
Early Life History Stages as Indicators and Predictors of Climate Variability and Ecosystem Change	
Convenors: Richard Brodeur (USA) Tony Koslow (USA) Ian Perry (Canada) Moto Takahashi (Japan)	
15:20	**Xuelei Zhang** Effects of global warming and ocean acidification on population recruitment and growth of marine economic species
15:40	**Motomitsu Takahashi** Effects of temperature and prey abundances on larval growth rates of Carangid fishes in the East China Sea
16:00	***Coffee Break***
16:20	**Janet Duffy-Anderson (Invited)** Examining ichthyoplankton across spatial and temporal scales as an approach to promote understanding and management of fisheries across Large Marine Ecosystems
16:45	**J. Anthony Koslow** The influence of climate on the biodiversity and community structure of fishes in the southern California Current, 1969 – 2011
17:05	**Esther D. Goldstein (*)** Patterns and processes: Spatial and temporal variability in ichthyoplankton assemblages across the Gulf of Alaska
17:25	**Peter C. Davison (*)** Basin-scale ichthyoplankton response to environmental change in the northeastern Pacific Ocean
17:45	**Toby D. Auth** Changes in the ichthyoplankton in the northern California Current during the 2015-16 warm 'blob' and El Niño phenomena
18:05	***End***
18:30 21:00	**Poster Session**

S4	[Salon A]
Climate Variability, Climate Change and the Reproductive Ecology of Marine Populations	
Convenors: John Field (USA) Sandi Neidetcher (USA) Michio Yoneda (Japan) Sukgeun Jung (Korea)	
15:20	**Hyun-Sung Yang (*)** Inter-annual variation in the reproductive pattern of Manila clam *Ruditapes philippinarum* and impacts of *Perkinsus olseni* infection on the reproduction observed from the west coast of Korea
15:40	**Sabrina G. Beyer (*)** Interannual variability in larval production of rockfishes (*Sebastes* spp.) in the California Current
16:00	***Coffee Break***
16:20	**Loretta O'Brien** Evaluating environmental effects on maturity, spawning stock biomass, and biological reference points of Georges Bank Atlantic cod using state-space models
16:40	**Peng Sun (*)** Fisheries-induced evolution effects on fish populations in the East China Sea and its management implications
17:00	**Moojin Kim (*)** Differences in biological characteristics and recruitment variability of walleye pollock (*Gadus chalcogrammus*) off the eastern Korean Peninsula during 1960s–2000s
17:20	**Sandra Neidetcher** Fecundity estimates for walleye pollock during varying climate conditions
17:40	
18:00	***End***

S3 [Salon B]

Source, Transport and Fate of Hydrocarbons in the Marine Environment

Convenors:
Hideaki Maki (Japan)
Staci Simonich (USA)
Robert Duce (GESAMP, USA)

15:10	**Kenneth Lee (Invited)** Sources, behaviour and environmental impacts of petroleum hydrocarbons released into the marine environment
15:40	**Tanika Ladd (*)** Physiological responses of marine phytoplankton to oil exposure in the context of the 2015 oil spill in the Santa Barbara Channel
16:00	***Coffee Break***
16:20	**Hideaki Maki** Photo-oxidation of crude fuel and its toxicity to marine amphipods
16:40	**Andrew Loh (*)** *In situ* formation of oil-suspended particulate matter aggregate during flushing activities
17:00	**Charles Hannah** How far will it go? The estimation of oil spill extents from surface drifter data
17:20	**Miriam O** A framework to assess vulnerability of biological components to oil spilled in the marine environment
17:40	Wrap up
18:00	***End***

S12 [Salon C]

Causes and Consequences of 25 Years of Variability in Ocean Conditions on the Ecosystems of the North Pacific

Convenors:
William Peterson (USA)
Jack Barth (USA)
Sanae Chiba (Japan)
Yury Zuenko (Russia)

15:20	**William T. Peterson** Effects of the Blob on phytoplankton and copepod species composition, community structure and biodiversity off the central Oregon coast
15:40	**C. Tracy Shaw** Euphausiid responses to recent warming events in the coastal upwelling zone off the Oregon Coast, USA
16:00	***Coffee Break***
16:20	**Nathan Mantua** Historical context for the atmospheric forcing of record high SSTs in the NE Pacific Arc in 2014-16
16:40	**Lingbo Li** The impacts of climate variability on the distribution of groundfish along the Northeast Pacific coastal shelf
17:00	**Angelica Peña** A decade of phytoplankton composition and environmental measurements along Line P in the NE subarctic Pacific
17:20	**Stephen B. Brandt** Variability in North Pacific Ocean conditions: Assessing habitat-specific vital rates and thresholds for fishes
17:40	Discussion
18:00	***End***

Friday, November 11 [Grand Ballroom]

Session 10
The Response of Marine Ecosystems to Natural and Anthropogenic Forcing: Past, Present and Future

Convenors:
Steven Bograd (USA)
Hiroaki Saito (Japan)
Jacquelynne King (Canada)
Sukyung Kang (Korea)

9:00 **Samantha Stevenson (Invited) (*)**
An ensemble approach to understanding climate change in the Pacific

9:25 **Edward Gregr**
Marine habitats in a changing world: Looking beyond correlation

9:45 **Antonietta Capotondi**
The influence of ENSO diversity on North Pacific ecosystems

10:05 **Ryan R. Rykaczewski (Invited) (*)**
Wind stress, stratification, and source waters: How will eastern boundary current upwelling processes respond to climate change?

10:30 ***Coffee Break***

10:50 **Haruka Nishikawa (*)**
Simulated influence of the 1976–77 regime shift on anchovy and sardine in the California Current System

11:10 **Masaki Miya (Invited)**
Environmental DNA metabarcoding from fishes (and other vertebrates) using universal primers MiFish: A data-driven approach for fish community research

11:35 **Desiree Tommasi (*)**
Seasonal climate predictions to improve fisheries management decisions

11:55 **Jennifer M. Sunday (Invited)**
The mechanics of range shifts in a warming world

12:20 ***End***

Poster presenters are expected to be available to answer questions from 19:00-20:00

Poster Sessions, November 8 and 10, 18:30-21:00

S1: Science Board Symposium
25 Years of PICES: Celebrating the Past, Imagining the Future

S1-P1 **Sonia Batten**
Highlights from 16 years of the North Pacific CPR program, a PICES MONITOR project.

S1-P2 **Robert Blasiak (*)**
Negotiating the international instrument on BBNJ: Long-term implications

S1-P3 **Michio j. Kishi**
25 years history of ecosystem modeling related to PICES and myself

S1-P4 **Monica Tydlaska (*)**
Visitor activities and awareness of Marine Protected Areas and species composition at rocky intertidal sites in San Diego

S1-P5 **Ichiro Imai**
Increase in the toxic *Alexandrium tamarense* blooms with the climate regime shift to warming in the eastern Bering Sea shelf

S2: BIO/TCODE/FIS Topic Session
Early Life History Stages as Indicators and Predictors of Climate Variability and Ecosystem Change

S2-P1 **Xiaodong Bian (*)**
Interactive effects of incubation temperature and salinity on the early life stages of Pacific cod *Gadus macrocephalus*

S2-P2 **Cameron Freshwater (*)**
Density dependent effects on growth and migratory rate during sockeye salmon early marine residency

S2-P3 **Zhe Li (*)**
Interactive effect of thermal gradient and prey mismatch on thermal selection of juvenile Pacific cod (*Gadus macrocephalus*)

S2-P4 **Jarrod Santora**
Climate-driven variability in forage fish biodiversity in the California Current

S2-P5 **Hui Zhang**
Autumn ichthyoplankton assemblage in the Yangtze Estuary shaped by environmental factors

S2-P6 **Isaac D. Schroeder**
Source water variability in the California Current System and implications to rockfish production

S3: MEQ Topic Session
Source, Transport and Fate of Hydrocarbons in the Marine Environment

S3-P1 **Joon Geon An**
Atmospheric concentration of petroleum derived polycyclic aromatic hydrocarbons after the *Hebei Spirit* oil spill

S3-P2 **Anna S. Vazhova** (presented by colleage)
Influence of ships bilge water on sea water pollution with petroleum hydrocarbons

S4: FIS Topic Session
Climate Variability, Climate Change and the Reproductive Ecology of Marine Populations

S4-P1 **Lyndsey S. Lefebvre (*)**
Plasticity in reproductive strategies for rockfish in the Southern California Current and linkages to maternal characteristics and climatic variability

S4-P2 **Cara Rodgveller**
Ovarian development, energy storage, and skipped spawning in female sablefish in Alaska

S4-P3 **Michael J. Malick (*)**
Effects of the North Pacific Current on productivity of 163 Pacific salmon stocks

S4-P4 **Tatyana Belonenko**
On identification of mesoscale eddies from satellite altimetry based on the area in the NW Pacific

S4-P5 **Susanne McDermott**
Influence of environmental factors and density dependence on variability in reproductive output and growth of Atka mackerel (*Pleurogrammus monopterygius*)

S4-P6 **Hiroshige Tanaka**
Temperature effects on the reproductive traits of walleye pollock *Gadus chalcogrammus*

S4-P7 **Gavin Fay**
Identifying robust model selection tools for including environmental links to recruitment in North Pacific groundfish stock assessments

S5: BIO/MONITOR/MEQ Topic Session
Understanding our Changing Oceans through Species Distributions and Habitat Models based on Remotely Sensed Data

S5-P1 **Yang Liu (*)**
Impacts of climate change on suitable region for Japanese scallop aquaculture in Shandong, China and southern Hokkaido, Japan, using RS/GIS

S5-P2 **Caren Barceló (*)**
Integrating habitat, prey and predators over space and time to assess distributional responses to environmental variability and climate change

S5-P3 **Yutaka Watanuki**
Distribution of Arctic and Pacific copepods and their habitat in the northern Bering and Chukchi Seas

S6: POC/MEQ/MONITOR/BIO Topic Session
What Factors make or break Trophic Linkages?

S6-P1 **Elizabeth A. Daly**
Anomalous ocean conditions in 2015 and the impact on spring Chinook salmon and their prey field

S6-P2 **Taketoshi Kodama (*)**
Interannual variation in phytoplankton blooms and its biological impacts in the Sea of Japan

S6-P3 **Ryan J. Hartnett (*)**
Developing marine food web models to evaluate blue whale, Cassin's auklet and salmon responses to long- and short-term changes in oceanography in the California Current

S6-P4 **Francis Juanes** (on behalf of Paris Duguid)
Fine scale oceanography and the ecology of juvenile Chinook Salmon in the Salish Sea

S6-P5 **Yoshikazu Sasai**
Impact of physiological flexibility of phytoplankton on modeled primary production in the western North Pacific

S6-P6 **Dimitris V. Politikos**
Climate events and recruitment dynamics of anchovy in the California Current: A mechanistic understanding using a climate-to-fish model

S6-P7 **Peter Lawson**
Deepening thermocline displaces salmon catch on the Oregon coast

S6-P8 **Jarrod Santora**
Biogeography of seabird assemblages in the Bering Sea: Spatial assessment of oceanographic drivers and multispecies aggregation hotspots

S6-P9 **Xiuning Du**
Winter phytoplankton blooms and trophic implications on copepod and krill biomass and egg production in the northern California Current

S6-P10 **James J. Ruzicka**
Jellyfish - fish trophic interactions in the Bering Sea: Ecosystem impacts of jellyfish population fluctuations

S6-P11 **Cheryl Harrison (*)**
Sim-turtle: Biophysical interactions in the mesoscale

S6-P12 **Brian P. V. Hunt**
Integrating stable isotope analyses of zooplankton and returning adult salmon tissues to inform high seas North Pacific food web dynamics

S7: POC/TCODE/MEQ Topic Session
New Stage of Ocean Acidification Studies: Responses of Oceanic Ecosystem Including Fisheries Resources

S7-P1 **Yumei Zhao**
Ocean acidification observation system at Bohai Gulf based on ocean acidification characteristic parameters

S7-P2 **Sanae Chiba** (on behalf of Minoru Kitamura)
Is there decadal change in shell morphology of planktonic foraminifera due to ocean acidification?

S7-P3 **Naohiro Kosugi**
Frequent column observations revealed low pCO_2 water under the sea ice melt in the Canada Basin of the Arctic Ocean

S7-P4 **Masahiro Hayashi**
The combined effect of high pCO_2 and warming on reproduction of Japanese whiting *Sillago japonica*

S7-P5 **Norma L. Oliva-Méndez**
Dynamic of aragonite saturation horizon depth in waters of Baja California, Mexico

S7-P6 **Tomohiko Tsunoda**
Development of communication tools on ocean acidificaton

S7-P7 **JeongHee Shim**
Seasonal variations of pH and aragonite saturation at oyster culture beds in Tongyeong and Geoje Bays, southeast coast of Korea

S7-P8 **Futian Li**
Physiological responses of coastal and oceanic diatoms to diurnal fluctuations in seawater carbonate chemistry under two CO_2 concentrations

S8: MoE/MEQ/TCODE Topic Session
The Effect of Marine Debris caused by the Great Tsunami of 2011

S8-P1 **Gayle I. Hansen**
Marine algae carried across the North Pacific on Japanese Tsunami Marine Debris (JTMD) and their invasion threat to the coasts of Oregon and Washington, USA

S8-P2 **Gayle I. Hansen**
Marine algae carried across the North Pacific on Japanese Tsunami Debris: How have they survived the journey?

S8-P3 **Cathryn Clarke Murray (*)**
Aerial surveillance for tsunami debris in British Columbia, Canada

S8-P4 **Kirsten Moy (*)**
Synthesizing the state of debris in Hawaii from 2015 aerial imagery and spatial analysis data

S8-P5 **Won Joon Shim**
Contamination of hexabromocyclododecanes (HBCDs) in styrofoam marine debris from Asia and Pacific region and the Great Tsunami

S8-P6 **Sandra Lindstrom**
An undescribed species of Japanese *Pyropia* appeared on the coast of British Columbia in 2015

S8-P7 **Reva Gillman**
Life history and environmental requirement analyses of Japanese tsunami marine debris (JTMD) biota

S8-P8 **Amy MacFadyen**
Trends in arrival and deposition of Marine Debris generated by the March 2011 Japan Tsunami on Eastern Pacific Shorelines

S9: FIS/TCODE Topic Session
Resilience, Transitions and Adaptation in Marine Ecosystems under a Changing Climate

S9-P1 **Mikhail A. Stepanenko**
Fluctuations of the Bering Sea pollock recruitment, abundance, distribution as impacts on environmental changes

S9-P2 **Pavel Emelin (*)**
Species composition and biomass dynamics of nekton in the upper epipelagial of the deep-sea part of Okhotsk Sea during the autumn periods in 1998-2015 years

S9-P3 **Alexey A. Khoruzhiy (*)**
Seasonal shifts of compound and structure of the nekton community in the North-western Pacific Ocean

S9-P4 **Atsushi Yamaguchi**
Inter-oceanic differences in macrozooplankton biomass and community structure in four regions around Hokkaido Island, Japan: Consequences for marine ecosystem structure

S9-P5 **Wendy Morrison**
Literature review of management approaches that improve resilience for species, ecosystems, and/or fishing businesses.

S9-P6 **Keliang Chen**
Advancing the practice of marine eco-compensation in China: Knowledge synthesis from implementation

S9-P7 **Jianguo Du (*)**
Food sources and trophic structure of fishes and benthic macroinvertebrates in a tropical seagrass meadow revealed by stable isotope analysis

S10: FUTURE Topic Session
The Response of Marine Ecosystems to Natural and Anthropogenic Forcing: Past, Present and Future

S10-P1 **Zhongxin Wu (*)**
The exploration for system stability in the coastal marine ecosystem of northern Yellow Sea of China

S10-P2 **Taewon Kim**
Effects of climatic stressors on behavioral and physiological response of marine animals

S10-P3 **Aimee A. Keller**
Species-specific responses of demersal fishes to near-bottom environmental conditions within the California Current large marine ecosystem

S10-P4 **James Christian**
Detection of anthropogenic impacts on ocean biogeochemical cycles

S10-P5 **Taketo Hashioka**
Potential responses of phytoplankton community structure to future global warming

S10-P6 **Albert J. Hermann**
Statistical downscaling of global projections to the Bering Sea, based on an ensemble of regional model output

S10-P7 **Jung-Ho Hyun**
Upwelling-induced changes in the structure of plankton assemblages and role of heterotrophic bacterioplankton in biogeochemical carbon cycles in the Ulleung Basin, East Sea

S10-P8 **Weiwei Xian**
Estuarine ecology and environment: in response to long-term variations of Changjiang (Yangtze River) runoff input and sediment load

S11: POC Topic Session
Advances in Understanding and Modeling of Physical Processes in the North Pacific in the Past 25 Years of PICES and Future Directions

S11-P1 **Konstantin Rogachev**
Rapid freshening of the Kamchatka and Oyashio currents

S11-P2 **Nan Zang**
Spreading of Antarctic Intermediate Water in the Philippine Sea

S11-P3 **Jilong Chen**
Recent change of sea level variations in the East China Sea from merged altimetry data

S11-P4 **Toshiya Nakano**
A long-term reference for detecting oceanic variations in the western North Pacific: JMA 50-year long 137°E repeat hydrographic section

S11-P5 **Rong-shuo Cai**
Comparison of chlorophyll-a responses to climate change in the tropical western Pacific marginal seas

S11-P6 **Yukiharu Hisaki**
Time interpolation of surface winds and its impact on the modelling of inertial currents in the North Pacific

S11-P7 **Seongbong Seo (*)**
Vertical mixing observed on the continental slope of the southwestern East/Japan Sea

S11-P8 **Sayaka Yasunaka**
Mapping of the air–sea CO_2 flux in the Arctic Ocean and its adjacent seas: Basin-wide distribution and seasonal to interannual variability

S11-P9 **Ferdenant A. Mkrtchyan**
About microwave radiometry and spectroellipsometric technologies for monitoring marine ecosystems

S11-P10 **Chan Joo Jang (*)**
Evaluation surface winds over the Korean Peninsula and its surrounding seas

S11-P11 **Eliana Gómez-Ocampo (*)**
Approach of dynamic physical thresholds on spatial-temporal phytoplankton variability in NE Pacific

S12: MONITOR/BIO/TCODE Topic Session
Causes and Consequences of 25 Years of Variability in Ocean Conditions on the Ecosystems of the North Pacific

S12-P1 **Christina Eunjin Kong (*)**
Reponses of marine primary productivity (PP) to the future climate change scenario: The role of the subsurface chlorophyll maximum (SCM) in the mid-latitudinal marginal seas

S12-P2 **Hitoshi Kaneko (*)**
Interannual variation of ocean environment in the Kuroshio Extension, Oyashio, and their transition area correlated with the recruitment of chub mackerel (*Scomber japonicas*)

S12-P3 **Timothy Jones (*)**
Mass mortality of small seabirds in NE Pacific 2014/2015: Consequences of NE Pacific anomaly

S13: MONITOR/TCODE Topic Session
Understanding the Changing Coastal Ocean: Advances and Challenges in Multi-parameter Observations

S13-P1 **Vadim Navrotsky**
Multifactor effects of near-bottom processes in the coastal ocean

S13-P2 **Tae-Hoon Kim**
Submarine groundwater discharge (SGD) and SGD-driven nutrient fluxes in Geoje Bay, Korea

S13-P3 **Semi Jeong (*)**
Biochemical composition of surface sedimentary organic matter and material fluxes at the sediment-water interface of Jaran Bay, Korea

S13-P4 **Yarong Zou**
Analysis on coastline change under ecological environment of coastal zone - A case of Sanya

S13-P5 **Jingsong Yang**
Typhoon storm surges observed by Chinese HY-2A satellite radar altimetry

S13-P6 **Chungho Lee**
The present and future of Ocean Research Stations (ORSs) of the Korea Hydrographic and Oceanographic Agency (KHOA)

S13-P7 **Sarah Ann Thompson**
Multivariate Ocean Climate Indicator (MOCI): Describing the California Current

S13-P8 **Seul-Ye Lim (*)**
Non-market value of marine ecosystem service in Saemangeum open sea in Korea

S13-P9 **Yong Lin**
Spatial-temporal pattern analysis of sea surface temperature evolution in North Pacific Ocean

S13-P10 **Luis Valdés**
New light for time series: international collaboration in ship-based ecosystem monitoring

S13-P11 **Fangfang Wan (*)**
Integration and duplication removal of the oceanographic and marine meteorological data at CMOC/China

BIO Contributed Poster Session 1
Recent Progress in Deep-Sea Research and Conservation: Lessons from Various Parts of the Globe

BIO-P1-1 **Alexei M. Orlov**
Range-wide analysis of spatial distribution of Pacific flatnose *Antimora microlepis* in the North Pacific

BIO-P1-2 **Alexei M. Orlov**
Spatial distribution, size composition, and dynamics of abundance of Okhotsk skate *Bathyraja violacea* in the North Pacific

BIO-P1-3 **Alexei M. Orlov** (on behalf of A. Brandt and M. Milyutina)
Joint German-Russian deep-sea expeditions in the NW Pacific

BIO-P1-4 **Lian E. Kwong (*)**
A novel approach to estimating active carbon flux using the biomass size spectra

BIO-P1-5 **Yongling Zhu**
Progress of Chinese deep sea research activities in recent 2 years

BIO-P1-6 **S. Kim Juniper**
Georeferenced sensor, survey and sample data for the Endeavour Hydrothermal Vents Marine Protected Area

BIO-P1-7 **Brandon M. Genco (*)**
Biogeographical analysis of abyssal bottom habitats: Using an abiotic province scheme and metazoan occurrence databases

BIO-P1-8 **Anders Knudby**
Data-driven bioregions for local ecosystem context in species distribution models

BIO-P1-9 **Ryan Gasbarro (*)**
A time-series of epibenthic community turnover along a dissolved oxygen gradient

BIO-P1-10 **Benjamin Grupe (*)**
Endeavour Hydrothermal Vents Marine Protected Area conservation and management supported through institutional collaborations and interdisciplinary research

BIO Contributed Poster Session 2

BIO-P2-1 **(Bin Zou?) Lijian Shi**
Green tide (*Entermorpha prolifera*) monitoring in the Yellow Sea and East China Sea using multi-sensor

BIO-P2-2 **Dharmamony Vijai (*)**
Effects of temperature on embryonic development and paralarval behavior of the neon flying squid *Ommastrephes bartramii*

BIO-P2-3 **Dharmamony Vijai (*)**
Atlas of neon flying squid embryonic and paralarval development

BIO-P2-4 **Alexei I. Pinchuk**
Spatial and temporal heterogeneity in distribution of euphausiid *Thysanoessa longipes* from the northern Gulf of Alaska

BIO-P2-5 **Masahiko Fujii**
Study on material cycling in the coastal waters and the role of the Kiritappu Wetland, in Hamanaka Town, Hokkaido: An analysis using surf clam (*Pseudocardium sachalinense*) as an environmental indicator

BIO-P2-6 **Xianhong Meng**
An overview of culturing and breeding of *Fenneropenaeus chinensis* in China

BIO-P2-7 **Yang Jin Jo and Won Gyu Park**
Temperature effects on the egg development time and productivity of *Acartia omorii* and *Acartia steueri*

BIO-P2-8 **Tae-Ho Yoon (*)**
Application of end-pairing sequencing technique for the phytoplankton community analysis in East Sea

BIO-P2-9 **Vladimir V. Kulik (*)**
Boreopacific gonate squid (*Boreoteuthis borealis*) abundance and its relation to climate indices in the Northwest Pacific

BIO-P2-10 **Lucie Hannah**
Pilot application of a framework to assess vulnerability of biological components to oil spilled in the marine environment to the Canadian Pacific Region

BIO-P2-11 **Hiroaki Saito**
Geographical variation in the concentration and form of biogenic elements in the North Pacific Ocean

BIO-P2-12 **Stephanie E. Nehasil (*)**
The dietary response of the California sea lion population during the 2013 Unusual Mortality Event

BIO-P2-13 **David Martínez-Cervantes (*)**
Density and distribution of seabirds on the Baja California Pacific islands, Mexico

BIO-P2-14 **Timothy S. Lee (*)**
Synthesis of benthic macroinvertebrate diversity in coastlines of the Puget Sound before and after shoreline restoration

BIO-P2-15 **Keyseok Choe**
Macromolecular compositions of phytoplankton in the Japan/East Sea

FIS Contributed Poster Session

FIS-P1 **Caitlin I. Allen Akselrud (*)**
Application of an age-length structured population dynamics model to data for eastern Bering Sea tanner crab (*Chionoecetes bairdi*), Pribilof Island blue king crab (*Paralithodes platypus*), and Pacific cod (*Gadus macrocephalus*)

FIS-P2 **Mikinori Ueno (*)**
Comparison of fish-killing activities of *Chattonella antiqua* and *Chattonella marina* against three fish species and possible mitigation effect of alginate oligomer on *Chattonella* sp.

FIS-P3 **HoJin Bae (*)**
Reproduction and growth of the spiny lebbeid shrimp, *Lebbeus groenlandicus* (Fabricius, 1775) (Caridea, Hippolytidae) in the East sea of Korea

FIS-P4 **Christopher N. Rooper**
Linking Pacific Ocean perch productivity to deep-sea corals and sponges in Alaska

FIS-P5 **Hiroki Yasuma**
Annual changes in distributions and abundances of dominant myctophid fishes in the Pacific side of Hokkaido, Japan

FIS-P6 **Gordon H. Kruse**
Cumulative effects of size-selective fishing on size-at-age of Pacific halibut in the northeast Pacific Ocean

FIS-P7 **HanJu Kim (*)**
Age and growth of damselfish *Chromis notata* (Temminck & Schlegel, 1843) in the Jeju Island, Korea

FIS-P8 **SeongEun Kim (*)**
Growth and reproduction of the Japanese mantis shrimp, *Oratosquilla oratoria* (De Haan 1844) in the coastal area of Tongyeong, Korea

FIS-P9 **Jun Shoji**
Effects of submarine groundwater on feeding and growth of juvenile marbled flounder *Pseudopleuronectes yokohamae* in the Seto Inland Sea, Japan

FIS-P10 **Hyun-Ki Hong (*)**
First report on an annual gametogenesis of *Hyotissa hyotis* (Linnaeus 1758), the subtropical oyster in Jeju Island off the south coast of Korea

FIS-P11 **Makoto Tomiyasu (*)**
Spawning migration tracking of adult Pacific herring (*Clupea pallasii*) using supersonic telemetry

FIS-P12 **Jie Kong**
Multiple-trait genetic evaluation of the Pacific white shrimp *Litopenaeus vannamei* in China

FIS-P13 **Mariella Canales (*)**
Climate and feedback structures influence the population dynamics of small pelagic fish population off Chile

FIS-P14 **Jung-Yeon Kim (*)**
Age validation and growth rate of *Mactra chinensis* (Bivalvia, Mactridae) by chondrophore

FIS-P15 **Chiyuki Sassa**
Ontogenetic changes and interannual variations in diet of Japanese jack mackerel (*Trachurus japonicus*) juveniles in the East China Sea

FIS-P16 **Minkyoung Bang (*)**
Changes in biomass of walleye pollock *Gadus chalcogrammus* in the East Sea: | The late 1980s regime shift

FIS-P17 **Yoshiki Kato**
Growth, migration and trophic interactions role of neon flying squid (*Ommastrephes bartramii*) in the North Pacific

FIS-P18 **Tetsuichiro Funamoto**
Importance of early life transports for recruitment of walleye pollock *Gadus chalcogrammus* in the Sea of Japan off Hokkaido Island

FIS-P19 **Kazuo Ishikawa (*)**
Successive recruitment of age-0 jack mackerel (*Trachurus japonicus*) in coastal areas along the Kuroshio

FIS-P20 **Shufang Liu**
Biodiversity patterns and changes in the fishery ecosystem of the Yellow Sea and the East China Sea

FIS-P21 **Shannon G. Obradovich (*)**
Bare hooks and other species interactions with benthic longline gear can influence hook-based abundance indices

FIS-P22 **James R. Hilger**
Disentangling the impact of regulation and climate on vessel productivity: A case study of the Leatherback Turtle Conservation Area closure and the California drift gill net swordfish fishery

FIS-P23 **Francis Juanes**
Does returning sockeye salmon (*Oncorhynchus nerka*) condition vary with climate in two BC rivers?

FIS-P24 **Matthew Baker**
Pacific sand lance in the San Juan Islands: synthesis of research 2010-2016

FIS-P25 **Matthew Baker**
Quantifying and evaluating implications for trawlable and untrawlable habitat

MEQ Contributed Poster Session

MEQ-P1 **Dong-Woon Hwang**
Evaluation of organic matter and trace metal concentration in Korean coastal sediment using geochemical assessment techniques

MEQ-P2 **Minkyu Choi**
Rapid determination of organochlorine pesticides in fish using selective pressurized liquid extraction and gas chromatography–mass spectrometry

MEQ-P3 **Hyung Chul Kim**
Estimation of carrying capacity for oyster farming in Korea and its economic benefits

MEQ-P4 **Taehee Lee**
Sediment oxygen consumption rate and hydrogen sulfide release by dissolved oxygen depletion in hypoxic area of the Gamak Bay, Korea

MEQ-P5 **Won Chan Lee (*)**
Modelling pollution contribution rate for watershed management in Masan Bay

MEQ-P6 **Osamu Tominaga**
Estimate the contribution of submarine groundwater discharge to the biological productivity in coastal waters by the stable isotope signal recorded in the shell

MEQ-P7 **Jianwei Wu (*)**
The design of an integrated Sino-Vietnam marine and island environment | information management system deployed in Beibu Gulf

MEQ-P8 **Haiyan Wang**
The levels of total phosphorous, total nitrogen, in sediments from ST06 areas, South Sea, China

MONITOR Contributed Poster Session

MON-P1 **Mi-Ok Park**
Distribution of the CDOM(Chromophoric Dissolved Organic Matter) in spring of 2012-2014 at southwestern East(Japan) Sea

MON-P2 **Clarissa Anderson**
How ocean observations work for you: A perspective from the U.S. IOOS Regional Association serving Southern California

POC Contributed Poster Session

POC-P1 **Lijian Shi**
Sea ice detection for the Bohai Sea using MODIS data

POC-P2 **Ki-Hyuk Eom**
Ocean acidification on coast of the korea

POC-P3 **Rong-shuo Cai**
Enhanced responses of sea surface temperature in offshore China to global warming and hiatus

POC-P4 **Carol Ladd**
Cross-isobath exchange in Bering Canyon

POC-P5 **Xiao-Hua Zhu**
The impact of monsoon winds and mesoscale eddies on the South China Sea western boundary current

POC-P6 **Dong Guk Kim**
Comparison between two types of moored vertical profiler

POC-P7 **Kwang-Young Jeong**
Mean sea level (MSL) trends around the Korea Peninsula with tide gauge and altimeter data

POC-P8 **Chan Joo Jang**
Regional characteristics of global warming: Linear projection for the timing of unprecedented climate

POC-P9 **Chan Joo Jang**
Recent cooling trend in the Yellow and East China Seas and the associated North Pacific climate regime shift

POC-P10 **A-Ra Choi**
Long-term changes of South China Sea surface temperatures in winter and summer

POC-P11 **Hee Dong Jeong**
Ferry based monitoring in the NEAR-GOOS Area

POC-P12 **Allen H. Andrews**
Nuclear bombs and coral: Guam coral core reveals operation-specific radiocarbon signals from the Pacific Proving Grounds

Section on *Ecology of Harmful Algal Blooms in the North Pacific* Poster Session

S-HAB-P1 **Lin Yang**
The detection of lipophilic toxins and hydrophilic toxins in shellfish collected from Chinese East Sea by LC–MS/MS

S-HAB-P2 **Polina A. Kameneva (*)**
Prorocentrum foraminosum Faust (Dinophyceae) as a potential source of DSTs in the Peter the Great Bay, Sea of Japan (East Sea)

S-HAB-P3 **Zhengguo Cui**
Treatment of saline aquaculture wastewater with a constructed wetland

Section on *Human Dimensions of Marine Systems* Poster Session

S-HD-P1 **Elizabeth D. Tobin (*)**
Linking traditional knowledge and ecological studies to improve understanding of paralytic shellfish poisoning and enhance sustainability of shellfish harvest in Southeast Alaska.

S-HD-P2 **Michael Waine**
Implementation of ecosystem-based fisheries management in U.S. Fisheries

S-HD-P3 **Lv Han**
Ecological service value assessment and distribution of seaweed aquaculture in China using GIS

S-HD-P4 **Jingmei Li (Shang Chen?)**
Valuing the loss of ecological benefits of wetland reclamation in Jiaozhou Bay based on choice experiments

S-HD-P5 **Keith R. Criddle**
Alaska's sablefish fishery after Individual Fishing Quota program implementation—A bioeconomic analysis

S-HD-P6 **Yoshioki Oozeki**
Evaluation of sustainability of fisheries products around Japan: Sustainable, Healthy and "*Umai*" Nippon seafood (SH"U"N) Project

W8: **POC Workshop**
Mesoscale and submesoscale processes in the North Pacific:
History and new challenges

W8-P1	**Hiromu Ishiyama** Global distribution of mergers and splits of oceanic mesoscale eddies
W8-P2	**Elígio de Raús Maúre** Impact of mesoscale eddies on spring bloom initiation in the Japan Sea
W8-P3	**Kyung-Jae Lee** Mesoscale eddies in the East/Japan Sea: Detecting methods and characteristics of eddy properties

W9: **POC Workshop**
The role of the northern Bering Sea in modulating Arctic environments:
Towards international interdisciplinary efforts

W9-P1	**Kirill Kivva (*)** Seasonal dynamics of dissolved inorganic nutrient in the Bering Sea

W10: **MEQ Workshop**
Distribution and Risk Analysis of Radionuclides in the North Pacific

W10-P1	**Delvan R. Neville (*)** Effect of migratory life history on North Pacific albacore (*Thunnus alalunga*) uptake of radiocesium
W10-P2	**Kankan Wu (*)** Application of environmental risk assessment for strategic decisionmaking in coastal areas: Case studies in China

Observing Organizations Posters

Argo	**Megan Scanderbeg** Argo in 2016: Sustaining core Argo and implementing recommended enhancements
CLIVAR	**Nico Caltabiano** Coordinated international activities on the climate study of ocean-atmosphere interactions
ESSAS	**Kenneth Drinkwater and Franz Mueter** Ecosystem Studies of Subarctic and Arctic Seas
IAMSLIC	**Debra A. Losey and Amy Butros** International Association of Aquatic and Marine Science Libraries and Information Centers
IATTC	**Daniel Margulies** The IATTC's research program on the reproductive biology and early life history of tunas in the eastern Pacific Ocean
IMBER	**Gro van der Meeren** The Integrated Marine Biogeochemistry and Ecosystem Research (IMBER) project
IOCCP	**Maciej Telszewski** International Ocean Carbon Coordinated Project
ISC	**Chi-Lu Sun and Gerard DiNardo** International Scientific Committee for Tuna and Tuna-like Species in the North Pacific Ocean
NANOOS	**Jan Newton** Northwest Association of Networked Ocean Observing Systems
NEAR-GOOS	**Vyacheslav Lobanov** North East Asian Regional GOOS
NPAFC	**Vladimir I. Radchenko** International Year of the Salmon: From idea to launch
SAHFOS	**Willie Wilson** Sir Alister Hardy Foundation for Ocean Science
SCCOOS	**Clarissa Anderson** Southern California Coastal Ocean Observing System
SCOR	**Ed Urban** Scientific Committee on Oceanic Research

Sessions and Workshops Descriptions

S1: Science Board Symposium
25 Years of PICES: Celebrating the Past, Imagining the Future

Co-Convenors:
Thomas Therriault (SB)
Angelica Peña (BIO)
Elizabeth Logerwell (FIS)
Chuanlin Huo (MEQ)
Jennifer Boldt (MONITOR)
Kyung-Il Chang (POC)
Toru Suzuki (TCODE)
Steven Bograd (FUTURE)
Hiroaki Saito (FUTURE)
Igor Shevchenko (Russia)

Invited Speakers:
Cornelius Hammer (International Council for the Exploration of the Sea (ICES))
Naomi Harada (Research and Development Center for Global Change (RCGC),
Japan Agency for Marine-Earth Science and Technology (JAMSTEC), Japan)
Alan Haynie (NOAA Fisheries' Alaska Fisheries Science Center, USA)
Guido Marinone (Centro de Investigación Científica y de Eduación Superior de Ensenada
(CICESE), Mexico)
Philip Munday (James Cook University, Australia)
Phillip Mundy (Alaska Fisheries Science Center, NMFS, NOAA, USA)
Essam Yassin Mohammed (International Institute for Environment and Development, London, UK)

In its 25 years of existence PICES has achieved remarkable success in furthering our understanding of the North Pacific's natural and socioeconomic systems. Dedicated and tireless efforts of the many natural and social scientists from all its member countries have enabled us to understand basin-scale phenomena that we did not know about 25 years ago, such as regime shifts and their ecosystem impacts—from biogeochemistry, through phytoplankton production, to higher trophic levels including fisheries and coastal communities. Building on these foundational results, we now embark on the next 25 years of PICES that should lead to better observations, improved understanding of mechanisms of change, and ultimately better predictions of status and trends in North Pacific ecosystems. Forecasting the effects of natural and anthropogenic change, especially climate change, will allow adaptation based on the ecological, societal, and economic resilience of our coasts and oceans. Increasing resilience is a key societal challenge and will only be possible with increased scientific knowledge of the North Pacific and intergovernmental collaborations like those developed within PICES.

The founders of PICES saw the vastness of the North Pacific Ocean not as something that separates us, but rather as a factor that unites us. They knew that to unravel the inner workings of the North Pacific, PICES member countries would need to work together. To recognize the leadership that set us on this path, we encourage contributions on how present day problems are being addressed with the science and tools that we developed over the past 25 years. Looking forward, we encourage visionary papers on what challenges might be expected over the next 25 years. The list of past and future topics of interest in PICES is long, and includes basin- and regional-scale issues such as coastal ecosystem stressors (eutrophication, hypoxia, pollution, ocean acidification), loss or changes of marine biodiversity, changing productivity and species distributions in response to climate change, developing outlooks or forecasts of future ocean ecosystems, and examining climate change impacts on ocean ecosystems and human society.

S2: BIO/TCODE/FIS Topic Session
Early Life History Stages as Indicators and Predictors of Climate Variability and Ecosystem Change

Co-Convenors:
Richard Brodeur (USA)
Tony Koslow (USA)
Ian Perry (Canada)
Moto Takahashi (Japan)

Invited Speakers:
Jon Hare (NOAA, USA)
Akinori Takasuka (National Research Institute of Fisheries Science, Japan Fisheries Research and Education Agency (Yokohama, Japan)

As management strategies become more ecosystem-based and climate-driven, there is a need for more information on the influence of oceanographic variability and climate change in regulating fisheries resources and on marine communities more generally. Ichthyoplankton abundance provides proxies for adult spawning stock biomass, so insight into changing fish communities can be obtained from ichthyoplankton time series. The early life stages of fish and invertebrates may also be critical in determining year class success and subsequent recruitment to fisheries. This session will examine changes in the abundance, distribution, and ecological relationships of early life stages (eggs to juveniles) of fish and invertebrate taxa in relation to climate. Studies that use these stages as indicators of ecosystem stress or long-term variability in relation to the ocean environment are encouraged, as are studies that use them as an indicator of future adult recruitment. Examples of the uses of ichthyoplankton or juvenile surveys in ocean observation programs and ecosystem assessment or management of stocks and in forecasting future trends in fisheries and fish communities are highly encouraged. The conveners especially seek presentations that examine the role early life stages may play in assessing ecosystem structure and dynamics and the vulnerability of ecosystems to climate change.

S3: MEQ Topic Session
Source, Transport and Fate of Hydrocarbons in the Marine Environment

Co-sponsor: GESAMP

Co-Convenors:
Hideaki Maki (Japan)
Staci Simonich (USA)
Robert Duce (GESAMP, Texas A&M University)

Invited Speaker:
Kenneth Lee (Commonwealth Scientific and Industrial Research Organization (CSIRO), Australia)

This session will focus on the behaviour, fate and effects of hydrocarbons in the marine environment. While it is expected that some examples of oil spills (catastrophic release of hydrocarbons) will be examined, most discussions will focus on chronic, low level releases from multiple sources that are far more evasive and widespread (e.g. ballast discharges, fuel release, harbour contamination). Following two successful sets of activities at PICES 2014 and 2015 (‘Microplastics’ and ‘Indicators of ocean pollution’), the WG-31 (Emerging Topics Marine Pollution; ETMP) proposes to organize, convene and facilitate the third in its planned series of Special Sessions. The topic for 2016 is to comprehensively address the science of ‘Source, transport and fate of hydrocarbons in the marine environment’. This is timely for PICES as it follows up on the 2015 workshop on short term response workshop (“Marine Environment Emergencies: Detection, monitoring and response”). This topic is also timely since oil and gas exploration, development and transport is taking place to varying degrees around the North Pacific Ocean. Thousands of different hydrocarbon compounds are found in fuels, each with different physical and chemical properties. The resulting complex interactions between these compounds and components of the marine environment highlight the importance of a multidisciplinary and up-to-date sharing of knowledge. This knowledge will provide insight into the consequent risks to biota, the design of monitoring programs, the choice of analytical methods, and management responses following leaks or spills. This Special Topic Session will feature invited speakers from several national organizations. A Special Issue in a scientific journal will arise from the presentations on "Source, transport and fate of hydrocarbons in the North Pacific Ocean". Presenters and others will be invited to submit a manuscript on the topic, with the goal of the resulting compendium being to become a useful reference work for scientists and managers.

S4: FIS Topic Session
Climate Variability, Climate Change and the Reproductive Ecology of Marine Populations

Co-Convenors:
John Field (USA)
Sandi Neidetcher (USA)
Michio Yoneda (Japan)
Sukgeun Jung (Korea)

Invited Speakers:
Olav Kjesbu (Hjort Centre for Marine Ecosystem Dynamics, Institute of Marine Research, Bergen, Norway)
Richard McBride (NOAA Fisheries, Woods Hole Laboratory, USA)

Ongoing efforts to understand the consequences of both climate variability and climate change on marine populations have focused on indirect metrics of productivity, primarily recruitment, growth, distribution. The question of how the reproductive ecology, particularly reproductive output, of marine fishes, invertebrates, mammals and other organisms may be altered by a changing climate is difficult to address. Fully understanding all aspects of the reproductive ecology of populations when developing and parameterizing stock assessment and other population models is key to accurately assessing reproductive output and potential, as those in turn relate to productivity and both static and dynamic views of carrying capacity. The appreciation for the significance of age and size dependent factors that relate to reproductive potential continues grow, particularly for many long lived and slow growing species for which factors such as size dependent fecundity, skipped spawning, multiple brooding and other maternal effects continuing to contribute to a greater appreciation for the need to understand reproductive complexity. Higher turnover species, particularly indeterminate spawners, are presumably more sensitive still to climate variability and change. Future climate change, with expected impacts on means, modes of variability, and the phenology of ocean conditions, will interact with the effects of fishing to alter reproductive potential in complex and unanticipated ways. This Symposium will seek contributions that focus on the mechanisms and consequences of environmental variability and potential change on the reproductive potential of marine fishes, or model and simulation studies that evaluate the likely or plausible consequences of such changing ocean conditions, with the ultimate goal to understand possible future changes to the carrying capacity and productivity of marine populations.

S5: BIO/MONITOR/MEQ Topic Session
Understanding our Changing Oceans through Species Distributions and Habitat Models based on Remotely Sensed Data

Co-Convenors:
Patrick O'Hara (Canada)
Elliott Hazen (USA)
Sei-Ichi Saitoh (Japan)
Yutaka Watanuki (Japan)

Invited Speaker:
Robert Suryan (Oregon State University, OR, USA)

Determining marine animal distributions directly through at-sea observations or tracking is costly and logistically challenging. Moreover, even with limitless time and resources, information is limited because many species disperse over long distances including trans-hemispheric migrants. Species Distribution Models (SDMs) provide a tool to estimate present distributions and to project into the future (assuming species-environment relationships remain strong), but these models require substantial environmental data to accurately predict distribution and change. Increasingly, SDM approaches rely on remotely-sensed satellite data as indices of environmental conditions, particularly as proxies for primary and possibly secondary productivity. Satellite datasets are inexpensive to use, widely served, well-documented (i.e., scientifically defensible), and globally synoptic, allowing for easy spatio-temporal comparisons. However, satellite-borne sensors measure characteristics of the ocean at the surface while marine organisms respond to spatial and temporal features of the ocean at depth, which may require more complex approaches. In this session, we will investigate the opportunities and challenges of using satellite-based habitat models and ways we can advance SDMs for a better understanding our changing oceans and for improving management. In particular, we solicit papers exploring the benefits and tradeoffs of using satellite-borne data to detect mechanisms of distributional and range shifts. This session will provide the PICES community and the FUTURE program with a better sense of the quality of fisheries, seabird, and marine mammal SDM under development in relation to climate change in the North Pacific.

S6: POC/MEQ/MONITOR/BIO Topic Session
What Factors make or break Trophic Linkages?

Co-Convenors:
Elliott L. Hazen (USA)
Jameal Samhouri (USA)
Shin-Ichi Ito (Japan)
Jennifer Boldt (Canada)

Invited Speakers:
Masashi Kiyota (National Research Institute of Far Seas Fishereis, Fishey Resarch Agency, Japan)
Kenneth Rose (College of the Coast & Environment, Louisiana State University, USA)

Mechanistic linkages from physics to phytoplankton to zooplankton to fish remain central to understanding climate forcing on marine ecosystems. Thus, it will be useful to understand how ecosystem linkages and species distribution are influenced by ocean features and how these linkages translate through the food web. Specifically, what information can be gained from moving beyond a single linkage (e.g. phytoplankton to zooplankton) towards a comparison across trophic levels in three very different North Pacific ecosystems. Examples of such factors may include but are not limited to broad scale anomalies (e.g. the blob, ENSO events, Kuroshio / Oyashio dynamics), temporal mismatches among physical processes, prey, and predators (match / mismatch hypothesis), and population fluctuations (e.g. lipid poor vs. lipid rich zooplankton). We have suggested (but are not limited to) three study areas, the California Current, the Kuroshio Current, and the Bering Sea to examine linkages from physics to phytoplankton, phytoplankton to zooplankton, zooplankton to fish, birds and mammals, and fish to birds and mammals. By looking at multiple ecosystems and trends and anomalies across multiple trophic linkages, we can better understand how climate variability and anthropogenic forcing may cascade through these marine ecosystems. We propose a topic session that will involve participation from multiple PICES committees and will focus on physical forcing and trophic linkages from physics to top predators. Specifically, we request presentations on topics that (a) examine how changes in physical oceanography lead to long term trends or anomalous responses in primary production, zooplankton, fish, and top predators, (b) examine how trophic relationships may respond to physical forcing and changes in species abundance and spatial distribution, and (c) test for threshold responses (non-linearity) across trophic levels to changes in physical oceanography and the population dynamics of other species (competitors, prey, and predators).

S7: POC/TCODE/MEQ Topic Session
New Stage of Ocean Acidification Studies: Responses of Oceanic Ecosystem Including Fisheries Resources

Co-sponsor: ICES

Co-Convenors:
Tsuneo Ono (Japan)
Jun Kita (Japan)
Debby Ianson (Canada)
John Pinnegar (ICES / UK)

Invited Speakers:
John Pinnegar (Centre for Environment, Fisheries & Aquaculture Science, UK)
George Waldbusser (Oregon State University, USA)
Steve Widdicombe (Plymouth Marine Laboratory, UK)

Considering over 20 years of progress on ocean acidification studies, our knowledge on biological responses in response to acidified ocean environments has accumulated to some extent. WGII report of IPCC AR5 illustrates a sensitivity matrix of ocean life to acidification among a wide range of species and pCO2 levels, showing our present terminus of this scientific topic. However, our progress simultaneously awakes various new questions, such as the response of biology to temporally-varied pCO2, inter-species interactions under acidified environments, and biological adaptation. Also, we have gradually come to realize the existence of ocean acidification by eutrophication, as well as by anthropogenic CO2, in coastal regions. Emergence of these new questions reveals that we are now moving into a new stage of understanding on the ocean acidification problem, in which we may be able to make more realistic and quantitative predictions about future biological/ecological responses to an acidified ocean, and socio-economic response of humans to changes in ocean conditions. In this session we recruit diverse studies on biological/ecological responses to ocean acidification, including fisheries resources, both in coastal and open ocean environments. We particularly welcome reports from advanced issues on this field, including the response of biology subjected to temporally-varied pCO2, inter-species interaction under acidified environment, and biological adaptation.

S8: MoE/MEQ/TCODE Topic Session
The Effect of Marine Debris caused by the Great Tsunami of 2011

Co-sponsors: PICES MoE ADRIFT Project

Co-Convenors:
Cathryn Clarke Murray (Canada)
Nancy Wallace (USA)
Hideaki Maki (Japan)
Thomas Therriault (Canada)

Invited Speaker:
James Carlton (Professor of Marine Sciences Emeritus, Williams College, USA)

The Great Tsunami of 2011 washed an estimated five million tons of debris into the Pacific Ocean. The Government of Japan estimates that 70% of that debris sank close to shore, leaving 1.5 million tons floating in the North Pacific with the potential to arrive on North American and Hawaiian coastlines. While shorelines worldwide already endure marine debris from terrestrial and aquatic sources there may be additional impacts from the increase in abundance and differing debris types associated with the tsunami. Aside from the impacts of additional marine debris itself, there is the possibility of debris carrying coastal Japanese species to new habitats. An event of this magnitude offers unique opportunities to investigate the transport of non-native species, oceanographic processes and impacts of marine debris in general. With Working Group 21 on Non-indigenous Aquatic Species completed in 2012 and Working Group 31 on Emerging Topics in Marine Pollution formed in 2013, PICES members are well-placed to contribute to research on the potential impacts of Japanese tsunami marine debris. Funded by the Ministry of Environment of Japan, research on the effect of tsunami marine debris is ongoing under the PICES project ADRIFT (Assessing the Debris-Related Impact of Tsunami). Session presentations may cover the surveillance and monitoring of tsunami-generated marine debris, modeling the movement of marine debris in the North Pacific, the social impacts of tsunami debris and the risk from potentially invasive species to coastal ecosystems. The conveners especially seek presentations that address the impacts of tsunami debris on coastal communities and ecosystems.

S9: FIS/TCODE Topic Session
Resilience, Transitions and Adaptation in Marine Ecosystems under a Changing Climate

Co-sponsor: ICES

Co-Convenors:
Franz Mueter (USA)
Ken Drinkwater (Norway)
Sei-Ichi Saitoh (Japan)
Emanuele Di Lorenzo (USA)

Invited Speaker:
Benjamin Planque (Institute of Marine Research, Tromsø, Norway)

Marine ecosystems respond to climate variability and anthropogenic forcing at a variety of spatial and temporal scales. While there is a growing literature on the capacity of social-ecological systems to cope with climate change, the resilience of physical and ecological marine systems to climate change remains poorly understood. In the context of ongoing climate change, resilience refers to the capacity of a system to absorb disturbances and to reorganize so as to maintain its essential structure, function, identity and feedbacks. This concept presumes the existence of alternative stable states or regimes that are separated by reversible transitions. The concept also presumes the possibility of thresholds or tipping points that may be irreversible and are associated with the loss of essential structure and function. In an ecological context, tipping points occur if key organisms are no longer able to adapt to changes in their environment. This session explores the concept of resilience (sometimes also called stability) in both physical ocean systems and in the associated ecological systems from plankton through fish. We invite theoretical studies and applied case studies that help refine our understanding of resilience in a marine ecosystem context, provide practical approaches to measuring resilience, define "essential structure and function" of marine ecosystems, identify thresholds beyond which essential structure and function may be lost, examine ways in which resilience of marine ecological systems can be enhanced, and explore the phenotypic and evolutionary adaptive capacity of marine organisms to deal with gradual changes and transitions. Our hope is that this session will ultimately contribute to the development of more plausible scenarios for future physical and biological changes in marine ecosystems, which are needed to facilitate climate change adaptation in socio-economic systems that depend on marine resources.

S10: FUTURE Topic Session
The Response of Marine Ecosystems to Natural and Anthropogenic Forcing: Past, Present and Future

Co-Convenors:
Steven Bograd, NOAA (USA)
Hiroaki Saito (Japan)
Jacquelynne King (DFO, Canada)
Sukyung Kang (NFRDI, Korea)

Invited Speakers:
Masaki Miya (Natural History Museum and Institute, Chiba, Japan)
Ryan Rykaczewski (University of South Carolina, USA)
Jennifer Sunday (University of British Columbia, Canada)
Samantha (Sam) Stevenson (National Center for Atmospheric Research, CO, USA)

'Forecasting and Understanding Trends, Uncertainty and Responses of North Pacific Marine Ecosystems' (FUTURE) is an integrative Scientific Program undertaken by the member nations and affiliates of PICES to understand how marine ecosystems in the North Pacific respond to climate change and human activities, to forecast ecosystem status based on a contemporary understanding of how nature functions, and to communicate new insights to its members, governments, stakeholders and the public. One of the principal aims of FUTURE is to improve our understanding of how marine ecosystems respond to natural and anthropogenic forcing, and how marine ecosystems will change in the future. In this session, we will (a) review our state of knowledge on how climate variability and change affect the processes underlying ecosystem structure and function, (b) identify critical gaps in our understanding, and (c) provide an assessment of our capacity to forecast climate-driven marine ecosystem changes. Advances in the understanding of climate impacts on marine ecosystems, and a broad dissemination of this information, is essential for preserving a healthy and sustainable North Pacific for FUTURE generations.

S11: POC Topic Session
Advances in Understanding and Modeling of Physical Processes in the North Pacific in the Past 25 Years of PICES and Future Directions

Co-Convenors:
Shin-ichi Ito (Japan)
Kyung-Il Chang (Korea)
Steven Bograd (USA)

Invited Speakers:
Michael Foreman (Scientist Emeritus, Fisheries and Oceans Canada, Canada)
Jerome Fiechter (Institute of Marine Sciences, University of California-Santa Cruz, USA)
Vyacheslav Lobanov (V.I. Il'ichev Pacific Oceanological Institute (POI), Russia)
Ichiro Yasuda (The University of Tokyo, Japan)

Since its birth in 1992, the Physical Oceanography and Climate Committee (POC) have promoted and coordinated physical and chemical oceanography, atmospheric science, and interdisciplinary research in the northern North Pacific. Impacts of climate variability and physical dynamics in coastal, shelf and open ocean areas are considered with emphasis on processes that are related to living marine resources and environmental quality. POC addressed the following topics in order to achieve the goals of PICES through its expert groups: ocean circulation, the Okhotsk Sea and the Oyashio region, modelling physical processes, carbon cycling, connection between ocean variability and climate change, exchange between continental shelf waters and the nearby ocean, and future climate projections in regional-basis. POC can continue to contribute to PICES and PICES scientists by deepening our understanding of physical and chemical processes in ocean and climate in the North Pacific and also by providing leadership in identifying key issues associated with a central issue of PICES, understanding and projecting the long-term variability of the North Pacific ecosystems. The session will review the advancement of processes that POC has identified and consider new challenges that POC should target to improve understanding of marine ecosystems in the North Pacific.

S12: MONITOR/BIO/TCODE Topic Session
Causes and Consequences of 25 Years of Variability in Ocean Conditions on the Ecosystems of the North Pacific

Co-Convenors:
Bill Peterson (USA)
Jack Barth (USA)
Sanae Chiba (Japan)
Yury Zuenko (Russia)

Invited Speakers:
Emanuele Di Lorenzo (Earth & Atmospheric Sciences, Georgia Institute of Technology, USA)
Art Miller (Scripps Institution of Oceanography, University of California-San Diego, USA)

Climate change is upon us in terms of both slow chronic change and increased physical and ecosystem variability. Slow increases in SST, ice melting, sea level, hypoxia, ocean acidification and northward shifts in species are cause for concern, however for many scientists, climate variability at the seasonal-to-interannual time scale is of greater interest. This is especially true for the North Pacific where PICES scientists have been leaders in showing how increased variability in physical forcing at the basin scale (e.g., the PDO, NPGO and ENSO) affects productivity of marine ecosystems. Indeed, recognition of the impact of physical forcing at the basin scale on local ecosystems was among the earlier focal points of PICES research and clearly opened our eyes to the need to look at the physical forcing across the entire basin, not just local drivers of ecosystem variability. In the 25 years since PICES was established, many unusual oceanographic events have occurred in the throughout North Pacific that have affected the physics, plankton and fisheries: change in the PDO from 20-30 year cycles to the 5-10 year cycles seen at present, the extended "warm ocean" period of 1993-1998 that resulted in the listing of many salmon species as threatened or endangered, the really big El Niño events of 1997-98 and 2015-16, the 2002 sub-Arctic intrusion, the smaller 2003-2005 and 2009-10 El Niño events, the cold North Pacific in 2008, and of course the warm Blob in 2014. We seek papers that analyze and synthesize regional variations in recent climate variability and ecosystem response in coastal waters off Asia as well as the Sea of Okhotsk, Bering Sea, and the major current systems: Kuroshio, Oyashio, North pacific and California Currents.

S13: MONITOR/TCODE Topic Session
Understanding the Changing Coastal Ocean: Advances and Challenges in Multi-parameter Observations

Co-Convenors:
Vyacheslav B. Lobanov (Russia)
Matthew Baker (USA)
Sung Yong Kim (Korea)
John Barth, USA (USA)
Daisuke Ambe (Japan)

Invited Speaker:
Hidekatsu Yamazaki (Department of Ocean Sciences, Tokyo University of Marine Science and Technology, Japan)

Major changes in coastal ocean ecosystems occur across the North Pacific and its marginal seas on a variety of time scales, from weeks to years. Examples include warming events associated with low (e.g., El Nino) and high latitude (“warm blob”) forcing, and coastal hypoxia influenced by both natural and anthropogenic forcing. These major changes involve physical, chemical, and biological processes and their interaction. Sustained, high-quality, multi-parameter coastal observations are required to discern changes from normal seasonal patterns and to detect long-term trends. We invite contributions that address the role of coastal ocean observations in advancing our understanding of these major physical-biological changes in North Pacific coastal oceans. These may include techniques for sustaining multi-sensor time series and the use of new measurement platforms, as well as new measurements and understanding of regional interactions and coastal-deep ocean interactions at various areas of PICES region. Subsequent discussion will facilitate an exchange on how major regional phenomena (e.g., ENSO, anomalous warming) are expressed at localized scales, best practices and new approaches in observational techniques, and regional comparisons.

W1: POC Workshop
Acidification of the North Pacific Ocean: a basin-wide assessment

Co-Convenors:
James Christian (Canada)
Tsuneo Ono (Japan)

Invited Speaker:
Karen Kohfeld (Simon Fraser University, AB, Canada)

Ocean acidification has been proceeding for a century, at an accelerating rate, and its impacts are beginning to be felt in many corners of the North Pacific. This workshop will bring together scientists from all of the PICES countries to synthesize our observations and projections of acidification processes and impacts in our respective countries’ waters and adjacent international waters. This workshop is the culmination of a two-year long process of collation of relevant information, and synthesis of data collected in each of the countries of the North Pacific basin. The workshop proceedings will form the basis for subsequent assessments, with improved understanding of which ocean regions are most vulnerable to acidification impacts, and how additional resources might best be deployed to predict or detect changes likely to produce significant impacts.

W2: MEQ Workshop
Conditions promoting extreme Pseudo-nitzschia events in the eastern Pacific but not the western Pacific

Co-Convenors:
Vera Trainer (USA)
Polina A. Kameneva (Russia)

Invited Speaker:
Inna Stonik (Zhirmunsky Institute of Marine Biology, Vladivostok, Russia)

There is clear evidence of contrasting occurrence and impacts of the toxin-producing diatom, *Pseudo-nitzschia*, between the western and eastern Pacific. In 2015, a massive bloom spanning from California to Alaska, had major impacts on the shellfish industry economic viability and on wildlife health. In contrast, *Pseudo-nitzschia* are not highly toxic and do not cause economic losses in the western Pacific. These data provide a unique opportunity for east-west Pacific comparisons to identify and rank those environmental factors that promote harmful algal bloom (HAB) success at different times. The recent PICES-funded workshop on HABs and Climate Change emphasized the importance of studying such extreme events to enhance our understanding of climate impacts. This workshop will focus on *Pseudo-nitzschia*, a diatom that historically has had massive economic impacts in the eastern PICES member countries, with low or no impacts in the western Pacific. The workshop foundation will be an extension of the current dataset to the 1990s and earlier where available, with PICES participants pre-submitting available data on: HAB species presence, maximum abundance, toxicity, optimal conditions for growth, time of year, temperature range, salinity range, water clarity, nutrients, wind, river flow (flooding), and upwelling indices. Workshop participants will evaluate the trends and patterns in these data to develop hypotheses for development into outlook products in the morning, and develop an outline for manuscript preparation in the afternoon, including writing assignments and submission deadlines. The manuscript will be targeted for an appropriate peer-reviewed journal.

W3: BIO Workshop
Distributions of habitat-forming coral and sponge assemblages in the North Pacific Ocean and factors influencing their distributions

Co-Convenors:
Kwang-Sik Choi (Korea)
Janelle Curtis (Canada)
Masashi Kiyota (Japan)
Chris Rooper (USA)

Invited Speaker:
Hiroya Yamano (Center for Environmental Biology and Ecosystem Studies, NIES, Japan)

Changes in the marine environment influence global and regional distribution patterns of marine organisms including corals and sponges in shallow, mesophotic, and deepwater ecosystems. The biogenic habitats formed by these organisms support a broad range of biodiversity, and provide critical habitats for some socio-economically important fishes and invertebrates that attract commercial fishing and other anthropogenic activities. The aim of this workshop is to improve our understanding of factors influencing the distributions of corals and sponges in the North Pacific Ocean, improve habitat models predicting their distribution, and predict how their distributions are likely to shift in response to natural and anthropogenic forcing, including climate change. In preparation for the workshop, WG-32 Members and collaborators will compile new data on corals and glass sponges in the North Pacific Ocean as well as existing environmental data to improve model prediction and interpretation based on a multi-model approach. Specifically, deep-sea coral habitat suitability models developed using records from all ocean basins will be improved with the addition of coral location data from the North Pacific Ocean. New habitat suitability models will be developed for deep-sea sponges and multi-model comparisons will be made for both coral and sponge taxa. Workshop participants will be invited to discuss, compare, and evaluate the influence of predictor variable data, and different modelling approaches on results. This process will help identify potential ecological and physiological mechanisms influencing their distributions and provide insight into the potential for changes in their distribution under different climate change scenarios. A novel contribution anticipated from this workshop will be the first habitat predictions for glass sponges (Hexactinellida) at a basin-wide scale in the North Pacific Ocean. Workshop participants will synthesize lessons to be learned from the modelling exercise, future tasks to further improve predictive accuracy, and possible applications for supporting marine spatial planning processes.

W4: FIS Workshop
Methods relating oceanographic conditions to the distribution of highly migratory species

Cosponsoring Organization: International Scientific Committee for Tuna and Tuna-like Species in the North Pacific Ocean (ISC)

Co-Convenors:
Gerard DiNardo (USA)
Chi-lu Sun (Chinese Taipei)

Invited Speaker:
Barbara Muhling (NOAA, USA)

This workshop will be convened by the proposed Joint PICES-ISC Working Group on Oceanographic Conditions and the Distribution and Productivity of Highly Migratory Fish, as identified in the Working Group's Terms of Reference (first workshop-PICES 2016 Annual Meeting in USA). The distribution and productivity of many commercial pelagic fish populations in the North Pacific are determined by large-scale oceanographic processes and climate variability. One hypothesis is that highly migratory pelagic species, such as albacore (*Thunnus alalungus*), have environmental thresholds and preferences that drive their distribution and productivity. This workshop will focus on statistical modeling approaches that link spatially explicit environmental data (e.g., satellite derived SST) to distributional fish data (e.g., commercial catch per unit effort data, CPUE) for highly migratory species. Group discussion will help facilitate identification by the Joint Working Group of a suitable methodology to use to develop habitat models of albacore and to provide possible scenarios for future fishery CPUE 'hot spots'. Papers that deal with common difficulties in relating spatially explicit data to fish distributional data (e.g., zero-inflated data, mismatch between spatial or temporal resolution of oceanographic to distributional datasets), are also encouraged.

W5: FIS Workshop
Modeling effects of climate change on fish and fisheries

Co-Convenors:
Anne B. Hollowed (USA)
Shin-ichi Ito (Japan)

Invited Speaker:
Michio Kawamiya (JAMSTEC, Japan)

S-CCME convened a workshop in August 2015 to discuss the details needed to establish an international effort to project the response of fish and fisheries to different climate change scenarios and fisheries management strategies. Several regional modeling teams were identified that would form the core of the S-CCME projection modeling research effort. S-CCME members were tasked with working with modelers within each of the modeling nodes to initiate projections in 2016. This workshop will provide an opportunity for S-CCME investigators and collaborating modelers in each of the regional nodes to meet to discuss the current status of their regional integrated modeling teams. Specific goals of this workshop are to: a) identify analytical approaches that are being used in each of the regional nodes; b) review methods for comparing projections derived from different suites of single species climate enhanced projection models, multispecies climate enhanced projection models, full food web (e.g., EcoSIM), and dynamic spatially explicit ecosystem models; and c) preliminary inspection of the implications of future climate change on commercially important marine fish stocks in the northern hemisphere. Results will provide a critical opportunity for S-CCME scientists to coordinate their regional modeling efforts. S-CCME members plan to use the scenarios derived from the regional modeling teams to provide climate-informed options for mitigation of, and management of harvested resources under a changing climate. The format will allow for breakout groups for intra-disciplinary discussions and plenary interdisciplinary research. Projected outcomes of these scenarios using population dynamics models of different approaches and complexity will allow analysts to compare and report on the relationship between model complexity, efficiency, and the computational costs of increased ecological realism in models. Expected products include a meeting report.

W6: BIO Workshop
Consumption of North Pacific Forage Species by Marine Birds and Mammals

Co-Convenors:
Andrew Trites (Canada)
Elliott Hazen (USA)
Tsutomu Tamura (Japan)
Yutaka Watanuki (Japan)

Invited Speaker:
Julie Thayer (Farallon Institute for Advanced Ecosystem Research, CA, USA)

Marine birds and mammals (MBMs) are known to consume substantial amounts of prey species, and can impact their abundance and sometimes induce trophic cascades. Therefore, MBMs can have large impacts on forage fish populations, the broader ecosystem, and can compete with other top-predators and fisheries. Quantifying the effects of MBMs on marine ecosystem requires detailed knowledge of diets and abundance of prey species consumed. Such data are also needed to examine the influence of climate variability and change on trophic linkages in the North Pacific, as well as to understand how changes in prey quantity, quality, composition and distribution affect the abundance and distribution of marine birds and mammals. Our proposed workshop is a key priority of S-MBM's new program (2015-2019) to assess the climate and trophic ecology of marine birds and mammals. We will invite modelers (movement and energetics of animals) and holders of dietary and distribution data for approximately ten of the most intensively studied species of seabirds and marine mammals in the North Pacific to 1) give succinct reviews and overviews of modelling techniques and the temporal and spatial data sets held by their agencies or collaborators (during the morning). Breakout groups in the afternoon will enable affirmation of species and regions of interest, discuss limitations of the data sets, identify alternative sources of data and information, and discuss synergies among the diet data and the movement and bioenergetic models. The conveners will meet the following morning to prepare the workshop report. Holding this workshop is an important first step in compiling and integrating the dietary and movement datasets we are seeking, and ensuring that the models that will be developed through the S-MBM are well thought through and have a high probability of success.

W7: MONITOR Workshop
Delivering quality multi-parameter data from the coastal ocean

Co-sponsor: Ocean Networks Canada

Co-Convenors:
Akash Sastri (Canada)
Chuanxi Xing (China)

Invited Speaker:
Rich Pawlowicz (University of British Columbia, Canada)
Zhifeng Zhang (National Marine Environmental Monitoring Center (NMEMC), SOA, PR China)

This workshop is a priority for the PICES Advisory Panel on North Pacific Coastal Ocean Observing Systems (AP-NPCOOS). We propose a 1-day workshop of talks and discussion toward the goal of developing 'best practices' for ensuring high-quality sensor observations in coastal marine ecosystems in the North Pacific. The coastal ocean is a region with important fisheries and other ecosystem benefits, while at the same time being subject to human pressures. In order to assess coastal marine ecosystem status and changes, including any long-term trends, high-quality observations of a variety of physical, chemical and biological variables must be made and sustained. Sensor-based observations are critical to coastal observation programs and are used as part of ship-based sampling programs, fixed-point platforms (i.e. long-term mooring and cabled deployments), mobile platforms (i.e. gliders, ferries), and are necessary to ground-truth remote sensing observations (i.e. turbidity, chlorophyll and CDOM). The quality of these observations depends on sensor choice, pre-deployment sensor preparation and calibration, platform and sensor deployment, post-deployment sensor calibration and data processing and dissemination. We invite contributions that deal with all aspects of delivering high-quality data from the coastal ocean, in particular techniques for measuring biogeochemical parameters (oxygen, nutrients, chlorophyll) and mitigating biofouling and sensor drift.

W8: POC Workshop
Mesoscale and submesoscale processes in the North Pacific: History and new challenges

Co-Convenors:
Kyung-Il Chang (Korea)
Hiromichi Ueno (Japan)
Annalisa Bracco (USA)

Invited Speakers:
Sachihiko Itoh (The University of Tokyo, Japan)
Naomi M. Levine (University of Southern California, USA)

Oceanic mesoscale flow fields like eddies, upwelling, and fronts at spatial scales of ~10 – 100 km have been extensively studied for their dynamics and various contributions to marine ecosystems. Motions on the submesoscale (~1 km) and their impacts on the marine ecosystem, however, are less well known. Submesoscale features are often found along the periphery of mesoscale eddies and involve larger vertical fluxes than those associated with mesoscale eddies which then have substantial effects on the phytoplankton productivity. Submesoscale processes also interact with mesoscale processes. Understanding the fundamental physics of these processes, their influence on lateral and vertical fluxes, and how they influence the functioning of the marine ecosystem is necessary in order to assess likely changes and shifts to the system under a changing climate. Faced with these important issues, however, observational skills, theoretical understandings, and modeling techniques are still immature. This workshop provides a forum to discuss the physics and biology of the ocean at the meso- and sub-mesoscales based on observations and modeling and to clarify our challenges in the next decades. Ideas and conclusions from this workshop may be incorporated into a new PICES working group.

W9: POC Workshop
The role of the northern Bering Sea in modulating Arctic environments: Towards international interdisciplinary efforts

Co-sponsor: North Pacific Research Board (NPRB)

Co-Convenors:
Lisa Eisner (USA)
Matthew Baker (USA)
Kirill Kivva (Russia)

Invited Speakers:
Seth Danielson (University of Alaska Fairbanks, USA)
Kirill Kivva (Russian Federal Research Institute of Fisheries and Oceanography (VNIRO), Russia)
Alexander Zavolokin (North Pacific Fisheries Commission (NPFC))

Despite the fact that the Bering Sea is outside the Arctic Ocean, in many ways it behaves as an Arctic sea. The northern Bering Sea influences the state of the southern Chukchi Sea ecosystem as well as the functioning of many other Arctic regions, including the central Arctic. The Pacific Arctic Region has received great attention during the past few years:

- RUSsian-American Long-term Census of the Arctic (RUSALCA) annual cruises and publications
- Adaptation Actions for the Changing Arctic AMAP Report part C (in preparation)
- The Pacific Arctic Region synthesis (Grebmeier and Maslowski, Eds., 2014).

Yet, the scientific efforts in the Northern Bering – Southern Chukchi Sea region are conducted mostly at the national level, and would benefit from joint multinational coordination.

The goal of this workshop is to bring together researchers representing multiple national and international institutions and multiple scientific disciplines (e.g. oceanography, plankton, fisheries) to share data, share knowledge, build collaborations and conduct outreach. We invite scientists interested in 1) physical oceanography and chemical fluxes, 2) plankton distribution and ecology, 3) fisheries and ecosystem dynamics, and 4) modeling efforts across the northern Bering Sea region. Talks will be followed by discussion periods. Depending on the success of the proposed workshop, and the interests of the participants, a PICES Study Group may be established to work on data sharing and coordination at the international level at future meetings (e.g., a 2nd workshop is anticipated for the fall 2017 annual meeting in Vladivostok, Russia).

Workshop products

Potential participants are encouraged to provide metadata describing past and present research efforts and to submit applicable Ecological Time Series Observations (ETSOs) presented or discussed during the workshop to the North Pacific Ecosystem Status Report. Results from this workshop will also be presented at the Alaska Marine Science Symposium in Anchorage AK, January 2017, and summarized in an article in the PICES Press semi-annual newsletter.

W10: MEQ Workshop
Distribution and Risk Analysis of Radionuclides in the North Pacific

Co-Convenors:
Yusheng Zhang (China)
Kathryn A. Higley (USA)

Invited Speaker:
Núria Casacuberta (ETH Zürich, The Laboratory of Ion Beam Physics and Environmental Physics, Switzerland)

The Fukushima Dai-ichi Nuclear Power Plant (FDNPP) accident resulted in a large pulse of radioactive contaminants being released into the North Pacific. While radiation is recognized as a potential stressor in environmental systems, this workshop will consider the data collected to date to determine if the radionuclides released have had significant impacts on ecosystems within the North Pacific. Participants will present and discuss radionuclide transport and fate, and any observed impacts from the FDNPP radionuclides on the marine ecosystem in the North Pacific. Participants will be encouraged to exchange information on new techniques and methodologies for monitoring environmental radioactivity and assessing the effects of radionuclides. Discussions on information gaps and research priorities in monitoring and assessment will also be conducted. The workshop organizers will invite other relevant international organizations (such as SCOR, ICRP/IAEA) as co-sponsors and invited speakers to share their reports on research and progress with regard to the monitoring and assessment on the marine environmental radioactivity in the North Pacific.

BIO Contributed Poster Session 1
Recent Progress in Deep-Sea Research and Conservation: Lessons from Various Parts of the Globe

Co-Convenors:
Alexei Orlov (Russia)
Tony Koslow (USA)
Orio Yamamura (Japan)
Evgeny Pakhomov (Canada)

In recent years, intensive study of deep-sea ecosystems (continental slope, seamounts, trenches, troughs, and mid-water layers) of the global ocean has received increased attention because of the high levels of endemism and extreme vulnerability of their biota to any impact, particularly due to human activities. In the past, deep-sea research was focused mainly on the qualitative and quantitative composition of particular species or component of deep-water ecosystem. Currently, studies of life cycles, evaluation of anthropogenic impact, conservation of biological and genetic diversity, safe and sustainable exploitation of biological resources and their protection from destruction during human activities (fishing, mining, shipping, etc.) have become increasingly important. Several projects under the “Census of Marine Life (CoML)” program were conducted during recent years, namely CeDAMar, Mar-Eco, CenSeam, ChEss, etc. There were also several local projects focused on deep-water biodiversity studies of the Sea of Okhotsk (SokhoBio), Japan/East Sea (SoJaBio) and Kurile-Kamchatka Trench (KuramBio). Protection of Vulnerable Marine Ecosystems (VME) in deep waters has received increasing attention, including data reporting requirements management action, in FAO, CCAMLR and a number of RFMOs such as NAFO, NEAFC, SEAFO, SPRFMO, etc. In the Southern Ocean German-led Antarctic Benthic Deep-Sea Biodiversity Project (ANDEEP) has provided critical new data that has been incorporated into the work of CCAMLR. For the Southern Indian Ocean, IUCN and SIODFA announced Benthic protected areas. Modern significant progress in deep-sea research became possible mainly due to development of new methodologies and technical equipment, including ROV’s, landers, various recorders, etc. This poster session will provide a forum for sharing recent advances in deep-sea research and conservation in various parts of the global ocean in the whole, and the North Pacific in particular. Contributions on recent biological studies and conservation in deep waters of the Pacific, Atlantic, Indian, and Southern oceans are encouraged.

BIO Contributed Poster Session 2

Co-Convenors:
Angelica Peña (Canada)
Se-Jong Ju (Korea)

The Biological Oceanography Committee (BIO) has a wide range of interests spanning from molecular to global scales. BIO targets all organisms living in the marine environment including bacteria, phytoplankton, zooplankton, micronekton, benthos and marine birds and mammals. In this session, we welcome abstracts on biological aspects of marine science in the PICES region, except those covered by other Topic Sessions or Workshops sponsored by the Biological Oceanography Committee (BIO).

FIS Contributed Poster Session

Co-Convenors:
Xianshi Jin (China)
Elizabeth Logerwell (USA)

This session invites abstracts addressing general topics in fishery science and fisheries oceanography in the North Pacific and its marginal seas, except those covered by other Topic Sessions or Workshops sponsored by the Fishery Science Committee (FIS).

MEQ Contributed Poster Session

Co-Convenors:
Chuanlin Huo (China)
Darlene Smith (Canada)

Abstracts are invited on all aspects of marine environmental quality research in the North Pacific and its marginal seas, except those covered by other Topic Sessions or Workshops sponsored by the Marine Environmental Quality Committee (MEQ).

POC Contributed Poster Session

Co-Convenors:
Kyung-Il Chang (Korea)
Michael Foreman (Canada)

Abstracts are invited on all aspects of physical oceanography and climate in the North Pacific and its marginal seas, except those covered by other Topic Sessions or Workshops sponsored by the Physical Oceanography and Climate Committee (POC).

MONITOR Contributed Poster Session

Co-Convenors:
Jennifer Boldt (Canada)
Sanae Chiba (Japan)

This session invites abstracts addressing general topics in monitoring and regularizing observations in the North Pacific and its marginal seas, except those covered by other Topic Sessions or Workshops sponsored by the Monitoring Committee (MONITOR).

S-HD Contributed Poster Session

Co-Convenors:
Mitsutaku Makino (Japan)
Keith Criddle (USA)

The Section on Human Dimensions of Marine Systems (S-HD) is holding a poster session for the promotion, coordination, integration and synthesis of research activities related to the contribution of the social sciences to marine science, and to facilitate discussion among researchers from both the natural and social sciences. We invite abstract submissions on any of these topics.

Abstracts
Oral Presentations

November 2

Workshop 3 (BIO)

Distributions of habitat-forming coral and sponge assemblages in the North Pacific Ocean and factors influencing their distributions

November 2, 09:25 (W3-11269)

Environmental factors affecting the distribution of habitat-forming shallow-water corals

Hiroya **Yamano** and Naoki H. **Kumagai**

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Tropical and subtropical islands are associated with coral reefs which provide ecosystem services, including fisheries, tourism and coastal protection. This is especially true for reef islands that are fully composed of reef-derived materials. Both global-scale (climate change) and local-scale (land-based pollution) factors have been causing significant change in corals. Japan provides an ideal setting to examine these changes, because it covers a wide latitudinal range, stretching from subtropical to temperate areas, and the latitudinal limits of coral reefs and coral distributions are occur in the Japanese islands. The seas around Japan have showed significant sea surface temperature (SST) rises in winter (January–March) from 1.1°C–1.6°C. Temperature is critical to determining the latitudinal limit of coral survival. This means that Japan provides a unique opportunity for examining baselines of species ranges and shifts in those ranges due to climate change, including SST warming and ocean acidification. In addition, some islands have a significant amount of sediment discharge from rivers as a result of extensive land development. So land-based pollution issues can also be examined. We present recent progress on examining environmental change and the effects on coral reefs around Japan, and show issues to be solved to understand their current and future distributions.

November 2, 10:05 (W3-10903)

First report on the annual gametogenesis of high-latitude corals *Alveopora japonica* (Eguchi, 1968) and *Oulastrea crispta* (Lamarck, 1816) on Jeju Island, Korea

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Populations of high-latitude corals *Alveopora japonica* and *Oulastrea crispta* have been increasing rapidly in Jeju Island off the south coast of Korea.No studies have investigated the reproduction of these species in Korea. In this study, we investigated annual reproductive cycle of these two species using histological methods. In 2015, corals were sampled monthly at Biyang-do (Northern coast of Jeju Island) and Bomok (Southern coast of Jeju Island). Annual surface seawater temperature of both sites ranged 13C~26C during the study period. Gonad development was analyzed through counting of the number of gonial cells (i.e., oogonia and spermatogonia) grouped by their stage of development. Histology revealed that the oocytes and spermaries of both species developed in separate mesenterial filaments of the polyps. At Biyang-do and Bomok, *A. japonica* oocytes first appeared in January and ripe eggs were released in late August, after 8 months of maturation. Oocytes of *O. crispata* were also first observed in January, and the ripe eggs were released in September. In summary, *A. japonica* and *O.crispata* have seasonal patterns of gametogenesis, with gonial mitosis occurring predominantly in late January and the major spawning of these two species appeared to follow a period of rising the water temperature in September in Jeju Island.

November 2, 10:50 (W3-11409)

Biogeographic patterns and hypotheses relating deep-sea coral distributions to water masses

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An analysis of distribution patterns of deep-sea octocorals is ongoing. In the North Pacific, there seems to be three main ecoregions(?) of octocoral distributions at lower bathyal (800 – 3500 m) depths: 1) an area encompassing the western North American continental margin and associated seamounts into the Gulf of Alaska and along the Aleutian Ridge; 2) an area including the Hawaiian Ridge, Nekker Ridge and nearby seamounts, with an extension of some species or their relatives into the NW Atlantic to the east, and to the SW Pacific seamounts to the west; and 3) the area of the NW Pacific from Kamchatka to south of Japan. We do not yet have a complete explanation for these patterns, but we hypothesize they are related to long-term ocean history and water mass circulation patterns. The latter aspect will be tested during a cruise to the Emperor Seamounts in June 2017 where we will sample octocorals from seamounts north and south of the Main Gap, through which three major currents flow from west to east or east to west, depending on depth. We propose that this "current wall" is a barrier to north-south distribution of deep octocorals. The Atlantic-Pacific connection has been established using genetic markers and we are investigating paleoceanographic current patterns for an explanation. The northeast Pacific and Aleutian octocorals seem to have been isolated from the rest of the North Pacific for a long time. Upper bathyal and mesophotic octocoral distributions have not been investigated by our group.

November 2, 11:30 (W3-11413)

Factors affecting the large scale distribution of deep sea corals and sponges in the Alaskan ecosystems of the North Pacific Ocean

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Environmental factors that control the distribution of deep sea corals and sponges in Alaska and the wider North Pacific basin can be important at a number of different scales. For example, large-scale basin wide modeling efforts have pointed to the effects of variables such as temperature, depth and water chemistry. However, modeling studies conducted at a regional scale such as those in Alaska indicate factors that are linked to the distribution of deep sea corals and sponges can vary from ecosystem to ecosystem. For example, tidal currents in the Aleutian Islands are a dominant feature shaping the distribution of deep-sea corals and sponges, while in the Gulf of Alaska, these currents are much smaller and play a less important role in determining benthic invertebrate distribution. At the transect scale, underwater imagery indicates that the most important factor controlling the distribution of deep-sea corals and sponges is the presence of suitable hard substrate for attachment. However, comparisons of the eastern Bering Sea and Aleutian Islands indicates that the presence of hard substrates may not always be enough to confer presence of invertebrates. In addition, past fishing activities can also influence the perception of the distribution and abundance of deep-sea corals and sponges. A summary of the factors controlling the distribution of benthic invertebrates from modeling and *in situ* studies conducted in Alaska will be presented for a variety of scales that may inform an examination of the larger North Pacific.

November 2, 11:55 (W3-11084)

Seascape ecology of glass sponge reefs: Fine scale measurements of habitat heterogeneity and its relationship to community structure

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Sponges create structured habitat and facilitate entire communities. However, it is unclear whether their positive influence is due to the structure they create or if other ecological processes also contribute to their role as facilitators. Further, we know little about how the spatial distribution of sponges influences community structure. Glass sponge reefs are ecosystems formed by Hexactinosid sponges, whose rigid skeleton persists long after the sponges' death. Anthropogenic activities have increased the spatial heterogeneity of both live and undamaged dead sponge skeletons within the reefs. Consequently, these reefs provide a unique opportunity to investigate the relative importance of live sponges and the spatial distribution of structured habitat for the diversity of marine ecosystems. In 2012 and 2013 we collected georeferenced video and imagery along 78 ROV transects in nine glass sponge reef complexes in the Strait of Georgia, BC. We described the distribution of live and undamaged dead reef-building sponges. We then compared the communities associated with areas of live and dead sponges. Finally, we examined the relationship between the spatial distribution of structured habitat and community composition. Areas of structured habitat supported significantly more diverse and abundant communities. The distribution of structured habitat was highly patchy on all reefs. When total habitat area was comparable, contiguous habitat supported a higher abundance of organisms than patchy habitat. These results suggest that human activities which damage the structure provided by both live and dead reef building sponges reduce the ability of these ecosystems to support fish and invertebrate communities.

November 2, 14:00 (W3-11318)

Resolving biogeographic patterns in the deep sea using species distribution modeling

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The fundamental niche of many deep-sea species remains poorly resolved despite decades of seafloor exploration. A better understanding of species' biogeographic distributions is essential for designing and implementing management plans, shaping future research efforts, and assessing anthropogenic impacts. We evaluated the niche and distribution of the cold-water coral *Lophelia pertusa* in the Gulf of Mexico using an ensemble modeling approach that integrated multiple techniques including maximum entropy (Maxent), random forest, and generalized additive models. Predictor variables were derived from high-resolution remotely-sensed data and included a suite of terrain metrics, seismic reflectivity of the seafloor, and the export of particulate organic carbon to the seafloor. The ability of models to predict occurrences in new regions (transferability) and to downscale from regional to local scales (scalability) was also assessed. Modeling results supported previous assumptions that *L. pertusa's* distribution is primarily driven by depth, locally elevated topography, and the availability of hard substrata suitable for recruitment. All models performed well with AUC scores greater than 0.8, however we found that adjusting models from their default settings improved transferability and scalability. Given these results, we suggest that future expeditions combine remotely-sensed data with species distribution models to increase the efficiency of deep-sea exploration. A similar approach is currently underway to model the distribution of vulnerable marine ecosystem (VME) taxa in the North Pacific Ocean.

November 2, 14:40 (W3-11423)

Data-driven bioregions for local ecosystem context in species distribution models

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Species Distribution Modeling (SDM) involves statistically relating species observations with co-occurring environmental variables, and then using the observed relationships to map species distributions from spatially extensive environmental data layers. Biological interactions, while also known to influence species distributions, are not explicitly taken into consideration in SDM. Biological interactions vary depending on local environment and community composition, and environmental proxies are needed to describe this local environmental context. Alternatively, if a distribution model is calibrated with data constrained by local species assemblages, the model can be considered to account for local species interactions. This project aims to define data-driven bioregions based on the turnover of species assemblages. Values of species turnover were generated by applying the Gradient Forest algorithm to trawl catch data from the Scotian Shelf, Canada. The turnover values were then plotted across principal components of environmental variables, and a cluster analysis was used to define distinct assemblages. The assemblages were then overlain onto the study area using associated primary component values. Depth and temperature were shown to be the most influential predictor variables in the gradient forest model. Three primary clusters were found, dividing the shelf into eastern and western regions, with the deep water as a separate region. Further validation of data-driven bioregion effects on SDM on the Scotian Shelf will require greater sampling in deeper waters.

November 2, 15:05 (W3-11418)

Selection of the proper spatial resolution for habitat modeling of cold-water corals

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Due to general paucity of species distribution data in deep sea areas, the need for habitat modeling of cold-water corals is increasing. It is important to select an appropriate spatial resolution of analysis depending on data availability, species characteristics and the extent of target areas. We examined appropriate spatial resolution for habitat analysis of large gorgonian corals at a local scale such as seamounts. Species occurrence data and high-resolution multi-beam bathymetry data were collected by ship-borne surveys in the Emperor Seamounts area in 2009 - 2013. Depth and terrain parameters were generated at six different grid cell sizes from 25 x 25 m to 800 x 800 m and used as environmental variables for habitat analysis. The values of terrain parameters showed different patterns at smaller (≤ 100 m) and larger (> 100 m) grid cell sizes. Accordingly, the topographic structures expressed by the raster maps changed with the grid cell sizes. Maxent habitat models showed higher prediction accuracy at smaller grid cell sizes, and predicted high habitat suitability at such locations as ridges on upper slopes and terrace edges and surface undulation on seamount tops. This suggested sloped and/or irregular sea floor is important habitat of large gorgonian corals. Our results indicate the value of high-resolution bathymetry data for predicting cold-water coral habitat in local scale of the Emperor Seamounts area.

November 2, 15:30 (W3-11227)

Testing the transferability of species distribution models between shallow seamounts in the North Pacific Ocean

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A lack of comprehensive biotic and abiotic spatial data for seamounts makes it challenging to understand the impacts of fishing on vulnerable marine ecosystems such as habitat-forming corals and sponges. In 2012, Cobb Seamount (an unusually shallow seamount, rising to 24 m depth) was rigorously surveyed using multiple underwater vehicles from 24 to 1200 m depth. Underwater images were collected and annotated for biotic and abiotic data. The data was used to produce species distribution models (SDMs) for numerous taxa of sponges and corals using predictors such as depth, slope and rugosity. We then used the SDMs produced for Cobb Seamount to predict the distribution of biogenic habitats such as corals and sponges on Bowie Seamount. Bowie Seamount is another shallow seamount that rises to 24 m of depth, but is located roughly 800 km to the north of Cobb Seamount. Bowie Seamount was surveyed in 2011 using a remotely operated vehicle and autonomous underwater vehicle, and in 2015 using a drop camera system. Underwater images from Bowie Seamount were also collected and annotated for biotic and abiotic data. We used these data to test the transferability of species distribution models among seamounts. We also analyzed the importance of predictor variables on species distributions. Preliminary analysis supports the hypothesis that seamounts have unique benthic communities; however, model refinement may improve model transferability among seamounts. Analyses of model transferability, such as ours, will aid in understanding seamount ecosystems and the distribution of corals and sponges.

November 3

Workshop 1
Acidification of the North Pacific Ocean: a basin-wide assessment

Workshop 2
Conditions promoting extreme Pseudo-nitzschia events in the eastern Pacific but not the western Pacific

Workshop 3 (no abstracts)
Distributions of habitat-forming coral and sponge assemblages in the North Pacific Ocean and factors influencing their distributions

Workshop 4
Methods relating oceanographic conditions to the distribution of highly migratory species

Workshop 6
Consumption of North Pacific forage species by marine birds and mammals

Workshop 7
Delivering quality multi-parameter data from the coastal ocean

Workshop 9
The role of the northern Bering Sea in modulating Arctic environments: Towards international interdisciplinary efforts

Workshop 10
Distribution and Risk Analysis of Radionuclides in the North Pacific

POC Workshop (W1)
Acidification of the North Pacific Ocean: A basin-wide assessment

November 3, 09:10 (W1-11385)

Assessing vulnerability to ocean acidification in the Strait of Georgia along the Canadian Pacific Coast

Karen E. **Kohfeld**[1], Debby Ianson[2], Susan E. Allen[3], Ellie Simpson[1], Ben Moore-Maley[3], Chris Harley[3], Paul Covert[4], Marty Davelaar[2], Kenny Scozzafava[2], Yves Perrault[5], Andre Comeau[6], Keith Reid[7] and Terry Learmonth[8]

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3 University of British Columbia, Vancouver, BC, Canada
4 Swiss Federal Institute of Technology (ETH), Zurich, Switzerland
5 Little Wing Oysters, Ltd, Okeover Inlet, BC, Canada
6 Okeover Organic Oysters, Powell River, BC, Canada
7 Stellar Bay Shellfish, Ltd., Bowser, BC, Canada
8 Salty Dogs Seafoods, Duncan, BC, Canada

In coastal waters, ocean acidification due to carbon dioxide invasion can be amplified by upwelling, terrestrial inputs, biological respiration, and remineralization, thus impacting marine ecosystems and coastal fisheries. The Canadian Integrated Coastal Acidification Program was launched in 2015 to measure and model spatio-temporal variability of acidification in near-shore areas where harvesters operate, with the goal of understanding how coastal acidification could impact commercially-important species and Canadian coastal communities. On the Pacific Coast, this project focuses on the Strait of Georgia (SoG), a large, semi-enclosed basin with extensive shellfish aquaculture that already is enriched in carbon and has low pH relative to the neighbouring open ocean. Although terrestrial and fresh water influences will be felt most nearshore, until recently, the carbonate system has not been measured in near-shore areas where shellfish and harvesting activities are likely to be impacted. We aim to characterize the carbonate chemistry of three nearshore regions in the Strait of Georgia with contrasting physical environments, including the highly productive Baynes Sound (where the majority of shellfish aquaculture in BC occurs). Through monitoring of dissolved inorganic carbon, dissolved oxygen, total alkalinity, temperature, salinity, and nutrient concentrations, we examine diurnal and seasonal variation and patterns of pH, pCO2, and aragonite saturation and place these measurements within the context of surface water properties measured on large ships within the Strait. We will integrate these observations into future and on-going biogeochemical modelling efforts that cover all of our study sites and use them to inform in-situ experiments with commercial species.

November 3, 14:00 (W1-11266)

Variations of carbon uptake and ocean acidification in the Bering Sea and Western Arctic Ocean from 1999 to 2014

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Carbon uptakes in the Bering Sea and the Western Arctic Ocean (WAO) were well measured and compared from 1999 to 2014 during 6 summer cruises of the Chinese National Arctic research Expedition (CHINARE). Distributions of $p\mathrm{CO}_2$ in both areas and their relationships with physical and chemical parameters were discussed. CO_2 system parameters were measured in discrete water column samples as well. According to the CO_2 uptake capacity, both areas could be divided into 4 regions respectively. Bering sea could be divided into Bering Shelf Region (BS), Bering Slope Current Region (BSC), the Northern Bering Basin Region (NBB) and the Southern Bering Basin Region (SBB), and the WAO could be divided into 4 regions as exchange area of the Arctic Ocean and the Pacific Ocean (Chukchi Sea), marginal ice zone, and pack ice zone, and unknown water under ice cover. Both side of Bering Strait (including Bering and Chukchi Shelves and Bering Sea slope) were the most strong carbon sink during summer. Judged from decadal changes of $p\mathrm{CO}_2$, Chukchi Sea maintains high carbon fluxes due to the plentiful nutrients supplements, however ocean acidification were happened seriously due to the Bering Through flow water. Discussed by carbonate parameters, from 1999 to 2014, surface and subsurface waters were acidification within the context of large-scale water mass exchange and local physical and biogeochemical processes from the northern North Pacific to Western Arctic Ocean.

November 3, 14:20 (W1-11326)

Reconstructing ocean acidification in deep coastal and estuarine waters of the northeastern Pacific Ocean (Cascadia Margin): A crab's eye view

Simone **Alin**[1], Beth Curry[2], Meghan Shea[3], Wendi Ruef[4], John Mickett[2], Richard A. Feely[1], Jan Newton[2], Allan Devol[4], Liam Antrim[5], Kathy Hough[5], Christopher Krembs[6] and Samantha Siedlecki[7]

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Upwelling along the Pacific Coast of North America exposes the continental shelf to dense, nutrient- and CO_2-rich but oxygen-poor water. It also provides the marine source water that fills the deep basins of Puget Sound, a glacial estuarine complex characterized by high variability and areas of restricted circulation. Throughout summer, upwelling and river inputs drive intense primary production in surface waters, which in turn drives deep-water remineralization of organic matter and exacerbates low-oxygen, corrosive conditions on the shelf and in Puget Sound. Both environments are home to the U.S. West Coast's perennially most valuable fishery: Dungeness crab.

Through ship-based sampling and moored time-series, we have observed the dynamic carbon cycle in coastal and estuarine waters of the northeastern Pacific Ocean since 2006. While survey cruises provide snapshots of water-column conditions and moored sensors provide high-resolution measurements of surface conditions, there are significant observational gaps in the deep environments where the most corrosive, hypoxic conditions develop and where important benthic and demersal marine communities dwell.

We developed empirical relationships for reconstructing carbonate chemistry from proxy data within the California Current System and Puget Sound based on calibration data sets from research cruises. We applied those relationships to near-bottom time-series collected throughout the Olympic Coast National Marine Sanctuary, Admiralty Inlet (sill at entrance to Puget Sound), and ORCA moorings in Puget Sound. Here we will show the seasonal progression of corrosive, hypoxic conditions on the Washington shelf and in Puget Sound, highlighting differences in extent, intensity, and duration of these seasonal conditions.

MEQ Workshop (W2): Conditions promoting extreme Pseudo-nitzschia events in the eastern Pacific but not the western Pacific

November 3, 09:00 (W2-11006)

Pseudo-nitzschia diversity, bloom events and their impacts in the North Pacific: An East-West comparison

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Diatoms belonging to the genus *Pseudo-nitzschia* are well known as domoic acid (DA) producers exerting a significant negative impact on human health, aquaculture, and marine wildlife. Intense *Pseudo-nitzschia* blooms are a frequent cause of mortality of marine birds and mammals in the eastern Pacific. Nevertheless, despite maximal concentrations of *Pseudo-nitzschia* cells in the western Pacific almost equivalent to those in the East, no severe toxic episodes have been reported from the West. Here, we will discuss the possible causes of this difference, which can be attributed to: (1) different dominant species, (2) higher DA concentrations in species in the East compared to those in the West, (3) different environmental factors affecting the bloom events (upwelling, riverine inputs, nutrient ratios, etc.), (4) differences in specific physiological conditions conducive to DA production, including the impact of bacteria. It should be noted that in Russian waters, and perhaps elsewhere in the western Pacific, the abundance of *P. multiseries* has drastically decreased since ca. 2002. This may be one of the possible causes of the lack of impact in the West, where significant levels of DA have been reported in cultures of this species. Special comparative East–West studies, regarding species and genetic diversity, and parameters controlling toxic blooms, are required to better understand these contrasting impacts.

November 3, 09:40 (W2-11080)

Pseudo-nitzschia species and domoic acid on the west coast of Vancouver Island, British Columbia, in 2015

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An unusually high incidence of domoic acid (DA) in British Columbia in 2015 appeared to be associated with an extremely large offshore diatom bloom, reported to stretch from California to Alaska. In early May, mussel samples from Barkley Sound on southwestern Vancouver Island tested at 25 µg DA g^{-1} by the Canadian Food Inspection Agency (CFIA). Between late April and late October, DA was detected in a total of 106 samples collected from all of the major sounds and inlets on the west coast of Vancouver Island (WCVI). The highest levels were found in Esperanza Inlet, peaking at 75.4 µg DA g^{-1} on June 14, but samples above the regulatory threshold of 20 µg DA g^{-1} were also taken from Nitinat in mid-May (49.4 µg DA g^{-1}), and Clayoquot Sound in mid-August (33.9 µg DA g^{-1}). Three peaks of DA were seen in WCVI sites, in May – June, August, and October.

Pseudo-nitzschia cells in images from Barkley Sound water samples in May were identified as *P. australis*. High concentrations of diatoms, including *Pseudo-nitzschia* species, were seen in water samples from Long Beach in June, with *P. australis* identified as the dominant species on June 11, and *P. fraudulenta* on June 15. Water samples from Esperanza Inlet in June and July also had high concentrations of *Pseudo-nitzschia* species.

Warm water off WCVI is suggested as an important factor in the *Pseudo-nitzschia* bloom and high DA; mean water temperature in January - May 2015 at Amphitrite Point was 1.7° C above average.

November 3, 10:05 (W2-11020)

Amnesic shellfish poisoning (ASP) potential in Japan

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Scallops and blue mussels were monitored for domoic acid in Ofunato Bay, on the northeast coast of Japan from 1994-1999. Domoic acid was detected in both shellfish at concentrations below the regulatory limit (20 μg g^{-1}). Domoic acid-producing diatoms were also monitored and *Pseudo-nitzschia multiseries* was isolated. High toxin production was confirmed in these cultured isolates (maximum level > 10 pg $cell^{-1}$). Seven other domoic acid-producing *Pseudo-nitzschia,* including *P. pseudodelicatissima*, *P. cuspidata* and *P. turgidula,* also were isolated, however the maximum toxicity was rather low (< 1 pg $cell^{-1}$). The characteristics of toxin production by *P. multiseries* were examined in a series of culture experiments showing that 1) toxin was produced in late stationary phase when some nutrient such as iron, silicate, or phosphate are depleted and 2) bacteria showed an important role in toxin production. These results suggest that high toxin accumulation in shellfish requires a severe bloom of *P. multiseries*, followed by a continued bloom with a minimal nutrient supply. Such conditions are rare in Ofunato Bay and throughout Japan. This is likely why ASP has not occurred in Japan. However, because Ofunato Bay experienced the large tsunami in 2011, the habitat of *Pseudo-nitzschia* and their association with bacterial assemblages may have been altered. Results of domoic acid monitoring that was resumed after the disaster will be also discussed to estimate the ASP potential in northern Japan.

November 3, 10:50 (W2-10948)

Pseudo-nitzschia and domoic acid on the US west coast: state of our knowledge and implications for the future

Vera L. **Trainer**[1], William P. Cochlan[2] and Mark L. Wells[3]

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Impacts from toxic *Pseudo-nitzschia* blooms along the US west coast have been persistent and profound over the last decade, and our understanding of these events has increased. The largest recorded coast-wide bloom of *P. australis* in 2015 was extraordinary for both its intensity and persistence over spring, summer and fall, causing devastating consequences to fisheries and marine life. The toxin, domoic acid (DA), was measured in zooplankton, shellfish, crustaceans, echinoderms, worms, marine mammals and birds, as well as in sediments, demonstrating the effectiveness of its transfer through both the environment and the marine food web. The degree of DA production, and intracellular retention by *Pseudo-nitzschia* spp. has been attributed to physiological stress associated with macronutrient physiology, trace metal acquisition, and changes in salinity, pH and temperature, demonstrating that the control of toxin production is complex. It is likely then that induction of DA production along any particular coastline may be controlled by unique combinations of stress, rather than by any single factor. The purpose of this workshop is to summarize recent advances in research of *Pseudo-nitzschia* species and the production of DA on the US west coast, including phylogeny, physiology, ecology, monitoring and public and marine ecosystem health impacts. The workshop goal is to use the extraordinary bloom event of 2015 to better evaluate the driving mechanisms causing toxic *Pseudo-nitzschia* blooms, and the likelihood that these events will become more frequent in the future warming ocean.

November 3, 11:25 (W2-10950)

Pseudo-nitzschia occurrence in the central California Current

Meredith L. **Elliott**[1], Gregg Langlois[2], Jan Roletto[3], Danielle Lipski[4] and Jaime Jahncke[1]

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Data pertaining to the occurrence and relative abundance of *Pseudo-nitzschia* are available for the central California Current region for years 2010-2015. As part of the ACCESS (Applied California Current Ecosystem Studies; www.accessoceans.org) program and the California's biotoxin monitoring program, phytoplankton samples are collected 3-5 times a year at 20-30 visited stations in the upper 9m of the water column using a hand-held 25cm diameter net with a 20µm mesh. ACCESS conducts at-sea surveys in the Greater Farallones, Cordell Bank, and northern portion of Monterey Bay National Marine Sanctuaries, in collaboration with Point Blue Conservation Science. Phytoplankton samples are analyzed by the California Department of Public Health for relative abundances of different species of phytoplankton, providing a qualitative measure of phytoplankton species. Concurrent with phytoplankton collections were conductivity-temperature-depth (CTD) casts, surface nutrients samples, and water color. We also maintain data series on basin-scale, regional, and local climate and ocean indices. ACCESS can provide: HAB species presence, maximum abundance, time of year, temperature range, salinity range, water clarity, nutrients, and upwelling indices. In addition, the presence of other phytoplankton species (e.g. *Alexandrium* spp.) and the assemblages of diatoms and dinoflagellates in the non-HAB species may also prove useful in understanding the optimal growth conditions for *Pseudo-nitzschia*. We believe our data will be a valuable contribution to the workshop in helping to understand the conditions contributing to *Pseudo-nitzschia* events in the eastern Pacific. In addition, our results may further our knowledge of HABs near the highly urbanized San Francisco Bay area.

November 3, 12:00 (W2-11035)

The effects of temperature and ocean acidification on the growth and toxicity of *Pseudo-nitzschia australis* from the California Current upwelling system

William P. **Cochlan**[1], Charles J. Wingert[1], Bridget L. Hansen[1], Christopher E. Ikeda[1] and Vera L. Trainer[2]

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Two critically important alterations of the coastal waters of the California eastern boundary upwelling system (EBUS) - increased temperature and elevated CO_2 levels, were examined in controlled laboratory studies of the impactful toxigenic diatom *Pseudo-nitzschia australis* Frenguelli. Our results demonstrate the adaptive capability of this pennate diatom to grow and produce the potent neurotoxin, domoic acid (DA), as a function of these abiotic factors during their nutrient-replete, exponential growth phase and their nutrient-depleted, stationary growth phase. Non-axenic strains of *P. australis,* isolated from Monterey Bay, CA during the massive blooms of this species in 2015, were exposed to a range of temperatures (5, 7, 9, 11, 13, 15, 17 and 19 °C) using a custom-build incubator, and to four pH levels (8.1, 8.0. 7.9 and 7.8) regulated by direct injection of compressed CO_2/air mixture into culture flasks. Laboratory findings demonstrate that this diatom species reaches maximal growth rates at ~17–18 °C with specific growth rates increasing by ~3-fold from 5 to 17 °C. Domoic acid production increased as the partial pressure of CO_2 (pCO_2) increased, and total DA was 2.7 fold greater at pH 7.8 compared to pH 8.1. However, exponential growth rates were not affected until pH of 7.8 was reached when growth rates declined by ~30%. These laboratory results reveal the capability of *P. australis* to rapidly increase its growth potential in warm waters, and to become increasingly toxic in more acidic waters - environmental conditions expected in the California EBUS due to CO_2-induced ocean acidification and greenhouse warming.

November 3, 14:00 (W2-11167)

Pseudo-nitschia harmful algal blooms (HAB) in the coast of China

Chunjiang Guan[1], Lin **Yang**[1], Douding Lu[2] and Hao Guo[1]

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According to incomplete statistics, 16 documented harmful algal blooms (HABs) of *Pseudo-nitszchia* (including synergy with other kinds of HABs) have been recorded since the first event in 1987 in the China Seas. The cumulative area in which these HABs have been observed is 1303.4 km^2. However, these *Pseudo-nitzschia* blooms have not caused marine life deaths or large economic losses. Approximately 9 HABs have occurred with *Pseudo-nitzschia* as the dominant species, with the total area of their occurrence at 276 km^2. The occurrence times and cumulative area accounted for 56.3% and 21.2% of the statistics, respectively. The species of *Pseudo-nitszchia* isolated from coast of China, including *P. pungens, P. cuspidata, P. multistriata, P. brasiliana, P. galaxiae* and *P. micropora*, had no measureable domoic acid (DA) by using high performance liquid chromatography (HPLC). In contrast, DA has been detected in regular monitoring: 23 of 176 samples collected in January 2008 from the coast of China had DA content greater than detection limit of 20 µg/kg.

November 3, 14:25 (W2-11386)

Temporal changes and toxicity of *Pseudo-nitzschia* species in Korean coastal waters

Weol-Ae **Lim**[1], Tae-Gyu Park[1], Jong-Gyu Park[2], Ka-Jeong Lee[1], Kwang-Soo Ha[1] and Gregory J. Doucette[3]

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Several species of the genus *Pseudo-nitzschia* in the coastal waters around the world produce the neurotoxin domoic acid (DA) known to be responsible for amnesic shellfish poisoning (ASP). The DA in shellfish (mostly oyster and mussel) in the southeast coastal waters of Korea has been investigated since 1993 and *Pseudo-nitzschia* species have monitored to the genus level since 1987. No human poisoning outbreaks due to ASP have been recoreded and DA has not exceeded regulatory levels in Korea.

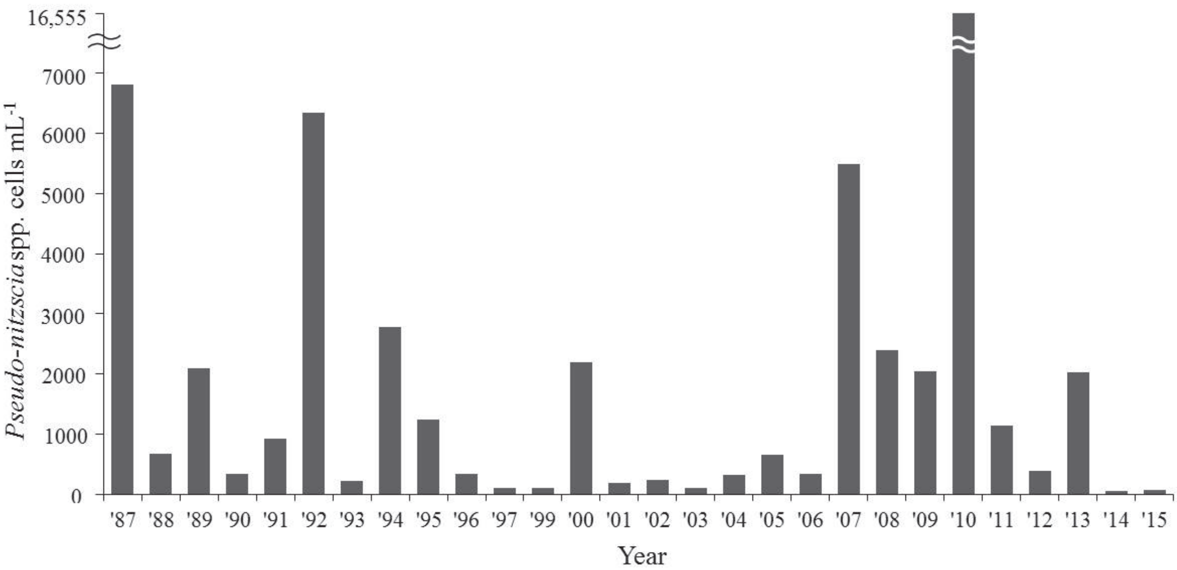

Fig. 1. Cell densities of *Pseudo-nitzschia* spp. in southeast coastal waters, Korea since 1987

Cell densities of *Pseudo-nitzschia* species fluctuated between 1987 and 2015. The cell densities exceeded 6000 cells mL^{-1} in 1987, 1992 and 2010. There are no apparent patterns associating *Pseudo-nitzschia* spp. blooms and environmental factors, such as water temperature, dissolved oxygen, nutrients etc., although the increase in *Pseudo-nitzschia* cell densities in riverine areas during rainfall season and were more closely related with increases in silicate rather than nitrate and phosphate. Particularly elevated abundances of *Pseudo-nitzschia* spp. were observed in summer-autumn following periods of heavy rainfall. Species compositions of *Pseudo-nitzschia* spp. and DA concentrations in cultured strains from Korea were determined during 2008 and 2009. The relationship among phytoplankton composition, physical and chemical water properties, and meteorological data also was analyzed.

The presence of the genus *Pseudo-nitzschia* was examined using light and scanning electron microscopy. Fourteen species were observed, including *P. americana*, *P. brasiliana*, *P. aciantha*, *P. calliantha*, *P. cuspidata*, *P. delicatissima, P. raudulenta, P. micropora, P. multiseries, P. multistriata, P. pseudodelicatissima, P. pungens, P. subfraudulenta, P. subpacifica* (Fig. 1). Each *Pseudo-nitzschia* species appeared in different months and periods during 2008 and 2009 (Table 1). Eight *Pseudo-nitzschia* species were cultured including *P. americana, P. brasiliana, P. caciantha, P. delicatissima, P. mannii, P. multiseries, P. multistriata* and *P. pungens*. Of the cultured eight species, the three species, *P. calliantha, P. multiseries,* and *P. multistriata,* produced DA. The concentrations of DA analyzed from *Pseudo-nitzschia* spp. cultures and from filtered seawater samples by LC-MS/MS were 0.5~206 µg L^{-1} in Feb 2008, July, August and September 2009.

Table 1. Monthly appearance of *Pseudo-nitzschia* spp. in southeast coastal waters, Korea in 2008 and 2009

species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
P. americana		+		+		+			+	+	+	
P. brasiliana		+			+		+	+		+		
P. caciantha		+					+	+		+	+	
P. calliantha							+		+			+
P. cuspidata					+	+			+			
P. delicatissima			+		+	+	+		+	+		+
P. fraudulenta					+	+						
P. micropora						+	+	+				
P. multiseris			+	+			+	+	+	+	+	
P. multistriata					+	+	+	+	+	+	+	
P. pseudodelicatissima						+	+					
P. pungens		+		+	+	+	+	+	+	+	+	+
P. subfraudulenta		+										
P. subpacifica								+	+	+		

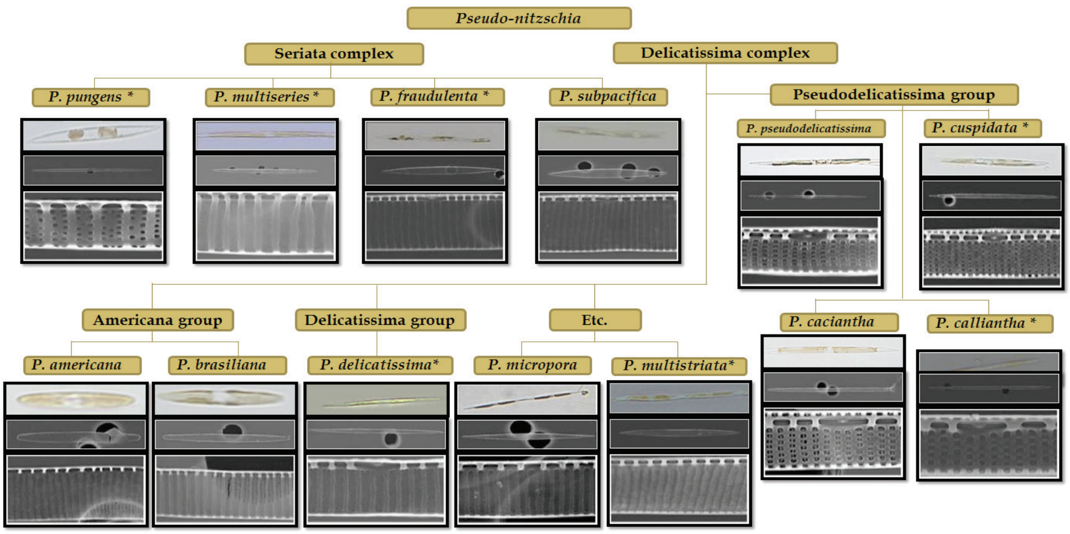

Fig. 2. *Pseudo-nitzschia* species in southeast coastal waters, Korea in 2008 and 2009

November 3, 14:50 (W2-10994)

Pseudo-nitzschia spp. and domoic acid in the waters of Haida Gwaii, British Columbia: A summary of occurrences and details on anthropogenic and environmental considerations

Tamara **Russell**, Nicky Haigh and Devan Johnson

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The government of Canada began monitoring domoic acid (DA)-a toxin produced by certain diatoms in the *Pseudo-nitzschia* genus- in British Columbia (BC) after the 1987 amnesic shellfish poisoning (ASP) outbreak on the east coast of Canada. There are two regions where DA events are known to occur in BC: Vancouver Island and Haida Gwaii, an archipelago off the north coast of BC. We used data from the Canadian Food Inspection Agency's (CFIA) marine biotoxin monitoring program, scientific literature, oceanographic data, and satellite images to assess *Pseudo-nitzschia* spp. blooms and DA events in Haida Gwaii since monitoring began in 1988. Of particular interest to the study was the relationship between the DA events and environmental phenomena like El Niño or changes in marine conditions. Further, investigative attention was given to a possible link between an ocean fertilization event off Haida Gwaii in July 2012 and DA concentrations in the following year. This review aims to characterize the distinct blooms of *Pseudo-nitzschia* spp. and DA levels in Haida Gwaii and to give an update on ASP events in the region.

November 3, 15:15 (W2-11063)

Pseudo-nitzschia species and domoic acid in southeast Vancouver Island, November 2015 to July 2016

Devan **Johnson**, Nicola Haigh and Tamara Russell

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In early November 2015, a concentration of 54 µg/g domoic acid (DA) was detected in blue mussels (*Mytilus edulis*) from Patricia Bay on the east side of Saanich Inlet by the Canadian Food Inspection Agency (CFIA). Water samples taken from the west side of Saanich Inlet in the following week were found to contain *Pseudo-nitzschia* species, including *P. australis*, which was previously unrecorded in this area. Water samples were analyzed for DA; those from sites with more *P. australis* were found to have higher levels of DA. A bi-weekly monitoring program was started in January 2016, to collect water samples and environmental data from six sites along western Saanich Inlet and southeast Vancouver Island. Discrete and net samples were quantitatively and qualitatively analyzed by light microscopy for *Pseudo-nitzschia* species, with identification to species level where possible. Samples were also collected for future DNA and DA testing. *P. australis* was identified at almost every sampling site from early January, but did not bloom with the intensity of the November 2015 event. A mixture of different *Pseudo-nitzschia* species were seen in most samples collected, with tentative identifications of *P. fraudulenta, P. pungens,* and *P. delicatissima*; *P. pungens* and *P. delicatissima* were more common and usually more numerous than *P. australis* and *P. fraudulenta*. No DA was detected in southeast Vancouver Island samples by the CFIA from December 2015 to June 2016.

November 3, 15:40 (W2-11285) CANCELLED

Population structure of *Pseudo-nitzschia australis* in the outer coastal waters of Washington State

Nicolaus G. **Adams**, Piper Schwenke and Vera L. Trainer

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Since 1991, contamination of razor clams with the neurotoxin domoic acid (DA) has resulted in closures of this important recreational and commercial fishery on the outer coast. Shellfish harvesting closures due to DA contamination have also occurred in the inland waters of Washington State. Domoic acid-producing diatoms of the genus *Pseudo-nitzschia*, including *P. australis*, have been observed in Washington State waters since at least 1990. *Pseudo-nitzschia australis* is frequently observed on the outer coast of Washington State as well as in Puget Sound, and was thought to be the causative organism in the first documented domoic acid event on the outer coast of Washington in 1991. *Pseudo-nitzschia australis* was also responsible for the first closure of shellfish harvesting in the Washington State inland waters as well as being the organism responsible for shellfish harvest closures all along the U.S. west coast in 2015. Microsatellite markers have been developed for use in identifying distinct *P. australis* populations and were used to evaluate the population structure of isolates collected from the outer coast of Washington State in 2015. By identifying distinct *P. australis* populations, future work to determine population-specific molecular markers as well as the relative toxicity of these populations can be performed. These tools may be used by resource managers to identify and mitigate future DA events.

November 3, 15:40

Washington State Pacific coast *Pseudo-nitzschia* bloom of 2016

Anthony **Odell**

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FIS Workshop (W4): Methods relating oceanographic conditions to the distribution of highly migratory species

November 3, 9:00 (W4-11149)

Ecology and management of Atlantic bluefin tuna under climate variability and change

Barbara A. **Muhling**[1,2], John T. Lamkin[3], G. Walter Ingram Jr.[4], John F. Walter[3], Sang-Ki Lee[5], Yanyun Liu[5,6], Ricardo Domingues[5,6], Mitchell A. Roffer[7], Frank E. Muller-Karger[8], Joseph Quattro[9] and David Lindo Atichati[10]

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5 NOAA Atlantic Oceanographic and Meterological Laboratory, Miami, FL, USA
6 Cooperative Institute for Marine and Atmospheric Studies, University of Miami, Miami, FL, USA
7 Roffer's Ocean Fishing Forecasting Service, Melbourne, FL, USA
8 College of Marine Science, University of South Florida, St Petersburg, FL, USA
9 Marine Science Program, College of Arts and Sciences, University of South Carolina, Columbia, SC, USA
10 Department of Engineering, Science and Physics, City University of New York, Staten island, NY, USA

Atlantic bluefin tuna (*Thunnus thynnus*) range throughout most of the North Atlantic Ocean, from near-equatorial to sub-arctic habitats. Similarly to Pacific and Southern bluefin tuna, spawning activity is restricted to sub-tropical, oligotrophic regions, and takes place within a relatively short time window. Unlike the two other bluefin tuna species, Atlantic bluefin is separated into an eastern and a western stock, based on spawning site fidelity. Both stocks have been subject to heavy historical exploitation, and are likely to be overfished, and currently undergoing overfishing. However, uncertainty in recruitment dynamics and adult habitat use hampers this assessment, particularly for the western stock. Oceanographic conditions are likely to be important drivers of spawning activity, recruitment success and habitat use, with implications for stock assessment and sustainable management. However, significant knowledge gaps remain in our understanding of these processes. In this presentation, we review several years of ecological studies on larval and adult Atlantic bluefin tuna, including oceanographic characteristics of spawning habitats, plasticity in spawning ground use and potential metabolic constraints on distribution. We describe the use of survey and fishery-dependent data, as well as *in situ* and remotely-sensed data products, to build multivariate predictive models linking habitat use to environmental conditions, across life stages. These models are then used to assess some potential climate change impacts on Atlantic bluefin tuna, and highlight future management challenges.

November 3, 9:40 (W4-10987)

Population dynamics of fish species in marine ecosystem: A case study in the Bohai Sea, China

Xiujuan Shan[1,2], Xianshi **Jin**[1,2], Fangqun Dai[1], Yunlong Chen[1,3], Tao Yang[1,4] and Jianping Yao[1,4]

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2 Qingdao National Laboratory for Marine Science and Technology, Qingdao, PR China
3 Institute of Oceanology, Chinese Academy of Sciences, Qingdao, PR China
4 Shanghai Ocean University, Shanghai, PR China

There were rapid shifts of dominant species in the Bohai Sea during the 1950s through the 1990s, with large-sized, high-valued species (e.g., small yellow croaker *Larimichthys polyactis* and large-head hairtail *Trichiurus lepturus*) being replaced by small-sized, low-valued species (e.g., Japanese anchovy *Engraulis japonicus* and half-fin anchovy *Setipinna taty*). From the 1990s to the present, small yellow croaker and some small-sized species (half-fin anchovy and *Konosirus punctatus*) have become the dominant species. The food web was simple, with species of relatively low trophic levels controlling the energy flow in the fishery ecosystem. Accordingly, the abundance of dominant species changed with the shift in community structure. The diversity of fish species decreased along with the changes in community structure, as well as the species number density, and the interannual and seasonal variations was found in species number density. The fish abundance showed a decreasing trend, and interannual and seasonal distribution also had greatly changed. The variations in the size of ecological niches of the dominant species regulated the succession of fish community, and the alteration of ecological niches caused the changes of fishery community.

November 3, 10:10 (W4-11143)

The impact of climate change on Pacific Bluefin (*Thunnus orientalis*) tuna distribution in the Eastern Pacific Ocean

Rosa **Runcie**[1], Gerard DiNardo[2], Toby Garfield[2], Elliott Hazen[3], Steven Bograd[3], Kylie Scales[3] and Jordan DiNardo[4]

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2 Southwest Fisheries Science Center, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, La Jolla, CA, USA
3 Southwest Fisheries Science Center, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, Monterey, CA, USA
4 Volunteer at the Southwest Fisheries Science Center, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, La Jolla, CA, USA

We investigate the impact of environmental variability and climate change on Pacific Bluefin tuna (PBF, *Thunnus orientalis*) distribution in the Eastern Pacific Ocean (EPO) using remotely-sensed environmental data and fishery catch and effort data in a habitat-modeling framework. Species distribution models are applied to determine species' potential habitats, to identify special areas of interest for biodiversity, and to inform fisheries management. We examine the effects of local oceanic conditions (e.g., sea surface temperature, surface chlorophyll, fronts), as well as large-scale oceanographic phenomena such as El Niño, on PBF distribution and relative abundance. Monitoring and understanding changes in the distribution and behavior of PBF, which are high level predators and are important in commercial and recreational fisheries, is necessary to provide a framework for climate vulnerability assessments and to implement an ecosystem approach to fishery management.

November 3, 11:00 (W4-11171)

Crossing the line: Albacore actively exploit submesoscale fronts to enhance foraging success

Stephanie **Snyder**[1], Suzanne Kohin[2], Yi Xu[2], Lynne D. Talley[1] and Peter J.S. Franks[1]

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2 NOAA Southwest Fisheries Science Center, La Jolla, CA, USA. E-mail: smsnyder@ucsd.edu

The boundaries between water masses, known as "fronts", are oceanic oases – known to harbor increased abundances of bacteria, plankton, forage fish, and pelagic predators. Fronts are productive fishing grounds, and provide critical habitat for species of commercial importance and conservation concern. However, the transient nature of fronts and the expense of offshore research expeditions have hindered the study of predators as they exploit fronts. Here, using biologging technology and high resolution satellite imagery, we document the behavior and physiological state of four wild, free-swimming juvenile albacore (*Thunnus alalunga*) as they simultaneously exploited a thermal front for two weeks in the waters off Baja California, Mexico. Of the 3,098 observed trips across the front, the albacore mainly swam between the warm side above the thermocline and the cold side below the thermocline with an average of 78 ± 20.4 daily trips across the front per fish. The warm surface waters provided a thermal resource, allowing the tuna to maintain higher body temperatures and thus forage more efficiently in the food-rich waters of the cold side of the front. Foraging success of the tunas decreased as the cross-front thermal gradient weakened. This first look into small-scale use of fronts demonstrates that ephemeral, submesoscale oceanic processes can play a significant role in shaping habitat of pelagic predators.

BIO Workshop (W6): Consumption of North Pacific forage species by marine birds and mammals

November 3, 09:10 (W6-11066)

Consumption of forage fishes by marine birds in the Gulf of the Farallones, California

Pete **Warzybok**[1], Jaime Jahncke[1], Russell Bradley[1], Meredith Elliott[1], Jared Santora[2], Brian Wells[3], John Field[3], Ryan Carle[4] and David Ainley[2]

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2 H.T. Harvey & Associates Ecological Consultants, 983 University Avenue, Bldg D., Los Gatos, CA, USA
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To effectively manage fishery resources we must quantify the energetic and consumption demands of consumers, such as marine birds, and how those requirements change in response to environmental variability and population dynamics. Point Blue Conservation Science has been compiling data on the abundance, reproductive success and diet of marine birds at the Farallon Islands in central California since 1968 in collaboration with the USFWS. We used long-term data to examine prey requirements of common murres (*Uria aalge*), Brandt's cormorants (*Phalacrocorax penicillatus*), rhinoceros auklets (*Cerorhinca monocerata*) and western gulls (*Larus occidentalis*) in the Gulf of the Farallones, California from 1986 to 2015. We estimated annual forage fish consumption by developing a bioenergetics model that incorporate species specific values for population size, daily basic energy needs (FMR), assimilation efficiency, the proportion of prey in the diet, the energy content of prey items (kJ/g) and the average size of the prey consumed. The most common forage species consumed were rockfish, anchovy, smelt, squid, salmon and flatfishes. Total biomass of forage fish and squid consumed exhibited considerable interannual variation ranging from 8 thousand metric tons in 1986 to more than 75 thousand metric tons in 2013. Population size had the greatest influence on overall forage fish consumption; reproductive success, dominant forage species eaten, and environmental variability were also important. Prey consumption was reduced in 1998, 2003, 2005 and 2006 and was contrary to population trends. Reduced prey consumption in these years was likely a result of unfavorable environmental conditions and diminished prey resources.

November 3, 09:30 (W6-11091)

Consumption of salmon fingerlings by Rhinoceros Auklets breeding in Hokkaido, Japan

Junpei Ookado[1], Yutaka **Watanuki**[1], Motohiro Ito[2], Makoto Hasebe[3] and Hideaki Kudo[1]

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2 Atomoshere and Ocean Research Institute, The University of Tokyo, Japan
3 Hokkaido Seabird Conservation and Research Group, Japan

Chum salmon *Oncorhynchus keta* is one of the important target species of coastal fisheries in Hokkaido Japan. The survival of chum fingerlings (0+ year-old) is poorly known during their migration to the first year nursery ground, Okhotsk Sea,. We estimated the numbers of fingerlings consumed by a piscivorous seabird, Rhinoceros Auklet (*Cerorhinca monocerata*), breeding at Daikoku Island (60,000 pairs), Hokkaido. The parents of this population forage in the shelf area of eastern Hokkaido where salmon fingerlings migrate to the north during the summer. Food-loads for chicks and stomach contents of adult auklets were sampled. Using a simple bioenergetic model, we estimated that this population of auklets consumed 689t of chum salmon fingerlings in 2014 and 41t in 2015 during 50 days of chick rearing. Based on the otolith marker, these fingerlings were determined to come from hatcheries in the Pacific coast of northern Japan. Thus the auklets at Daikoku Island consumed 0.5 – 7.9% of chum salmon fingerlings released from hatcheries in this region. Assuming that the adults fed on the same prey species as they brought to their chicks, we estimated the prey consumption by the auklets breeding at other colonies, i.e. Teuri Island (400,000 pairs), Matsumaekojima (80,000 pairs) and Todojima (35,000 pairs) located in the central, south and north of the Sea of Japan off Hokkaido, and report the regional and interannual variation of their consumption.

November 3, 09:50 (W6-11270)

The records of Chum salmon fingerling predation by avian predators at the coastal area of Otsuchi, Japan

Motohiro **Ito** and Takaaki Abe

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Predation has been suggested to be a major source of natural mortality for Chum salmon *Oncorhynchus keta* fingerlings (0+ year-old) during their early marine life. However, the predation risk faced by the fingerling just after they are released from the hatchery into the river and enter the ocean is poorly known. In this study (March to May 2016), coastal and river surveys were conducted to determine the avian predators consuming Chum salmon fingerling around Otsuchi Bay and River, Iwate. The fixed point observations at the river near the hatchery were also conducted to determine how many fingerlings were taken by avian predators. We confirmed that 15 avian species foraged on the fingerlings around the survey area. Black-tailed gulls *Larus crassirostris* were one of the major avian predators in the bay and river. In the river, about 50 Black-tailed gulls and a few other gull species made foraging flocks and foraged on the fingerlings continuously, 1 day after fingerling were released in late April. Also, 1-2 Great cormorants *Phalacrocorax carbo*, Great egrets *Ardea alba* and Grey herons *A. cinerea* occasionally joined those flocks. These flocks lasted 3 days on average, per release of Chum fingerlings. The estimated maximum predation rate was < 1% (6700 fishes / 1 million released fingerlings). We concluded that Chum salmon fingerling might be the important prey option for avian predators during early spring, but that the predation rate might not be very high in the Otsuchi area, at least during late April.

November 3, 10:10 (W6-10905)

Spatio-temporal variations in the stable carbon and nitrogen isotopic compositions of Delphinidae species in the western North Pacific

Yu **Kanaji**, Hideyoshi Yoshida and Makoto Okazaki

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Cetaceans have species-specific habitats that are characterized by ambient biotic- and abiotic factors. In the subtropical and its adjacent waters, several species of small odontocetes share the habitat spatially. Even if their habitats overlapped considerably, resource partitioning is expected to occur to a certain degree to reduce inter-specific competition. Resource partitioning of animals has been recognized on three dimensions: space, time, and diet. The study aims to characterize habitat and resource partitioning among four Delphinidae species in the western North Pacific. The stable carbon (δ13C) and nitrogen isotope ratio (δ15N) of skin biopsy samples were analyzed for four species of Delphinidae. The δ13C and δ15N were highest in common bottlenose dolphins, followed by pantropical spotted, striped, and common dolphins. Common bottlenose dolphins have larger body sizes, and thus can feed on large-sized species at higher trophic positions. Eating a wide variety of prey including benthic fish and squids could be also attributed to higher isotope values in common bottlenose dolphins. The δ13C and δ15N tended to be higher in lower longitudes for all four species, while δ15N tended to be lower in lower latitudes for common bottlenose and pantropical spotted dolphins, but lower in higher latitudes for striped and common dolphins. These variations are considered to relate to north-south and coastal-offshore variations in nitrogen and carbon sources, as well as nitrogen fixation in Kuroshio water. Seasonal variations in the δ13C and δ15N might be affected by seasonal north-south migration patterns of respective species.

November 3, 11:00 (W6-11301)

Predator consumption of forage species in the California Current

Julie A. **Thayer**, Amber I. Szoboszlai and William J. Sydeman

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Understanding how much forage pelagic marine predators consume is challenging because of the need to synthesize disparate data for a large number of species. The California Current Predator Diet Database (CCPDD) consolidates published data on forage species in the diet of upper trophic-level predators along the west coast of North America over the past century. We used a relational database to compile predator and prey metadata, including spatio-temporal detail, as well as amounts of forage species consumed by pelagic seabirds, marine mammals, bony and cartilaginous fishes, and giant squid. The CCPDD contains data for over 120 predators from more than 190 published reports, technical articles and theses. Predator consumption was ranked for 32 forage categories, with juvenile rockfish, anchovy, krill, herring, and market squid ranking highest in terms of the number of predator species eating them (>50 predator species). Only 15 of 120 predators had high-resolution datasets (>20 years, > half of the regions in a species' range, >3 citations, >1000 samples). The majority of diet data was collected during summer, restricting inference about predator consumption of forage species in other seasons. Another limitation was standardization of various units in which data were published. We will present an example of weighted calculations of predator diet that addresses different predator life-history stages, geographic regions, seasons, and other factors. We will also review bioenergetic models of anchovy and sardine consumed during summer in the California Current (~800,000mt and ~300,000mt, respectively) and caveats of these models.

November 3, 11:30 (W6-11037)

Spatial estimation of prey consumption by common minke, Bryde's and sei whales in the western North Pacific: A preliminary attempt

Hiroko **Sasaki**[1], Tsutomu Tamura[2], Takashi Hakamada[2], Koji Matsuoka[2], Hiroto Murase[1] and Toshihide Kitakado[3]

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A preliminary study of the spatial pattern of prey consumption by common minke, Bryde's and sei whales was carried out in the western North Pacific area. Two models were constructed for each species of whale. The first was a generalized additive model (GAM) that estimated the spatial pattern of relative abundance of whales in relation to oceanographic conditions (species distribution model). The second model estimated the amount of prey consumed by individuals in relation to oceanographic conditions (diet pattern model). The product of these two models yielded the spatial pattern of prey consumption. Data included sightings data and prey information obtained during the summers of 2002–2013. Depth and satellite derived sea surface temperature (SST), sea surface chlorophyll-*a* concentration and sea surface height anomaly were used as environmental factors. The models show that prey consumption by sei whales was greater in the northern region later in the summer. Estimated amounts of prey consumed (using the spatial model) were comparable to estimates based on point estimates without information about spatial distribution. SST was selected as the driving environmental factor in the first and second models. However, the effect of SST was stronger in the species distribution model than in the diet pattern model. Thus spatial distributions of sei whales were largely determined by SST at the meso scale (> 100 km), but feeding appears to be related to optimal oceanographic conditions at the micro scale (> 10 km).

November 3, 11:50 (W6-11252)

Simple models to predict daily energy requirements may not yield accurate estimates of prey consumption by marine mammals in the North Pacific

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Determining how much marine mammals consume requires knowing what they eat (from the percentage of ingested biomass of prey species in diets), the energetic values of the ingested prey (from calorimetry or proximate composition analyses), and how much they must eat each day to meet their daily requirements (using bioenergetic models). It also requires knowing how many marine mammals there are (to determine total consumption), and where they feed (to determine the spatial distribution of prey biomass extracted by marine mammals). In general, considerable attention has been paid to obtaining accurate estimates of diet and population abundance, and little thought has been given to whether estimates of daily food requirements from mass-based models are reliable. Yet estimates of prey consumption may be most sensitive to errors in predicted energy requirements. In general, smaller species have higher mass-specific energy requirements than bigger species (e.g., 4-5% for dolphins and 2-3% for large whales). However, comparing food requirements derived from detailed species-specific bioenergetic models with simple mass-scaled estimates shows that energy needs do not necessarily scale with mass. This apparent disconnect between body size and energy requirements in some species reflects the fact that some marine mammals have higher metabolisms and higher functioning musculature that require more prey to fuel their needs. This suggests that the simple models used to determine daily rations are ineffective to estimate the food requirements of marine mammals, and that new means are required to yield better estimates of prey consumption.

November 3, 12:10 (W6-11299)

Prey consumption by marine birds in the eastern Bering Sea: Variability over time

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PICES Scientific Report 14 provided the best available estimate of prey consumption by marine birds and mammals in the subarctic North Pacific Ocean as of 2000. Since then, a great deal of new information on the distribution and abundance of marine birds has been obtained in the eastern Bering Sea, much of it in a period of highly variable climate. Here we examine variability in prey consumption over time scales of decades to years to assess how consumption has changed since the 1970s, and how it varies between years with early and late sea-ice retreat. Since the 1970s, the numbers of many seabird species (particularly the more abundant species) have declined, some possibly by as much as 30%. Other less abundant species have increased, but overall, there is now less marine bird demand for prey than there was in the 1970s and 1980s. On a shorter time-scale, there have been significant shifts in abundance and cross-shelf distribution of seabirds between years with early sea-ice retreat and those with late sea-ice retreat, which affected the amount and distribution of prey removal by marine birds. Our results suggest that, with climate warming (and reduced extent and duration of sea ice), the eastern Bering Sea will support a different mix of marine bird species, though it is unclear whether there will be a significant change in the amount or types of prey removed.

MONITOR Workshop (W7): Delivering quality multi-parameter data from the coastal ocean

November 3, 09:00 (W7-11003)

Delivering quality multi-parameter data from on-line monitoring network in estuaries and bays: A case study in Bohai Sea

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Land-ocean interactions in estuaries and bays are intensified in Bohai Sea, which as a whole is an enclosed sea of North China. It is of vital importance to obtain high quality on-line monitoring data for the study of physical and biogeochemical processes of nutrients in the Bohai Sea, which were transported from watersheds to the estuary and adjacent coastal waters, and cause serious eutrophication problems in this shallow-water area. In this study, a 3-D hydrodynamic model is established to optimize monitoring sites in Bohai Strait, Liaodong Bay and Liaohe Estuary, to improve the spatial representation of the monitoring network. On-line multi-parameter monitoring platforms were setup in the starting point of the tidal section of Liaohe River, to obtain continuous data for the concentration and flux of nutrients from the watershed to the estuary, and different types of nutrient sensors were verified by comparison tests, based on data obtained from high frequency sampling and analysis in laboratories. A Unified QA/QC protocol was established thereafter, for the setting up of monitoring sites and the operation of an on-line monitoring platform for physical and biochemical parameters in estuaries and bays in the Bohai Sea.

November 3, 09:45 (W7-11131)

Joint Environmental Data Integration System: JEDI System in 2016

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The JEDI System is a JST-funded CREST project entitled "Novel technologies to evaluate multi-scale variations of pelagic marine communities and biodiversity under the influence of the Kuroshio and internal waves in coastal habitats". This project has two main goals: 1) To develop and apply advanced field methods to monitor dynamic changes, diversity and processes in planktonic communities under the influence of strong physical forcing (Kuroshio and internal waves) and 2) To develop a new ecosystem model for open waters using a closure approach and to validate it using field observation. The JEDI System consists of five subprograms: S1) Multi-biodiversity statistical model, S2) New NPZ closure model, S3) Regional/local hydrodynamic model, S4) Biodiversity and environmental monitoring system and S5) Prediction of biodiversity from S3. We have developed a unique monitoring system that combines a cabled observatory (CO) and a new AUV. The monitoring system (Oshima Coastal Environment data Acquisition Network System, OCEANS) was deployed at the southern tip of Oshima Island where the Kuroshio flows near the coast. Both the CO and the AUV carry a new plankton imaging system (Continuous Plankton Imaging and Classification System, CPICS), and measure various physical/biological parameters simultaneously. The AUV also carries a microstructure package (TurboMAP) in addition to CPICS. We will present the technical detail of OCEANS as well as the AUV and the type of data we are collecting from the field.

November 3, 10:05 (W7-11435)

Identification of potential eutrophic zones in the Northwest Pacific region

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The Northwest Pacific region, which includes parts of northeast China, Japan, Korea and southeast Russia, is one of the most densely populated areas of the world. Eutrophication is an emerging environmental problem in this region, where a significant number of red tides and hypoxic conditions have been reported in coastal waters - possibly due to anthropogenic influences such as extensive chemical fertilizer use and sewage effluent. Although no international legislation has been passed in this region to address the problem, the Action Plan for the Protection, Management and Development of the Marine and Coastal Environment of the Northwest Pacific Region (NOWPAP) of the United Nations Environmental Program (UNEP) has been implemented by China, Japan, Korea and Russia since 1994.

Within the framework of NOWPAP, the Special Monitoring and Coastal Environment Assessment Regional Activity Centre (CEARAC) has developed "Procedures for assessment of eutrophication status including the evaluation of land-based sources of nutrients for the NOWPAP region" (NOWPAP Common Procedures). The NOWPAP Common Procedures include the screening procedure to detect symptoms eutrophication within the selected parameters; trend in Chemical Oxygen Demand (COD) or Total Organic Carbon(TOC), frequencies of red tide and hypoxia events and level and trend in satellite derived chlorophyll-a concentration (Chl-*a*).

Trial application of the NOWPAP Common Procedures were carried out by a group of national experts nominated from NOWPAP member countries to identify potential eutrophic zones in the Northwest Pacific region. Obtained results are being mapped on a web GIS system and will be made available for the public.

November 3, 10:50 (W7-11324)

Monitoring of coastal ocean in the Western Seto Inland Sea, Japan

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We have been observing the coastal marine environment and ecosystem in the Western Seto Inland Sea, Japan since the early 2000s using fixed-point platforms and ship-based sampling programs. At first, we introduce the studies by the fixed-point platforms on the aquaculture facility. We have investigated the effects of oceanic water intrusion into coastal regions on the coastal marine ecosystem by several thermistor-chain platforms which observe high-frequency, multi-depth water temperatures at a substantially low cost. We have also investigated the long-term variation of nutrient concentrations by daily nutrient monitoring from 2004 at cape Sada-Misaki which is located at the tip of the Sada-Misaki peninsula (the longest thin peninsula in Japan). These monitoring results indicated that the coastal marine ecosystem in the Western Seto Inland Sea was mainly supported by nutrient supply from the periodic intrusions of Kuroshio subsurface water. We also introduce recent ship-based observations for high-resolution horizontal distributions of biogeochemical parameter (nitrate and chlorophyll, ca. 600m) with UV nitrate- and chlorophyll sensors.

November 3, 11:10 (W7-11241)

Analysis on the patterns and formation dynamics of the summertime coastal circulation system in the western Bohai Sea

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Coastal circulation system influences the seasonal development of the local marine ecosystem through distributing nutrients. For the purpose of early warning and treatment of marine ecosystem hazards, it is necessary to observe and study the coastal circulation system and its formation dynamics. In this study, we analyzed the current data obtained with four sets of ADCP-equipped (Acoustic Doppler Current Profilers) seabed-based observation systems in September 2013 and the data suggested that there seemed to be a clockwise eddy-shaped circulation system during the observation period in the Qinhuangdao coastal area, where severe 'brown tides' frequently happen during summer. The coastal circulation system and its formation dynamics were then examined with the 3-D ocean circulation model ROMS. The simulation results suggested that coastal currents formed a clockwise eddy-shaped circulation system with the diameter of 65km and the tides and summer monsoon induced the circulation system. Both the tidal residual currents and wind currents induced by summer monsoon transported water northward, thus resulting in a higher water level in the north than that in the south which then generated a southward pressure compensation current. Consequently, the northward coastal residual current and the offshore compensation current form the eddy-shaped circulation. The summer monsoon is an important driving force to generate the observed coastal circulation system.

November 3, 14:00 (W7-11139)

What do we do with observatory data? A user's perspective

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The impetus to build and fund observatories over the last 15 years has led to the availability of floods of "data", available online. The original vision of these observatories was that they would provide useful measurements of a wide variety of ocean parameters at the click of a button to anyone who cared. In practice, however, using this data correctly almost always seems to require a significant investment in time and effort, as well as highly specialized expertise, in close collaboration with observatory staff. A corollary is that usage by nonspecialists who are unaware of these problems and just download numbers may result in highly misleading and incorrect conclusions. Data problems are many and varied. Site-specific issues may make interpretation of some aspects of the data problematic at some times. Semi-experimental instrument software acquired from vendors may have subtle bugs. This may also be true for the software, written by observatory staff, that is used to convert raw voltages into measures of physical parameters. These measures of physical parameters, even if they pass the quality-control checks of engineers and observatory data specialists, often have calibration problems, which can range from the subtle (values biased by a few percent) to the gross (current directions off by more than 90 degrees). Finally, data searches to produce a long-term time series from multiple platform deployments can be extremely complex. In this talk I give examples of these issues and discuss a framework for how the situation might be improved.

November 3, 14:45 (W7-11248)

Data quality assurance/ quality control approaches for coastal ocean multi-parameter data from a cabled observatory in the NE subarctic Pacific

Marlene **Jeffries**, Michael G. Morley, Reyna Jenkyns, Akash Sastri and Kim Juniper

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Ocean Networks Canada (ONC) operates an ecosystem-scale cabled observatory (fixed and mobile assets) extending from coastal and offshore waters of British Columbia to the Juan de Fuca mid-ocean ridge. Each instrumented ONC site delivers real-time, multi-parameter data comprising core measurements (temperature, salinity, dissolved oxygen) as well as data from a variety site-specific instruments (e.g. cameras, ADCP's, seismometers, bottom pressure recorders, and hydrophones). The complex nature of these time-series has necessitated the continued development of metadata and data practices for complex and simple scalar data types. Best practices consider instrument preparations, data archival, data quality, and data distribution. Here we present our: 1) current data quality/data assurance procedures for our recently expanded coastal installations; 2) our instrument testing and calibration protocols; and 3) our current approaches (benchmarking and statistical techniques) to identify and account for data quality issues such as instrument fouling. QA/QC tools increase the value of the data archive and provide information on instrument health to the observatory maintenance program. To maximize interoperability, ONC's metadata data distribution framework adheres to international standards and contributes to specialized repositories.

November 3, 15:05 (W7-11319)

Tracking ocean acidification in coastal settings using land-based Burke-O-Lator pCO_2/ TCO_2 Analyzers

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In response to the increasing threat of ocean acidification, we have outfitted several land-based facilities, including shellfish hatcheries, along the North American west coast with cutting-edge measurement technology to track, in real-time, seawater calcium carbonate corrosivity and pH. The U.S. effort is supported by the Integrated Ocean Observing System (IOOS) and the National Oceanic and Atmospheric Administration Ocean Acidification Program, and the more recent Canadian effort is supported by the Hakai Institute. Data from the now seven instrumented sites are provided to the public via the IOOS Pacific Region Ocean Acidification Data Portal (IPACOA; ipacoa. org). The analytical system, developed at Oregon State University, is a combination CO_2 partial pressure (pCO_2) and total dissolved CO_2 (TCO_2) analyzer known as a "Burke-O-Lator", and tracks these parameters in unaltered seawater entering the facilities. Here we detail the functionality of this analyzer and describe example datasets that span the northern extent of the IPACOA domain including the states of Alaska and Washington and the province of British Columbia. Implementing this technology in hatchery facilities has proven key for adapting management strategies to increasing corrosive conditions.

November 3, 16:40 (W7-11032)

Optical discrimination of *Cochlodinium polykrikoides* blooms from non-harmful blooms in Korean coastal waters

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Harmful *Cochlodinium polykrikoides* blooms have occurred and caused large damage to the fishery industry in coastal waters of the Korean peninsula since late 1980s. In order to effectively detect and monitor the spatial and temporal distributions of widespread *C. polykrikoides* blooms, in-situ radiometric measurements and/or satellite remote sensing can be used. In this study, we estimated the apparent optical properties (AOPs) from the inherent optical properties (IOPs) of *C. polykrikoides* blooms using forward calculation and exploited distinctive optical characteristics to discriminate *C. polykrikoides* blooms from non-harmful blooms in the visible wavelength. We developed the optical discrimination method where R_{rs} band ratios (R_1: $R_{rs}(555)/R_{rs}(531)$, R_2: $R_{rs}(488)/R_{rs}(443)$) were simulated using the Hydrolight software. Even under optically complex water conditions, *C. polykrikoides* blooms show clear differences in simulated R_{rs} spectra due to an increased effect of *C. polykrikoides* absorption properties in the bloom waters where chlorophyll-a concentrations were high (≥ 15 μg l^{-1}). In-situ $R_{rs}(\lambda)$ was comparable within the results of simulation. Consequently, the optical discrimination of *C. polykrikoides* blooms under non-bloom conditions is plausible in R_{rs} band ratios space, using both simulated and measured in-situ data.

November 3, 17:00 (W7-11247)

Real-time sea-surface measurements of coloured dissolved organic matter (CDOM) in the Strait of Georgia, Canada: Developing techniques to account for sensor fouling

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The VENUS coastal cabled observatory (operated by Ocean Networks Canada), maintains a suite of oceanographic and meteorological instruments aboard three BC Ferries vessels which transit the Strait of Georgia (SoG) 8-10 times a day between Vancouver Island and Vancouver, BC (~50km). Underway sea surface measurements (every 10 seconds) include temperature, salinity, oxygen, Chlorophyll *a*, coloured dissolved organic matter (CDOM) and turbidity. Standard meteorological measurements are complemented by above water hyperspectral radiance/irradiance measurements. Here we focus on best practices for measuring CDOM in this very productive body of water. CDOM fluorescence is particularly sensitive to bio-fouling and we discuss three different approaches to account for signal attenuation over time: 1) the use of standard benchmarks; 2) direct comparisons to in situ absorbance-based measurements of CDOM; and 3) a simple regression approach between CDOM and salinity given that Fraser River freshwater discharge is the dominant source of CDOM to the system. Accurate CDOM measurements are also important for interpreting ocean reflectance especially in the short visible wavelengths as detected with the autonomous above-water hyperspectral sensors on the ferries and the Sentinel 3 satellite.

POC Workshop (W9): The role of the northern Bering Sea in modulating Arctic environments: towards international interdisciplinary efforts

November 3, 09:10 (W9-11274)

Currents and water mass structure in and near the Gulf of Anadyr

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Relatively salty and nutrient-rich waters from the Bering Sea's Aleutian Basin cross the Gulf of Anadyr en route to the Bering Strait, helping support chlorophyll blooms and benthic hotspots on both the northern Bering and the Chukchi continental shelves. These same waters also eventually feed the Canada Basin's cold halocline and represent a nutrient and carbon source to the western Arctic Ocean. We provide a water mass analysis using CTD data taken along the Bering slope, across the Gulf of Anadyr, and near St. Lawrence Island in order to better understand the pathways and modifications of Bering slope water as it transits the shelf toward the Arctic. Notable features that guide our understanding of the thermohaline structure and associated circulation include regionally persistent thermal inversions, water column homogenizations, and lateral property gradients.

November 3, 09:40 (W9-11144)

Impact of oceanographic fluctuations on the northwestern Bering Sea ecosystem

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During the last decades there has been increasing evidence of strong impacts of oceanographic fluctuations on Bering Sea ecosystems. We examined how changes in water circulation and sea surface temperature affected nekton and zooplankton communities as well as their trophic interactions in the northwestern Bering Sea. The work is based on the data collected during TINRO-Center's pelagic surveys in the western Aleutian Basin and adjacent waters in 2002-2013. From 2007 to 2011, a significant change in water circulation occurred in the Bering Sea. The longitudinal current from Near Strait to Commander Basin intensified while the latitudinal current from Aleutian Basin to north and west became markedly weaker,and probably resulted in lower water inflow in north regions. This apparently caused changes in nekton structure and decreases in biomass (by 46%) due to reductions in fish migration from southern to northwestern Bering Sea. After 2011, when water circulation returned to a "normal" regime, nekton biomass went back to a former level. Fluctuations in oceanographic conditions also greatly influenced zooplankton communities. Although total plankton biomass varied relatively little from year to year, its composition changed significantly, resulting in increases of cold-water species (*Themisto libellula* and others). Variations in nekton and zooplankton affected trophic structure of pelagic communities. Our results show that oceanographic fluctuations have a strong impact on northwestern Bering Sea ecosystems and potentially can affect productivity of commercial fish species.

November 3, 10:10 (W9-11182)

Climate related changes in abundance and range shifts of pelagic fishes and jellyfish in the eastern Bering Sea during late summer, 2002-2015

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Climate change is expected to alter the abundance and distribution of marine species in the Arctic. We use new standardized geostatistical delta-generalized linear mixed models from Thorson (2015) to estimate annual abundance and center of gravity of pelagic fish and jellyfish in the eastern Bering Sea during late summer for a 14 year period (2002-2015). Next, we examine whether changes in abundance and distribution are correlated with variability in sea ice and temperatures in the eastern Bering Sea. Sea ice is important in determining ecosystem structure in the eastern Bering Sea, therefore understanding how species relate to past environmental conditions during periods of variable sea ice and temperature will help us understand how marine species will respond to future climate change.

November 3, 10:30 (W9-10890)

Environmentally driven variability of zooplankton composition in the northwestern Bering Sea and its influence on the pollock fishery

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Summer oceanographic conditions on the fishing grounds at Cape Navarin are determined by the Laurence Cold Pool (LCP) in the subsurface layer formed in winter on the shelf. The density gradient at its edge supports geostrophic streams known as the Bering Slope Current and Navarin Current. In recent decades, there were several shifts between periods with large and small LCP and correspondent changes in the patterns of currents. Sometimes warm years occurred within the cold periods (large LCP), and cold years within the warm periods (small LCP).

Zooplankton communities have similar large-scale changes, but the abundance of many species have a bell-shape dependence on subsurface water temperature; these species (including high biomass copepods: *Neocalanus plumchrus*, *Calanus glacialis*, *Metridia pacifica*, *Oithona similis*, and euphausiids) are more abundant in warm years within the cold periods and in cold years within the warm periods. This appears to be related to the medium position of the Bering Slope Current, which provides greater transport of allochthonous species from the high-productive area along the continental slope toward Cape Navarin. Other high biomass species prefer warmer (*Pseudocalanus minutus* and *Euclanus bungii*) or colder conditions (*Neocalanus cristatus*).

The Russian pollock fishery is more successful in years with abundant allochthonous plankton, mostly because of longer periods of feeding for pollock within the Russian EEZ, i.e. in transitory environments between the “cold” and “warm” types. Otherwise, the pollock schools migrate to this area for a short time and leave earlier – that was typical for the period starting in 2008, with large LCP and lowered abundance of allochthonous plankton, until the most recent years.

November 3, 11:20 (W9-11315)

Spatial and temporal variations in late summer chlorophyll a and zooplankton distributions in the northeastern Bering Sea

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Phytoplankton and zooplankton composition have been shown to impact fisheries (e.g. Walleye Pollock) and ecosystems in the southeastern Bering Sea. Here, we expand this analysis to describe lower trophic level variations in the northeastern Bering Sea. Chlorophyll a (an estimate of phytoplankton biomass), and zooplankton abundance and biomass were sampled during Bering Aleutian Salmon International Surveys (BASIS) on fisheries oceanography cruises during late summer (August-September) on the northeastern Bering Sea shelf (60-65 °N), 2002-2012. Spatial variations in chlorophyll a and zooplankton distributions are related to changes in water masses (temperature, salinity and nutrient characteristics) over this region. Interannual variations in lower trophic levels also are evaluated for the north Bering Sea and compared to regional environmental variables (e.g., sea ice, winds and water temperature). Finally, we compare and contrast the north and southeastern Bering Sea and factors driving variations in plankton, and explore implications for fisheries.

November 3, 14:00 (W9-10915)

Summer water masses and fish communities in the north-western Bering and western Chukchi Seas in 2003-2010

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Multidisciplinary oceanographic surveys of the north-western Bering and western Chukchi Seas are performed on a regular basis by TINRO-Center (Russia). Here, we analyzed the data from July-August for 2003, 2007, 2008, and 2010 which covers the entire region. We used the water mass terminology by Pisareva et al. (2015) with minor changes. Six water masses (WM) were present in the study area in 2003-2010, four of which were distributed both across the Bering and Chukchi Seas. Siberian Coastal Water was observed in the Chukchi Sea only. Relatively fresh and warm coastal WM was distinguished in the Bering Sea only. An in situ density anomaly gradient was observed between the dense water in the western part of the region and lighter water in the eastern part. Its maximal values were registered along an isopycnal of 26.2. As the Navarin Current in the north-western part of the Bering Sea is the main source of the relatively warm and salty Pacific Water to the Chukchi Sea, in some years it may be a channel for migrations of herring, chum, chinook, and sockeye salmon from the Gulf of Anadyr to the Chukchi Sea. In the Chukchi Sea, Polar cod, capelin, and sand lance avoid the Pacific WM and keep away from the Bering Strait. In the Gulf of Anadyr, pollock and cod usually form denser communities in the Navarin Current. Conversely, the main stocks of Polar cod and capelin there stay within colder waters of local origin.

November 3, 14:30 (W9-10889)

Crab larvae in the northeastern Bering Sea and southern Chukchi Sea: Abundance relative to water masses in 2012

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A significant knowledge gap exists in species-specific crab larval ecology in the Arctic. This is problematic for understanding adult stock distributions for the economically and ecologically important species in the region. We investigated abundance and distribution of seasonally present Anomura and Brachyura crab larvae from a relatively cool oceanographic period in August-September 2012, in the U.S. northeastern Bering and southern Chukchi Seas. We compare larval abundances from 505µm mesh 60cm Bongo zooplankton net samples with concurrent pelagic environmental data and benthic adult crab distributions to discern larval advection processes into the Arctic. Crab larvae in the region appear to segregate by water mass. Early stage larvae and Paguridae (hermit crabs) species are more abundant in warmer, less saline Alaska Coastal Waters; while late stage larvae and Lithodidae (hairy and king crabs) species were more abundant in colder, saltier Bering / Chukchi Shelf Waters. Late zoeae stages of snow crab were found throughout the study region, while a hot-spot in megalopae biomass was found in the Chirikov Basin. These results are some of the first of their kind in a region in which larval crab transport and settlement to the benthos remain undescribed. We plan to expand our data set both regionally and over several years to examine potential mechanisms governing larval distributions, likely including factors such as larvae origin and developmental rate, water flow dynamics, available downstream nursery habitat, and pelagic predation.

November 3, 14:50 (W9-11287)

Defining critical periods for Yukon River Chinook salmon

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Chinook salmon (*Oncorhychus tshawytscha*) are an important cultural, commercial, and sport salmon species to the people of Alaska. Recent sharp declines in returns of Chinook salmon to Alaska rivers have led to disaster declarations for some communities by the State of Alaska and Federal Government. The question is: "where have all the salmon gone?" We examine the early marine ecology of Chinook salmon along the northeastern Bering Sea shelf by utilizing integrated ecosystem components including a climate driven regional ocean model, nutrient-phytoplankton-zooplankton model and a bioenergetics model. The first summer at sea is a critical period for juvenile Chinook salmon where survival is dependent on rapid growth in nearshore habitats and attaining sufficient size and energy reserves before winter. Inputs to the model and improved model parameterization come from the Bering Aleutian Salmon International Survey (BASIS) conducted during August – October (2002 – 2012). Size-selective mortality for Yukon River Chinook salmon during the critical periods was determined by comparing time series (1970 – 2012) of size distributions of juveniles from the model to those determined from adult scales (survivors). Our goal is to assess the effect of climate change and variability on growth, fitness, and survival of juvenile Yukon River Chinook salmon during these critical periods.

November 3, 15:10 (W9-11492)

Statistical downscaling of global projections to the Bering Sea, based on an ensemble of regional model output

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We compute the covariance between 1) the large-scale forcing patterns from IPCC global model projections and 2) regional biophysical indices generated by a 10-km resolution model of the Bering Sea (Bering10K-NPZD), driven by nine separate realizations of that large-scale forcing. This analysis – a model-based form of statistical downscaling – proceeds using both simple regression and multivariate EOF analysis of the output from global and regional models. Such EOF-based methods– sometimes referred to as "regression on the pattern level" – have in fact been widely used in both global and regional climate prediction. Ideally this would enable the direct use of forecast realizations of the IPCC climate models to effectively predict the Bering Sea indices, without the need to rerun simulations with Bering10K-NPZD for each global realization. At a minimum, this method provides an economical way to estimate forecast uncertainty and other statistics of the regional indices, given the large number of global realizations which have emerged (and will continue to do so) under IPCC Assessments Reports.

November 3, 15:30 (W9-11340)

Opportunities for data sharing in the northern Bering Sea – Research and data to support international and interdisciplinary analyses

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This talk will address international efforts to coordinate data exchange relevant to understanding processes, structure, and interactions in the northern Bering Sea and associated ecosystems. Information will be presented on research efforts and associated data and metadata supported by the North Pacific Research Board (NPRB) and implemented by US research agencies. The Pacific Arctic Region is experiencing significant change in climate and reduction in seasonal sea ice. These shifts in the physical environment have impacts on system productivity, phenology, and ecology of upper trophic level species, including distribution, relative abundance, and community structure. Understanding system interactions and potential shifts in ecosystem structure requires reference data and information exchange across the full extent of the dynamic marine ecosystems that connect the Pacific and Arctic. Through the Intergovernmental Consultative Committee, collaborative agreements between the US and Russia have been proposed to implement integrated ecosystem research in the Arctic to better understand system processes, regional structure, and the ecology and interactions of indicator species. Plans include survey coordination and collaborative exchange of scientific personnel, samples and data. The US has secured funding to conduct surveys and integrated ecosystem research in the northern Bering and Chukchi seas 2017-2021. This presentation will review national research efforts, international research programs (e.g., NPAFC, RUSALCA), and new efforts (e.g., NPRB Arctic Integrated Ecosystem Research Program) and provide an overview of existing ecological time series observations and potential new mechanisms for data sharing and exchange. The intent is to communicate existing efforts and foster discussion on new opportunities for exchange.

MEQ Workshop (W10): Distribution and risk analysis of radionuclides in the North Pacific

November 3, 09:00 (W10-11093)

Assessment of the distribution of radionuclides (^{137}Cs, ^{134}Cs, ^{90}Sr, ^{129}I, ^{236}U and Pu-isotopes) in the coast off Japan derived from the Fukushima Dai-ichi nuclear accident

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In the years following the Fukushima Dai-ichi Nuclear Power Plant (FDNPP) accident in 2011, several cruises took place in the coast off Japan with the aim to quantify the impact of radioactive releases to the Pacific Ocean. Main emphasis has been on caesium isotopes (^{137}Cs and ^{134}Cs). Due to their half-lives (30 years for ^{137}Cs and 2 years for ^{134}Cs) and their large radiological impact these isotopes are of major public concern. However, the sole focus on those gamma-emitting radionuclides masks the entire environmental impact of the accident, and other isotopes need to be studied to attain a more holistic assessment of the Fukushima nuclear disaster. This is the case for ^{90}Sr, Pu-isotopes, ^{129}I and ^{236}U. During the past five years our studies embraced these radionuclides, with special attention to ^{90}Sr, as it was a major contaminant in waters accumulated within the nuclear facility and storage tanks. Our results helped understanding the distribution and fate of radionuclides in surface waters in the coast off Japan, and corroborate studies that found indications for ongoing radionuclide releases from the FDNPP. Upper boundary estimates of ^{137}Cs, ^{90}Sr and ^{129}I releases during the years following the nuclear accident are minor compared to the total amounts released in 2011. Yet this study indicates that continuous surveillance tot the Pacific Ocean is still required.

November 3, 09:40 (W10-10946)

Transport of the Fukushima radioactivity plume to the eastern North Pacific

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The large discharge of radioactivity into the northwest Pacific Ocean from the 2011 Fukushima Dai-ichi nuclear reactor accident has generated considerable concern about the spread of this material across the ocean to North America and its transport to the eastern North Pacific. Time series measurements of ^{134}Cs and ^{137}Cs in seawater on Line P revealed the initial arrival of the Fukushima signal by ocean current transport at a location 1500 km west of British Columbia, Canada in June, 2012, about 1.3 years after the accident. By June, 2013, the Fukushima signal had spread onto the Canadian continental shelf and by February, 2014 had increased to a value of 2 Bq/m^3 throughout the upper 150 m of the water column resulting in an overall doubling of the fallout background from atmospheric nuclear weapons tests. Between February, 2014 and August, 2015 the Fukushima ^{137}Cs signal continued to increase in the upper 150 m to levels in excess of 8 Bq/m^3. Circulation model estimates that match our measured values indicate that future levels of Fukushima ^{137}Cs off the North American coast will begin to decline in 2016 and approach levels closer to the fallout background of about 1 Bq/m^3 by 2020. The increase in ^{137}Cs levels in the eastern North Pacific from Fukushima inputs will likely return eastern North Pacific concentrations to the fallout levels that prevailed during the 1980s, but does not represent a significant threat to human health or the environment.

November 3, 10:05 (W10-11024)

Five years monitoring activity on radioactive cesium in seawater after the Fukushima Dai-ichi Nuclear Power Plant accident

Hideki **Kaeriyama**[1], Daisuke Ambe[1], Yuya Shigenobu[1], Shizuho Miki[1], Takami Morita[1], Hiroya Sugisaki[1], Manabu Shimizu[2] and Tomowo Watanabe[2]

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After the Fukushima Dai-ichi Nuclear Power Plant (FDNPP) accident, many data on radioactive cesium (Cs-134 and Cs-137) in seawater had been collected and published. Present study summarizes details the radioactive cesium dispersion pattern in the North Pacific and adjacent seas. Briefly, the Fukushima-derived radioactive cesium dispersed eastward as surface water and extended to the eastern side of the North Pacific in 2014, and was also observed via a southward intrusion to subsurface waters as Subtropical Mode Water and Central Mode Water. The radioactive cesium movement related to mode water is important in terms of the circulation of cesium into the ocean interior. The most remarkable temporal changes of Fukushima-derived radioactive cesium off the coast around the FDNPP site were observed during the first six months of 2011. After that, continuous decreasing trend has been observed until 2015. Because higher concentrations of radioactive cesium (ca. 5 Bq/m^3) than the background levels measured before the accident (ca. 1 Bq/m^3) are still detected. Continued monitoring is still necessary, especially the possible sources of the continued effluxes of FDNPP-derived radioactive cesium into the coastal area should be clarified such as via river.

November 3, 10:50 (W10-11019)

Radioactive cesium in marine biota off Fukushima

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Large amounts of radioactive cesium (^{134}Cs and ^{137}Cs) were released into the ocean through direct and atmospheric pathways by the Fukushima Dai-ichi Nuclear Power Plant accident. Especially, from March to April in 2011, the extremely high contaminated water leaked directly into oceans elevated the radioactive cesium levels in a variety of marine biota off Fukushima. The concentration of radioactive cesium in seawater had been rapidly decreased in ocean process, and consequently the concentrations in the pelagic fishes, invertebrates and seaweeds had been also done because of their radioactive cesium concentrations depending strongly on that in surrounding seawater. The concentrations in the demersal fishes has been also steadily decreasing over time. The monitoring research by Fukushima Prefecture showed 57.1 % of inspected marine fish samples were over the Japanese regulatory limit (100 Bq/kg-wet for radioactive cesium) in the period immediately following the Fukushima Dai-ichi Nuclear Power Plant accident (April – June 2011), but the ratio had been gradually reduced and continues to be 0 % since April 2015.

November 3, 11:15 (W10-11051)

Concentrations of strontium-90 in marine fishes after the Fukushima Dai-ichi Nuclear Power Plant accident

Shizuho **Miki**[1], Ken Fujimoto[2], Yuya Shigenobu[1], Daisuke Ambe[1], Hideki Kaeriyama[1], Kaori Takagi[3], Tsuneo Ono[4], Tomowo Watanabe[5], Hiroya Sugisaki[1] and Takami Morita[1]

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Strontium-90 (Sr-90) was released together with cesium-137 (Cs-137) from the Fukushima Dai-ichi Nuclear Power Plant (FDNPP) to marine environment in March (fallout), spring (1st leakage of waste water) and December (2nd leakage of waste water) 2011. In this study, we investigated the concentrations of Sr-90 and Cs-137 in marine fishes of Japan. Sr-90 concentrations in all samples collected outside of Fukushima prefecture were not detected (detection limit, 0.040 Bq/kg-wet). Except for within a 20 km radius from the FDNPP, Sr-90 concentrations higher than the background level (< 0.046 Bq/kg-wet) were only detected in some samples collected off Fukushima. The important thing is that the concentrations of Sr-90 in marine fishes were notably lower than those of Cs-137. Our results with together analysis of other data sets indicated that the influence of the FDNPP accident on Sr-90 in marine fishes was limited to the area near the FDNPP. We also discuss the activity ratios of Cs-137 to Sr-90 in marine fishes and sea water.

November 3, 11:40 (W10-11039)

Spatio-temporal variation of radiocesium in sea sediment around off Fukushima

Daisuke **Ambe**[1], Shigeho Kakehi[2], Toru Udagawa[3], Kazuhiro Aoki[1], Yuya Shigenobu[1], Tsuneo Ono[1], Hideki Kaeriyama[1], Ken Fujimoto[4], Shizuho Miki[1] and Takami Morita[1]

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To understand the effect of Fukushima Dai-ichi Nuclear Power Plant (FDNPP) accident on bottom marine ecosystem, the Fisheries Research and Education Agency (FRA) has addressed a crucial issue of comprehending the spatio-temporal distributions of the radiocesium concentration in sea sediment since 2012. The radiocesium derived from the FDNPP were mainly distributed at shelf area off Ibaraki, Fukushima and Miyagi Prefectures, in the period of early investigations. The radiocesium concentrations in sea sediment did not simply relate to the distance from the FDNPP, but those were strongly determined by the pathway of radiocesium-contaminated bottom water and the adsorption response of radiocesium caused by the sediment grain size. We observed that, in general, these concentrations have gradually decreased by following investigations. For example, the spatial average concentrations of Cs-137 (about 30-yrs of half-life) in 2015 was about 30 % of that in 2012 or 50 % of 2013, respectively. One of the reasons for this decrease is that the resuspension and transportation of sediment by wave and bottom flow. The radiocesium elution from sediment to seawater was also suggested as another reason for the decrease by a measurement of the radiocesium concentration in pore water of sediment. Furthermore, the radiocesium occupancy in the lithogenic fraction (minerals) of sea sediment tended to increase with time. These results indicate that the potential effect of the sea sediment on marine ecosystem has been steadily decreasing.

November 3, 12:05 (W10-11046)

Distribution of radionuclides in sediment and sedimentation rates in Dalian Bay

Jinqiu **Du**[1,2], Ziwei Yao[1], Hui Gao[1], Daoming Guan[1,2], Guangshui Na[1] and Chuanlin Huo[1]

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Radionuclides are enriched by clay materials and eventually buried in marine sediment. Distribution of radionuclides in sediment are thus significant indicators of marine environmental process. This research utilizes Dalian Bay as target area, 8 surface sediment samples and 1 shallow sediment core sample were collected in July 2014, which were measured by HPGe γ spectrometer to analyze the content and distribution of radionuclides. The result show that the content of ^{238}U, ^{226}Ra, ^{210}Pb, ^{40}K and ^{137}Cs in surface sediment are 45.2~76.8, 24.0~49.7, 55.9~80.4, 791~954 and 1.26~4.23 Bq/kg dry weight respectively, the trend of radionuclides' horizontal distribution is not obvious. The Uranium series are unbalanced, excessive level of ^{210}Pb was recorded in comparison with matrix ^{226}Ra, and a deficit in ^{226}Ra level was recorded in comparison with matrix ^{238}U. There exists a positive correlation between ^{137}Cs and ^{40}K. The content of ^{238}U, ^{226}Ra, ^{210}Pb, ^{40}K and ^{137}Cs in shallow sediment core sample are 46.3~69.0, 32.7~58.0, 38.6~88.9, 506~582 and 0.91~2.25 Bq/kg dry weight respectively, content of ^{40}K shows no apparent change with depths, levels of other radionuclides fluctuate as depth increases, maximum value of ^{137}Cs was recorded at the depth of 12cm. Using $^{210}Pb_{ex}$ method and ^{137}Cs estimation method, we have calculated that the sedimentation rate in Dalian Bay target area are 0.49cm/a and 0.43cm/a respectively.

November 3, 14:00 (W10-10927)

Effect of settle time on absorption of AMP to ^{137}Cs in co-precipitation method

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In order to assess the effect of settle time on absorption of AMP to radiocesium, ten groups of experiments with three parallels each were conducted, the average recovery of 137Cs in all experiments is 94.30%, with the range from 88.18% to 97.39% in each group, and no obvious difference between the recovery of different settle time after co-precipitation was observed. The results show that settle time after co-precipitation will not affect the absorption of AMP to radiocesium, that mean the solution can be immediately filtered after reaction.

November 3, 14:25 (W10-10938)

Preliminary results from modeling of radionuclide transfer through marine food web using a multi-organ fish model

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We describe in this talk recent implementation of a new a multi-organ fish model into the radionuclide transfer model in the marine environment. In recent years authors have reported dynamic biota models (BURN) to calculate the transfer of radionuclides through the pelagic and benthic food webs. This model solves a single dynamic equation for each of marine species considered. For fish species the target tissue-based BURN model was used. The model simulation results for the Fukushima accident are in good agreement with available measurements for ^{137}Cs accumulating in flesh. However, model simulation results for accidental release of ^{90}Sr from Fukushima Nuclear Power plant (NPP) and regular releases of ^{60}Co and ^{54}Mn from Forsmark and Ringhals NPPs (Sweden revealed that the single-target-tissue model considerably underestimated concentrations these radionuclides and subsequently motivated development of a new radionuclide transfer model in fish. This model solves a single dynamic equation for each of marine species other than fishes. Three independent dynamic equations governing the transfer of radionuclides to flesh, bone and organs for marine fishes were used for non-piscivorous and piscivorous fishes, demersal fish, benthic predator fishes and coastal predator fish. The different values of extraction coefficient in uptake term and biological half-life in loss term were used for tissues. Summing up the concentrations for flesh, bone and organs multiplied by corresponding fractional factors gives rise to the total concentration accumulated in fishes. The model results are found to be encouraging for concentration of ^{90}Sr in fish after the Fukushima accident. Application of the new model to the near field of two NPPs in Sweden for reproducing of ^{60}Co and ^{54}Mn turnover in the fish has also shown a good agreement with measurements.

November 3, 14:50 (W10-10908)

Marine radioactive environmental quality assessment method of China

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During a period of two years from 2010, Chinese marine scientists have researched an integrated approach to the scientific, managerial and societal issues surrounding the environmental effects of contaminants emitting ionizing radiation, with an emphasis on marine biota and ecosystems , which is similar to the ERICA and GRADED. ^{110m}Ag, ^{58}Co, ^{60}Co, ^{134}Cs, ^{137}Cs, ^{3}H, ^{131}I, ^{40}K, ^{54}Mn, ^{226}Ra, ^{90}Sr, ^{232}Th, ^{238}U and ^{65}Zn are chosen as the assessment nuclides. 13 types of marine organisms are chosen as the reference organisms. This method contains three assessment functions. The first function is the marine radioactive environmental quality grading, which includes 4 grades indicating safe to dangerous. The second function is radiation effort assessment of marine organism, which adopts ERICA ecosystem screening benchmark of 10 μGy/h. The third one is the risk of long-time discharge of low-level radioactive wastes. In order to simplify the related assessments, a software with the name of MREQAC has been drawn up. MREQAC can be used in any Windows System without installation. There are three models in the software and each of them corresponds to one function mentioned above, which are independent of each other and can be used simultaneously. The user just need to start to the software and input the corresponding parameters such as the activities of the environmental mediums, the software can output the assessment results and save them as excel documents automatically. It is powerful and easy to operation, which can satisfy the need of the marine radioactive environmental quality assessments.

November 3, 15:15 (W10-11428)

The *in-situ* measurement of ocean radioactive base on HPGe detector

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An in-situ γ-spectrometer designed for ocean radioactive consisting of HPGe detector with cryocooler, electronics, data acquisition and processing electronic. The system overcame poor energy resolution of NaI detector and high intrinsic radioactive of $LaBr_3$ detector. The efficiency calibration was used laboratory measurements and Monte Carlo simulations. The characteristics of the system and results obtained during operational tests and deployment in the Tian Jin port and Fang Cheng port are presented and it was obtained high resolution water and seabed spectra. The results were validated by laboratory measurements.

November 3, 15:40 (W10-11493)

Nuclear bombs and coral: Guam coral core reveals operation-specific radiocarbon signals from the Pacific Proving Grounds

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To perform fish age validation studies in the western Central Pacific, radiocarbon (^{14}C) analyses were performed on a coral core from Guam to provide a regional chronological reference. Analyses on this coral core revealed anomalous peaks in the early bomb ^{14}C record. The typical marine bomb ^{14}C signal, one that is phase lagged and attenuated relative to atmospheric bomb ^{14}C, is present in the coral core and is consistent with other North Pacific records. However, ^{14}C levels that are well above what can be explained by air-sea diffusion alone punctuate this pattern. This anomaly has been demonstrated to a limited extent in other coral cores of the Indo-Pacific region, but is unmatched in magnitude and temporal resolution in the Guam coral core. In most cases, the early $\Delta^{14}C$ peaks were small and hypothesized to have originated from the thermonuclear test series "Operation Castle" in 1954, but the Guam coral $\Delta^{14}C$ record provided three strong pulses in 1954-55, 1956-57, and 1958-59. Each of these peaks was directly linked to close-in fallout from thermonuclear testing in the Pacific Proving Grounds at Bikini and Enewetak atolls of the Marshall Islands. The measurable lag in reaching Guam was tied to ocean surface currents and was traced to other locations with current modeling as distant as Okinawa, Palmyra, and the Indian Ocean.

November 4

Section on Harmful Algae Bloom Meeting

Workshop 5
Modeling Effects of Climate Change on Fish and Fisheries

Workshop 8
Mesoscale and Submesoscale Processes in the North Pacific: History and new challenges

Section on Harmful Algae Bloom Meeting

November 4, 11:15 (S-HAB-11226)

First record of the genus *Azadinium* (Dinophyceae) from the Puget Sound, western Washington State

Joo-Hwan **Kim**[1], Brian D. Bill[2], Nicolaus G. Adams[2], Urban Tillmann[3], Myoung-Soo Han[1] and Vera L. Trainer[2]

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Some species of the genus *Azadinium* produce a suite of lipophilic toxins called azaspiracids. *Azadinium spinosum* was first described as a toxin-producing species from the North Sea in 2009. Since that time, numerous other species have been identified from many regions of the world. Most *Azadinium* species are < 18 µm in cell length (the exception is *A. caudatum*) and thus are difficult to collect in common phytoplankton nets for single cell isolations. While no shellfish toxicity events due to azaspiracids have been described from the northeastern Pacific, researchers found evidence of *Azadinium* spp. in Puget Sound in 2014 and 2015 based on molecular probe studies using filtered seawater. In the present study, *Azadinium* cultures were established from Puget Sound sediments for phylogenetic study. A total of 5 *Azadinium* species (*A. obesum*, *A. cuneatum*, *A. poporum*, *A. dalianense*, and *A.* cf. *dalianense*) were identified. *Azadinium obesum* and *A. poporum* had similar ITS and LSU rDNA sequences to *Azadinium* isolated from Europe. Specifically, the pairwise sequence diversity of the ITS LSU rDNA sequences between *A.* cf. *dalianense* and *A. dalianense* from Puget Sound was 0.047 and the pairwise sequence diversity of *A.* cf. *dalianense* and a Chinese *A. dalianense* strain was 0.071. The Puget Sound *A.* cf. *dalianense* and *A. dalianense* isolates showed compensatory base changes within helix I and III of ITS2 secondary structure implying that they are different species. The confirmed presence of the genus *Azadinium* in Puget Sound underlines the potential risk to shellfish safety in the northeast Pacific coastal waters.

November 4, 11:40 (S-HAB-11207)

A review of unusual phytoplankton dynamics and oceanographic conditions favoring diatom growth in the Strait of Georgia, Canada 2015

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We present a summary analysis of ~1300 phytoplankton samples collected bi-weekly from February to October 2015 in the Strait of Georgia (SoG), Canada. The spring bloom was recorded unusually early, and the dominant species was a diatom - *Skeletonema costatum*. In contrast to the West Coast of Vancouver Island, the East Coast of Vancouver Island did not experience extreme *Pseudo-nitzschia* spp. events. Throughout the sampling period, the majority of the SoG biomass was comprised of diatoms, while the dinoflagellate contribution was unusually low, and silicoflagellates and raphidophytes almost absent. Here, we examine linkages between composition, abundance and distribution of phytoplankton and environmental parameters (sea surface temperature and salinity, dissolved nutrients, fluorescence, oxygen, and turbidity) and discuss the conditions in the Strait that appeared to promote diatom dominance in 2015.

November 4, 12:05 (S-HAB-11236)

Development of a Harmful Algal Bloom Forecast System for Coastal California

Clarissa **Anderson**[1], Raphael M. Kudela[1], David M. Anderson[2], Fred L. Bahr[2], Yi Chao[3], Dale H. Robinson[4] and Richard P. Stumpf[5]

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Our NASA and NOAA-funded projects to develop an operational HAB forecasting system in coastal California builds on years of proof-of-concept studies in various hot spots off the U.S. West Coast. Here, we describe development of an application system to predict the spatial likelihood of Pseudo-nitzschia blooms and dangerous levels of domoic acid (DA) using a blend of numerical models, ecological forecast models of target phytoplankton species, and gap-filled satellite ocean color imagery. Daily predictions that merge reconstructed satellite fields from Data Interpolating Empirical Orthogonal Functions (DINEOF) with physical fields from Regional Ocean Model System (ROMS) are run routinely at the Central and Northern California Ocean Observing System (CeNCOOS) and posted on their public website. We are now moving this application system to a NOAA supercomputer at the University of Wisconsin (S4) for demonstration in an operational environment. By 2018, the system will operate from NOAA's National Centers for Coastal Ocean Science and National Weather Service and will be incorporated into NOAA's operational HAB forecasting system and Bulletin. The first two years of the project capture two of the largest domoic acid events on record, coincident with the warm "Blob" and widespread food web contamination, including unprecedented Dungeness crab closures. Pier sampling and historical stranding data are compared with the model, and marine mammals appear to be good sentinels of the offshore onset of a DA event at large spatial scales. Seasonal (hindcast) predictions appear to provide an accurate assessment of risk levels to fisheries over longer time scales.

Keywords: domoic acid, *Pseudo-nitzschia*, model, forecasting, prediction

FIS Workshop (W5): Modeling effects of climate change on fish and fisheries

November 4, 09:05 (W5-11389)

Earth system and climate modeling activities toward CMIP6 in Japan: A review

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There are three groups in Japan planning to contribute to Coupled Model Intercomparison Project (CMIP6): Meteorological Research Institute (MRI) of Japan Meteorological Agency (JMA); Team MIROC, which is a joint effort among JAMSTEC, the University of Tokyo, and NIES; and NICAM development team consisting of UT, RIKEN and JAMSTEC. The first two groups are joining most of the endorsed MIPs with their different model versions combined, while the NICAM team, developing a global cloud system resolving model, joins CMIP6 in a more selective manner due to the immense computer resource requirement. The third generation of the Earth Simulator, whose theoretical computational speed is 1.3PFlops, will be used for most of the CMIP6 experiments, while the K computer will be utilized for some NICAM experiments. Many activities in Japan for CMIP6 are supported by the SOUSEI project funded by MEXT, which covers wide range of impact assessment studies for global change including those for fisheries. Since the project is coming to an end in March, 2017, a forum has been set up involving both the scientific community and funding agencies to discuss overall direction of climate science beyond the SOUSEI project.

November 4, 09:30 (W5-11411)

CERES (Climate change and European Aquatic RESources): Socio-political scenarios for use alongside climate change projections

John K. **Pinnegar**[1,2]

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CERES is a 4-year European Union Horizon 2020 project, starting in March 2016, with 26 international partners. CERES aims to enhance understanding of how climate change will influence Europe's most important fish and shellfish resources and the economic activities depending on them. Within CERES, Task 1.2 will create a suite of exploratory socio-political scenarios that can be used throughout the project alongside outputs from climate change models. Scenarios are needed in order to constrain the number of possible permutations of climate vs economic vs political storylines, using a single coherent framework. Topics that will be addressed in the CERES scenarios will include future fuel and fishing costs, assumed domestic and global demand for fisheries/aquaculture products, technological developments and changes in European policy and management.

The four-quadrant scenario approach has become the dominant architecture used in future projection studies following its earlier adoption by the Intergovernmental Panel on Climate Change (IPCC). In recent years however, the IPCC has developed five 'Shared Socioeconomic Pathways' (SSPs) for use alongside it's Representative Concentration Pathways (RCPs). In order that the CERES model outputs are compatible with this latest IPCC approach, and that outputs might also be useful in the 6th Assessment Report (AR6), the prototype CERES scenarios will build heavily on the new SSP framework, but provide considerable extra detail with regard aquaculture and fisheries in Europe. Throughout 2016 these draft scenarios will be refined and elaborated at a range of spatial scales (regional, national, international). They will include both marine and freshwater considerations.

November 4, 09:55 (W5-11309)

Climate change is projected to reduce carrying capacity in North Pacific pelagic marine ecosystems

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Climate change is expected to impact marine ecosystems, and in turn, the fisheries that rely upon them. Here, we examine the ecosystem impacts of projected changes in epipelagic temperature and zooplankton density through the output of a suite of 11 CMIP5 earth system models. We find that under RCP8.5, increasing temperatures may alter the spatial distribution of tuna and billfish species richness across the North Pacific basin. Furthermore, warmer waters and declining zooplankton densities may act together to lower carrying capacity for commercially valuable fish by 2 – 5% per decade over the 21st century. These changes have the potential to significantly impact the magnitude, composition, and distribution of commercial fish catch across the pelagic North Pacific. Fishery managers should anticipate these climate impacts in order to ensure sustainable fishery yields and livelihoods.

November 4, 10:15 (W5-11399)

The Alaska Climate-change Integrated Modeling project (ACLIM): Identifying impacts and management solutions for Eastern Bering Sea fisheries

Kirstin **Holsman**, Anne Hollowed, André Punt, Kerim Aydin, Jim Ianelli, Jonathan Reum, Paul Spencer, Wei Cheng, Al Hermann, Stephen Kasperski and Alan Haynie

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Climate change is a global issue affecting marine ecosystems and species that span multiple international boundaries, and is one of the most universal challenges facing fisheries scientists and managers. This is particularly true for cold-water species in the Eastern Bering Sea (AK) where significant warming and shifts in productivity are anticipated over the next century. Historically, the region has long supported some of the most productive fisheries in the US, representing nearly 50% of annual catches nationally while maintaining harvest rates below overfishing limits. Ensuring that regional fisheries management continues to be sustainable and is "climate ready" requires understanding how different fisheries management approaches might attenuate or amplify climate-driven changes to fish and shellfish biomass. The 3 year ACLIM project was developed to address this need, and brings together climate, ecosystem, fishery management, and socioeconomic experts to quantify the interacting effects of global emissions, climate change, natural variability, and harvest on fish and fisheries. The project provides a proof-of-concept implementation of a Management Strategy Evaluation (MSE) framework for assessing the performance of fisheries management strategies under different climate change scenarios. Here we discuss some initial results and discuss challenges and approaches to coupling global climate and regional circulation models to multiple climate-enhanced biological and socio-economic models. As each model has unique assumptions and treatments of cumulative pressures and adaptive potentials, they yield disparate, yet equally plausible future trajectories. Thus we also discuss some approaches to summarizing results and presenting risk in an informative and cohesive manner in the context of divergent future scenarios.

November 4, 10:50 (W5-11346)

Climate-change driven range shifts of exploitable chub mackerel (*Scomber japonicus*) projected by bio-physical coupling individual based model in the western North Pacific

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We projected the effects of warming ocean on the range shift of biomass of chub mackerel (*Scomber japonicas*) covering from the larval to the adult stages up to age 3 yr by developing and applying individual-based models (IBM) based on a regional ocean circulation model for the western North Pacific and two climate change scenarios. From laboratory experiments, we observed a diurnal cycle in the buoyancy of larval mackerel. Our IBMs tentatively suggested that the larval and juvenile mackerel in the Korea Strait, the Japanese coastal areas and the Kuroshio extension areas are mostly transported from the East China Sea where they were hatched. Despite the greater uncertainty, the preliminary results of our IBMs projected that, by the 2050s, the strengthened Tsushima warm current in the Korea Strait and the East Sea, driven by global warming, will shift the young-of-the-year mackerel biomass distribution north to the East Sea, and adult mackerel biomass north, especially in the Yellow Sea. To improve the model performance, international cooperative researches among the regional countries are required, especially for extensive ichthyoplankton surveys in the East China Sea.

November 4, 11:10 (W5-11153)

Updated plan for modeling effects of climate change on fish and fisheries in the western North Pacific Ocean

Shin-ichi **Ito**[1], Takeshi Okunishi[2], Takashi Setou[3], Akinori Takasuka[3], Takahiko Kameda[3], Naoki Yoshie[4], Kazuyoshi Watanabe[5], Hiroshi Kuroda[6], Motomitsu Takahashi[7], Toru Hasegawa[7], Satoshi Kitajima[7], Michio Yoneda[8], Kosei Komatsu[1] and Takaaki Yokoi[1]

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5 Japan Fisheries Information Service Center, Tokyo, Japan
6 Hokkaido National Fisheries Research Institute, FRA, Kushiro, Japan
7 Seikai National Fisheries Research Institute, FRA, Nagasaki, Japan
8 National Research Institute of Fisheries and Environment of Inland Sea, FRA, Imabari, Japan

Under the project entitled "Development of mitigation and adaptation technologies to climate change in the sectors of agriculture, forestry, and fisheries" supported by the Ministry of Agriculture, Forestry and Fisheries (MAFF), model developments have been conducted to evaluate the effects of climate change on fish and fisheries in the western North Pacific. The western North Pacific is one of the most productive areas in the world and it shows high biodiversity. Therefore, it is an important task to evaluate the future status of fisheries production and biodiversity in the western North Pacific. As a scientific collaboration within PICES member countries, a physical-biological coupled model, NEMURO.FISH, which is able to connect climate and fish production through prey plankton production, was developed, and NEMURO.FISH has been applied to the western North Pacific. The lower-trophic level ecosystem model (NEMURO) has been improved to increase the prey plankton functioning (eNEMURO) under the project. We are now developing a coupled model between ROMS and eNEMURO in the western North Pacific. Our plan is to include fish growth and migration into the coupled model and evaluated the effects of climate change on fish and fisheries in the western North Pacific. One of the limitations of NEMURO.FISH is that the model can be applied only to the plankton feeders. We also introduce a plan to extend the model to include fish feeders.

November 4, 14:40 (W5-11432)

A review of species distribution modeling in the Northeast U.S. Shelf Large Marine Ecosystem

Jonathan A. **Hare**[1] and Vincent S. Saba[2]

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A number of efforts are underway in the Northeast U.S. Shelf Large Marine Ecosystem to project shifts in abundance and distribution in response to multi-decadal climate variability and climate change. The methods range from qualitative vulnerability assessments to quantitative species distribution modeling. Past and current species distribution modeling efforts will be summarized with a focus on the statistical model used, the linkages to climate models, and the climate scenarios and time periods used in projections. From this summary, guidelines will be developed so that results from separate studies can be combined to better understand the structural uncertainty in the approaches. The development of Regional Fishing Pathways and the use of process-based species distribution models will also be discussed.

November 4, 15:00 (W5-11416)

Report on the 2016 ICES/PICES Workshop on Economic Modelling of the Effects of Climate Change on Fish and Fisheries

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The ICES/PICES Workshop on Economic Modelling of the Effects of Climate Change on Fish and Fisheries (WKSICCME_Econ) was held in Brest, France on June 3-4, 2016.

The workshop was associated with the larger ICES/PICES MSEAS symposium, ‘Understanding marine socio-ecological systems.’ The workshop had the three following primary goals:

Identify the socioeconomic data and features of the suite of representative future fishing and ecosystem scenarios identified in the August 2015 inter-sessional workshop that could be employed for use in evaluating climate change effects on fish and fisheries.

Identify how fisheries management policies will interact with climate change and identify how researchers can best evaluate what management tools are most likely to be resilient to climate change effects on fisheries.

Identify suites of bioeconomic and spatially explicit models of fishery behavior that can be used to project the implications different climate models on commercially important marine fish stocks in the northern hemisphere.

This talk will summarize the key results from the workshop and discuss manuscripts and on-going collaboration that has come from the workshop.

POC Workshop (W8): Mesoscale and submesoscale processes in the North Pacific: History and new challenges

November 4, 09:00 (W8-11229)

Finescale variability of isopycnal salinity in the southern California Current System

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The California Current System (CCS) is a three-dimensional confluence of various water masses. There are four major source water masses, the North Pacific Subarctic water from the North Pacific Central water from the west, the equatorial Pacific water from the south, and the water pumped up by the coastal upwelling, which are distinguished by temperature, salinity dissolved oxygen and nutrient concentrations. The fronts of these water masses often accompany meanders of the currents and mesoscale eddies, and smaller-scale features indicating vigorous stirring and mixing are observed. Previous studies found that the meso- and submesoscale variance of isopycnal spice is strong in layers of large-scale isopycnal gradient in spice, suggesting the role of the fronts. However, details of isopycnal tracer variability and the relevant physical processes have yet to be confirmed. In the present study, we analyzed the temperature and salinity data from the California Underwater Glider Network that continuously operates the spray glider missions along the three CalCOFI lines with a horizontal resolution of 1–5 km since 2006. From approximately 350 sections (in total ~50,000 profiles), we investigated the fine scale variability of isopycnal salinity. Variance of isopycnal salinity was large around $\sigma_\theta = 25.0$, especially in autumn. The spatial spectra were generally fitted to a power law of k^{-2}, similar to those obtained in other regions, while those in a scale range larger than the Rossby radius of deformation showed bluer gradient up to k^{-1}. Seasonal variability and influences of the recent warming event are also shown in the presentation.

November 4, 09:30 (W8-11029)

Eddy trajectory in a closed rectangular oceanic basin

Yasuhide **Kobayashi** and Atsushi Kubokawa

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Many mesoscale oceanic eddies were observed by recent satellite measurements. In this study, we have investigated the trajectory of an isolated anticyclonic eddy in a rectangular ocean basin using a β-plane reduced gravity model, since the eddy trajectory in a closed basin and its determination mechanism were still unknown. The eddy translates westward initially until it collides with a meridional western boundary. Then it migrates clockwise along the western, northern and eastern boundaries and separates from the eastern boundary at a certain latitude. When the initial latitude of the eddy is near the northern boundary, the eddy returns to almost the initial position after the clockwise migration, while it is not the case when the initial latitude is further south. Such behavior has not been reported as far as we know. Then, we constructed a point vortex model including effects of mirror image and β-induced westward movement in order to demonstrate the eddy trajectory by Hamiltonian contour. Although the point vortex must translate along the same Hamiltonian contour, the eddy with a finite size cannot always translate along the same contour. It is shown that our new point vortex model including the eddy size which is connected to the diffusive effect, can qualitatively represent the trajectories obtained by numerical experiments. In this workshop, we talk about these topics and new research results. We suggest that "transfer Hamiltonian contour mechanism" is one of the dominant factors for the eddy translation.

November 4, 09:50 (W8-11130)

Mesoscale and submesoscale wavenumber spectra from the Geostationary Ocean Color Imager (GOCI)

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The Geostationary Ocean Color Imager (GOCI) continuously monitors the northeast Asian waters around Korea with 500 m horizontal resolution. These high resolution ocean color data enable us to study submesoscale processes much smaller than 10 km as well as mesoscales. Two regions, one in the southwestern part of East Sea (128-134°E and 35-39°N) and the other in the western Pacific south of the Kuroshio (132 - 142°E and 25 - 29°N), were selected. We then conducted spectral analysis using the bootstapping method for summer and winter respectively. At scale greater or equal to 10 km during summer in both areas the wave number spectra follow -5/3 power law as predicted by the surface quasi-geostrophic theory. In winter the spectrum becomes flatter due to mixed layer instability. The effect of the mixed layer instability (the degree of flattening) is greater in the East Sea where the available potential energy is greater. At scales less than about 5 km, the spectral slope is flatter in all cases suggesting active stirring and forward cascading.

November 4, 10:10 (W8-10912)

Mesoscale eddies in the western subarctic North Pacific

Hiromichi **Ueno**, Hiromu Ishiyama, Yuki Okada and Yuka Karasawa

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Mesoscale eddies in the western subarctic North Pacific have a significant impact on the heat, freshwater, macro- and micro-nutrient and biota exchanges between shelf and offshore regions and thus play an important role in the marine ecosystem of the offshore region. In this talk, we review the studies on mesoscale eddies in the western subarctic North Pacific and discuss what should be studied in the near future for the better understanding of marine ecosystem in the region from the view point of mesoscale and sub-mesoscale eddies. In addition, we discuss the formation and propagation of eddies in the western subarctic North Pacific through analysis of 20-year time series of satellite altimeter data. In the analysis, a neighbor enclosed area tracking algorithm able to detect mergers and splits of mesoscale eddies was applied to track each eddy.

November 4, 14:00 (W8-11314)

Competition in a patchy world: submesoscale dynamics, phytoplankton growth, and carbon export in the oligotrophic North Pacific

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In the ocean, physical dynamics act to create variability in the availability of resources generating environmental niches at every scale from micrometers to kilometers. Given the nonlinearity of most biological dynamics, it is important to understand how fine-scale bio-physical interactions may propagate to large scale ecosystem dynamics and carbon cycling. Here I present an approach for generalizing the impact of submesoscale bio-physical interactions on ecosystem dynamics using a statistical description of the perturbations induced by submesoscale processes. I use this model to investigate the impact of fine-scale heterogeneity in resource environment on ecosystem dynamics and carbon cycling. The model was applied to the Hawaiian Ocean Time-series site to explore the importance of fine-scale spatial and temporal heterogeneity on ecosystem composition and carbon dynamics at the site. Results suggest that community composition and export are impacted by the frequency of submesoscale front formation and that community dynamics in a heterogeneous resource environment differ significantly from a homogenous field.

November 4, 14:30 (W8-11355)

Mesoscale structures and Pacific saury fishing grounds in the Northwestern Pacific

Elena I. **Ustinova**[1] and Viktor N. Filatov[1,2]

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The role of mesoscale structures in the fishing grounds formation is shown on the basis of experience of saury fishing scientific support implemented by TINRO-Center in the Northwestern Pacific. The region is characterized by strong mesoscale variability associated with the Oyashio current branches, anticyclonic and cyclonic eddies, processes of frontogenesis and frontolysis. Historically, many useful relationships between mesoscale inhomogeneities and fish spatial distribution and the fishing grounds formation were found during the scientific programme "Polygon" in 1978-1990 (high-resolution surveys by 3-5 R/Vs synchronously). Important factor determining of the large-scale saury distribution and the concentration of fisheries activity is the presence and the position of the large anticyclonic eddy (diameter ~160-190 km) off east Hokkaido Island in summer and autumn. This eddy affects the saury fishery during several months. In some cases it is possible to trace the inflow of cold water with very different biological characteristics in the center of this eddy leading to the formation of local fronts inside it, where saury fishery has been successful during 1 week. The average duration of sustainable fishery is ~1 week for cyclonic eddies (~18 km), and 1-2 days for submesoscale eddies. Operational detection of high-gradient frontal zones is based on SST and altimetry data. Usage of SST data obtained *in situ* by research and fishing vessels allowed us to improve the SST fields in the fishing area and to identify the local and submesoscale inhomogeneities promising for fishery (areas of the fronts, individual eddies, etc.) and to trace their evolution.

November 4, 14:50 (W8-11370)

The cross-shelf transport by the eddy-pair in the Northern South China Sea in June 2015

Dongfeng **Xu**[1,2], Xianqiang He[1,2], Chenghao Yang[1,2], Jun Wang[1,2], Mingquan Xu[1,2], Hong Chen[1,2] and Yaochu Yuan[1,2]

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The cross-shelf transport is of great importance for the nutrient and other material exchange between shelf sea and deep ocean in the Northern South China Sea (NSCS). During June 19th to 29th of 2015, we conducted a multi-discipline observation by research vessel "Nanfeng". CTD profile, satellite tracked surface drifters and moored subsurface buoy were used for the in situ observation of T,S, chlorophyll and velocity. The results show that a low-salinity (32 psu) with high-chlorophyll water jet, which is ~500 km long, 100 km wide and lasting more than 19 days occupied the area between an anticyclonic-cyclonic eddy-pair. The riverine rich-nutrient coastal water was transport into the oligotrophic deep basin of SCS by the jet. The mooring velocity data showed the baroclinic velocity structure of the jet, the upper 100m was off-shelf and deep layer was in-shelf. The altimetric SLA data shows that such eddy-pair happens every year in this area. The role of the eddy-pair in the material exchange between shelf sea and deep ocean in the NSCS need further quantitatively study.

November 7

KEYNOTE

Session 1: Science Board Symposium
25 Years of PICES: Celebrating the Past, Imagining the Future

KEYNOTE

November 7, 10:30

Projecting ecosystem consequences of climate variability and change: Aspirations for the next 25 years of PICES

Ryan R. **Rykaczewski**

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Research associated with the goals of PICES has transformed scientific perceptions of ecosystem variability. The vibrant forums of PICES meetings and coordinated efforts by scientists from participating regions have stimulated understanding of the relationships between large-scale atmospheric processes, oceanographic conditions, and marine ecosystems--notably at decadal scales. Even while the mechanisms of decadal scale variability continue to be investigated, the PICES community must also devote attention to changes associated with increasing greenhouse gas emissions. Our improving understanding of low-frequency, climate-ecosystem interactions may inform understanding of ecosystem responses to anthropogenic climate change. However, responses to climate change will be unlike responses to natural variability. Recognized patterns of natural climate variability have been characterized as oscillatory in space, with signs of change that differ regionally. Anthropogenic change, in contrast, is expected to result in large-scale physical forcing of a similar sign throughout ocean basins; as concentrations of carbon dioxide rise, surface temperatures, water-column stratification, and ocean acidity will increase in nearly all regions. Projecting the consequences of such forcing on other physical characteristics, biogeochemical properties (namely subsurface dissolved oxygen content, carbonate speciation, nutrient supply, and primary production) is possible. However, understanding ecosystem responses at scales relevant to individual populations, community structure, fisheries, and human society remains extremely challenging, particularly as conditions cross thresholds not experienced in the recent past. Physical, chemical, and biological anomalies in the Northeast Pacific over the last several years have demonstrated the insufficiency of describing of conditions using a combination of well recognized atmosphere-ocean modes.

During the next 25 years, marine scientists will face the challenge of distinguishing the effects of anthropogenic climate change from those of natural variability, fisheries exploitation, and other anthropogenic stressors. Investigations of the frequency, intensity, and spatial patterns of natural variability, their sensitivities to climate change, and their ecological consequences are necessary. Developing technologies and increasing computational power provide research opportunities that were nearly inconceivable two decades ago, but maintaining and expanding long-term ocean observing systems capable of concurrent physical, chemical, and biological measurements remains essential for resolving changes relevant to biogeochemical cycles and ecosystem structure. Creating conceptual and operational models that can relate physical variability to human society, represent ecological mechanisms that are robust to climate change, and convey appropriate levels of uncertainty will be critical. Developing "objective advice on scientific questions with great practical implications" was one of the primary justifications for the creation of PICES. We continue to make progress toward this goal, but effectively applying new oceanographic understanding to improve management of marine resources remains difficult. Achieving this goal requires consideration of both short-term model forecasts with practical utility as well as long-term model projections with more strategic emphasis. Continued multinational collaboration among PICES members and partnerships with other marine science organizations are crucial to addressing these challenges.

Session 1: Science Board Symposium
25 Years of PICES: Celebrating the Past, Imagining the Future

November 7, 11:15 (S1-10968)

Predicting evolutionary responses to climate change in the sea: Progress and challenges

Philip L. **Munday**

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The need to consider evolutionary responses when predicting the impacts of climate change on marine ecosystems is increasingly recognised, yet relatively few studies have tackled this critically important question. In part, this stems from a lack of understanding about how evolutionary responses can be tested and included in climate change models. In this talk I will explain why an evolutionary perspective is crucial to understanding climate change impacts in the sea. I will then discuss the different approaches that may be useful for addressing this challenge and examine progress that has been made to date. I will first examine evidence that phenotypic plasticity may assist marine species to persist in a rapidly changing climate. I will then outline the various experimental approaches that can be used to estimate evolutionary potential. I will describe the benefits of each approach and how they can be combined to gain a deeper understanding of adaptive responses to climate change in the sea. Recent examples and a summary of current state-of-knowledge will be presented.

November 7, 11:45 (S1-11384)

Why people matter: Past and future analysis of the role of humans in marine ecosystems

Alan C. **Haynie**

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One fundamental change that has occurred during the first 25 years of PICES is the increased awareness by marine scientists that humans play a central role in marine ecosystems. While humans clearly take a primary role as drivers and beneficiaries of marine ecosystems, it is not always obvious to natural scientists how to make the connection between their research and the work of economists and social scientists from diverse fields. The PICES Section on Human Dimensions represents one significant effort to work across nations to improve research and data collection efforts among economists and social scientists, to better communicate the importance of this work to natural scientists, and to work with natural scientists on interdisciplinary problems. Beyond PICES, large and diverse projects are occurring at both the national and international levels to achieve similar goals. After briefly discussing several of these research projects, this talk will provide one vision of how the future might evolve in a manner that most usefully integrates social sciences and economics into PICES and marine science more generally. Evolving technology, socioeconomic data collection, improved management institutions, better long-term collaboration among natural and social scientists, and expanding research efforts together offer a hopeful future for better interdisciplinary science and a more sustainable marine environment.

November 7, 12:15 (S1-10957)

Applying fractionalization indices to transboundary fish stocks to forecast future conflict hotspots

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3 Stockholm University, Stockholm, Sweden

Unpredictable shifts in the distribution and abundance of transboundary fish stocks are a major concern, with implications for local and regional economies, food security, and public health. Within a geopolitical context, however, they also have the potential to spark or exacerbate international conflict. A common assertion is that cooperation is more likely among homogeneous players, while high levels of heterogeneity can hamper or preclude such processes. We will present initial results of our efforts to test this assertion within a fisheries context using fractionalization indices. Often used by political scientists to assess conflict potential, fractionalization indices can be calculated to represent the relative homogeneity of states or regions. We calculate a series of economic, cultural and governance fractionalization indices at the regional level for transboundary fish stocks. In each case, the "region" is not necessarily defined geographically, but instead by the participating fishing nations (including distant water fishing nations), and the respective fractionalization within each group. We conclude by forecasting future hotspots for conflict based on best available science related to climate-related changes in the distribution of transboundary stocks.

November 7, 14:00 (S1-11112)

PICES-ICES Cooperation: Where we are and where to go?

Cornelius Hammer

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It is in the nature of scientific oceanographic work to cooperate. Even research on local phenomena must be reflected on a broader scale: is it a local phenomenon or is it of greater significance? This has become of greater importance since research started on events of world-wide importance that emerged throughout the 1970s and 1980s: pollution, coral bleaching, diseases, change of biodiversity, harmful algal blooms, and non-indigenous species. In reaction international cooperation started on a project-level. However, since the 1990s common problems have risen to another magnitude: global warming, change of entire ecosystems, meltdown of the Arctic ice sheet, and acidification. Scientific problems of this scale can only be dealt with by common research. Therefore it was only logical for PICES and ICES to start closer cooperation beginning in 2000, being not research institutes, but organizers of research. The cooperation takes place on three levels: firstly, common organisation and sponsoring of symposia (25) and conducting common theme sessions (what has been done? Where are we now?), secondly, organising workshops and strategic initiatives (to work together on concrete issues) and thirdly, developing together new research fields (what should be done in future?), as it has been done with "human dimension". This is also the way forward: the future of PICES-ICES cooperation is seen in continuing these successful science-supporting initiatives but also in defining directions of research as the basis for politics and administrations for research funding. Prominent examples are the Arctic, acidification, and change of ecosystems.

November 7, 14:30 (S1-11095)

Oceanography of the Mexican Pacific Ocean: An interactive region between north and south

Guido **Marinone**

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PICES' 25 years of history have produced a high level of knowledge of the North Pacific in aspects related to climate and its two-way coupling to ocean circulation and biogeochemistry. PICES science has also helped elucidate biological cycles within the North Pacific's ecosystem and food web, and the associated impacts on fisheries and socio-economics. All this information generated from within and in collaboration among PICES member countries allows for better management of resources. To date, while recognizing the importance of global and larger basin-scale signals, PICES' efforts have focused mainly on regions northward of 30°N.

The waters off the Mexican Pacific coast are a transition area where the California Current leaves the continent towards the North Equatorial Current, resulting in a biogeographic boundary between warmer (tropical) and cooler (sub-tropical) waters. In this same region, coastal-trapped waves propagate poleward from the Equator into the North Pacific Ocean. Expected climate effects will heighten the importance of understanding possible biogeographic shifts and energy propagation (e.g., associated with more frequent El Niño events) along this dynamic southern PICES boundary.

We will highlight contributions from Mexican institutions during the last 25 years in this region of the Pacific. Perhaps more importantly, we also describe the challenges we anticipate in the coming 25 years, and how Mexico, together with PICES, can contribute to the advancement of a better understanding of the functioning and management of the North Pacific's resources.

November 7, 15:00 (S1-11421)

The UN role in for ocean science and ocean governance

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The ocean is the greatest ecosystem on Earth. It provides tangible goods and commodities (e.g., food, energy, minerals, transportation routes...) as well as ecosystem services (climate regulation, coastal protection, production of oxygen, nutrient cycling, carbon sequestration, etc.). It vast dimension interconnects all the continents and their resources are not fenced by national boundaries. The ocean is a classic example of a "global common".

Where natural resources are shared among many countries or pollution spreads across international boundaries (floating and drifting debris and microplastics) individual countries cannot act on their own. Regulation of ocean uses needs of collective action at international scale. This international stewardship is provided by intergovernmental organizations, such as PICES, ICES and others under the legitimacy of the UN system, such as FAO, WMO, IMO and the IOC-UNESCO among others.

If real progress is to be made towards reversing coastal and marine degradation in the face of the accelerating warming, loss of biodiversity, pollution, etc., it is urgent that the states adopt strategies towards science for sustainability. The creation of new international frameworks of cooperation for ocean research and governance, scientific cooperation, capacity development and transfer of technology between developed and developing countries such as the UN Sustainable Development Goal14 for the ocean (*Conserve and sustainably use the oceans, seas and marine resources for sustainable development)* are examples of actions that could contribute substantially to address those urgent needs.

This talk explores the role of the UN system as driver of international cooperation and facilitator for ocean knowledge.

November 7, 15:20 (S1-11099)

Recent advances, ongoing challenges, and future directions in ecosystem approaches to fisheries management in the central North Pacific

Jeffrey **Polovina**[1], Anela Choy[2], Phoebe Woodworth-Jefcoats[1,4] and Johanna Wren[1]

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For 25 years PICES has been a leader in promoting a holistic and multidisciplinary approach to marine ecosystem research including advancing our understanding of ecosystem carrying capacity, regime shifts, and impacts from climate change. We have been engaged with PICES from the beginning and our subtropical pelagic ecosystem research has greatly benefitted from this association. We have used a suite of data and tools including fishery data, fish diet data, outputs from earth system models, and ecosystem models to document a top-down response in the pelagic ecosystem due to fishing and to project future climate change impacts including an expanded subtropical gyre with lower productivity and lower fishery catch rates. A multispecies maximum yield is proposed to maintain ecosystem structure and biodiversity. Going forward we are evaluating how spatial ecosystem models, indices from micronekton sampling, fish size structure, and ocean vertical structure may provide more operational ecosystem advice.

November 7, 15:40 (S1-10929)

Can we use zooplankton diversity to fill the global indicator gap of the Aichi Biodiversity Target 10?

Sanae **Chiba**[1,2], Stephen Fletcher[2] and Sonia D. Batten[3]

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This presentation will review the potential to develop zooplankton diversity into one of the global indicators for the Aichi Biodiversity Target 10, which aims to minimize multiple anthropogenic pressures on marine ecosystems impacted by climate change or ocean acidification. Zooplankton species composition, size structure and other functional traits are sensitive to environmental variations, and any changes will affect trophic linkages and biogeochemical cycles. Zooplankton diversity has been proposed by various regional studies as a useful indicator of marine ecosystem responses to climate change and anthropogenic pressures, recruitment success of plankivorous fish, and the efficiency of the biological carbon pump. Several international initiatives are currently attempting to identify essential biological variables to measure at the global scale, in order to assess the temporal trend and present status of the earth's ecosystems and biodiversity. With the quasi-global spatial coverage of present zooplankton observation efforts, zooplankton diversity is well positioned to become an essential biological variable, e.g. it has been recommended to be one of the candidate Essential Ocean Variables by the GOOS Biology and Ecosystem Panel. Aichi Biodiversity Target 10 is one of the drivers of development of the essential biological variables. However, some of the components, e.g. trends in the state of vulnerable ecosystems, have yet no specific global indicators except coral reef ecosystems. We examine the extent of relevance, data coverage, and international coordination of zooplankton observations, and discuss the possibility to develop zooplankton diversity to fill the gap of global indicators for the Aichi Target 10.

November 7, 16:20 (S1-11407)

Harnessing blue capital for blue growth: Why invest?

Essam Yassin **Mohammed**

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The term 'blue capital' refers to marine and coastal ecosystems (e.g. coral reefs, mangroves, salt marshes and sea-grass beds) that provide economically significant goods and services. Depending on national circumstances, blue capital underpins marine and coastal economic development by protecting cities and communities from flooding; regulating water quality; attracting tourism; or sustaining fisheries. Certain marine and coastal ecosystems also sequester more carbon dioxide than terrestrial vegetation, and are therefore crucial regulators of climate change. The focus of my talk will be to identify practical development pathways that enhance both the: (1) health of marine and coastal ecosystems; and (2) contribution of these ecosystems to livelihoods and economic growth. Specific questions addressed by the presentation include:

Why invest? – Present a clear and accessible synthesis of current knowledge concerning the economic benefits of healthy marine and coastal ecosystems; and

How to invest? – Drawing on a large selection of case studies, set out a diverse suite of globally relevant legal, policy and financial options for maintaining and enhancing these benefits.

November 7, 16:50 (S1-11111)

Marine Ecological Capital: Assessment, management and investment

Shang **Chen**, Yongfu Sun, Tao Xia and Linhua Hao

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Marine Ecological Capital (MEC) is defined as marine ecological resources which have direct or indirect contributions to human social and economic production and provide benefits for humans. MEC is the important component of natural capital. MEC value is defined as the monetized benefits for humans from marine ecological capital, including both the standing stock value of marine ecological resources and the value of marine ecosystem services. Marine ecological resources (MER) consist of marine living resources and their habitats (e.g., seawater, surface seabed), as well as the marine ecosystem that they act upon as a whole. Ecological (or natural) capital has become an emerging issue in both scientific and economic communities. Cooperation on marine ecosystem services has already been accepted in the outcome list of the 8th Sino-US Strategic and Economic Dialogue (June 2016 in Beijing). Three scientific issues are preliminarily addressed in this presentation: assessment frameworks, management mechanisms and investment models of marine ecological capital. Ecosystem-based marine management needs mainstreaming of MEC in both marine management and commercial investment activities. The MEC theory and approaches may play a key role to balance both the ecological and economic benefits from human marine activities.

November 7, 17:10 (S1-11044)

Potential environmental changes in the western Arctic and the western North Pacific: Their impacts on lower trophic level organisms

Naomi **Harada**, Katsunori Kimoto, Jonaotaro Onodera, Eiji Watanabe, Koji Sugie, Masahide Wakita and Tetsuichi Fujiki

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The reduction of sea ice in the Arctic Ocean, which has progressed more rapidly than previously predicted, has the potential to cause multiple environmental stresses, including warming, and acidification. For acidification, the saturation horizon in the subarctic North Pacific has become the shallowest not only for aragonite but also calcite (~150m) in the world's pelagic ocean (Wakita et al., 2013, Biogeosciences, doi:10.5194/bg-10-7817-2013). Observations by time-series sediment trap experiments and model simulations have both helped to clarify the impact of environmental stressors on the dynamics of marine organism processes and biogeochemical cycles. In this presentation, we focus on the western Arctic, which has experienced the most rapid retreat of sea ice in the Arctic Ocean, and the western subarctic North Pacific, where under-saturation of $CaCO_3$ is causing problems for marine calcifiers. We will report on the impact of the current reduction of sea ice on primary production in the western Arctic Ocean, and identify the key mechanism of changes in biogeochemical cycles, namely increased frequency of appearance of mesoscale anticyclonic eddies. We also introduce a new evaluation method of acidification using micro X-ray computer tomography for marine calcifiers and represent their rapid response associated with seasonal change in pH condition from the western subarctic North Pacific (maybe from the Arctic Ocean, too).

November 7, 17:40 (S1-11408)

Future Global Ocean Observing System – Built on requirements, promoting alignment, delivering relevant information

Maciej **Telszewski**[1], Toste Tanhua[2] and Albert Fischer[3]

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Since the OceanObs'09 Conference, the ocean observing community has been improving coordination and collaboration among physical, biogeochemical and biology/ecosystem communities. Significant progress has been made through the introduction of the Global Ocean Observing System (GOOS) Framework for Ocean Observing in 2012. Societal and scientific requirements for sustained observations have been captured in Essential Ocean Variables (EOVs), many of which are also essential climate variables (ECVs, defined by the Global Climate Observing System (GCOS) reporting to the UNFCCC). Defined and emerging disciplinary EOVs are based on analysis of feasibility and impact, and how they deliver the needed data for scientific questions and societal requirements. With advances in observing technology, and the definition of EOVs, clear opportunities exist to improve the coordinated planning and implementation of observing activities measuring across the three disciplines and all relevant temporal and spatial scales, eventually leading to truly fit-for-purpose observing system design. GOOS works directly with several formal bodies programmatically connected to IOC-UNESCO, WMO, as well as the WMO-IOC JCOMM to integrate ocean observation information into the GCOS Implementation Plan in support of the UNFCCC, the World Summit on Sustainable Development, the Group on Earth Observations, and other international and intergovernmental strategies.

In our opinion, a direct communication and coordination with regional communities such as PICES is necessary to fully connect the opportunities arising in the decision and policy-making arena with technical developments occurring globally and regionally. The 25th PICES Annual Meeting could serve as a platform for exactly that type of communication and coordination.

November 7, 18:00 (S1-11290)

Marine birds, mammals and PICES: History and roadmap for the future

William J. **Sydeman**[1], George L. Hunt Jr.[2], Douglas F. Bertram[3], Yutaka Watanuki[4], Rolf Ream[5], Kaoru Hattori[6], Hidehiro Kato[7] and Ken Morgan[8]

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The PICES Section on Marine Birds and Mammals (MBM) began in 1995 as PICES Working Group 11, which was charged with assembling information on the prey consumption by marine mammals and seabirds in the PICES area. Their work culminated in the Advisory Panel for Marine Birds and Mammals (AP-MBM, now Section-MBM), which has been active in the PICES community since 1999. In this presentation, we review the accomplishments of the AP/Section, including research foci, results of workshops and theme sessions held, and provide a roadmap for future activities. Previous research has emphasized four interrelated themes: (1) diet analyses, estimates of prey consumption, and top-down effects of MBM on pelagic food webs; (2) climate variability and change and bottom-up effects on MBM species and populations; (3) use of seabirds and marine mammals as ecological indicators for fisheries and ecosystem-based management, as well as sentinels of contaminants in marine systems; and (4) 'hotspots' and spatial ecology of seabirds and marine mammals in the North Pacific. Special volumes on the spatial ecology of MBM and climate change impacts leave a legacy of previous workshop and theme session efforts. As we look towards the future, integrating MBM into models of fisheries is an important next step, as is predicting how climate change will impact MBM distribution and abundance. The signals provided by MBM also continue to provide early-warning indicators of ecosystem change across the PICES domain.

November 8

Plenary Session

Session 5
Understanding our Changing Oceans through Species Distributions and Habitat Models based on Remotely Sensed Data

Session 6
What Factors make or break Trophic Linkages?

Session 7
New Stage of Ocean Acidification Studies: Responses of Oceanic Ecosystem including Fisheries Resources

Session 8 (Day 1)
The Effect of Marine Debris caused by the Great Tsunami of 2011

Session 11 (Day 1)
Advances in Understanding and Modeling of Physical Processes in the North Pacific in the Past 25 Years of PICES and Future Directions

November 8, 09:00 (S1-11394)

A reference frame of environmental time series observations for detecting change in North Pacific Ecosystems; the North Pacific Ecosystem Status Report

Phillip R. **Mundy**[1], Peter Chandler[2], J. Anthony Koslow[3], Vladimir Kulik[4], Se-Jong Ju[5] and Hiroya Sugisaki[6]

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3 Scripps Institution of Oceanography, UC San Diego, La Jolla, CA, USA
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6 National Research Institute of Fisheries Science, Yokohama, Japan

How can the scientific community inform other sectors of society about the extent of changes in the ecosystems of the North Pacific? The complex task of detecting and describing ecosystem-level changes on a large geographic scale across multiple scientific disciplines and nations is well suited to the capabilities of North Pacific Marine Science Organization. On the 25th Anniversary of PICES we present a significant milestone in promoting international scientific cooperation on a mutually beneficial basis, which is a fundamental principle of the PICES treaty. The third edition of PICES' North Pacific Ecosystem Status Report, NPESR, establishes an international network of scientists to provide observations for detecting changes and informing society about ecosystem-level change on timely basis. A total of 287 environmental time series composed of 28 different types of observations were nominated by PICES standing committees and expert groups. The observations span the Large Marine Ecosystems of the North Pacific, characterizing the current status of North Pacific marine ecosystems, and documenting changes due to factors such as industrialization and climate change. Time series selected for NPESR are contributed directly by scientists through an online interface to a data management system that organizes them into a data base. Queries of the data base can produce summaries and basic reports that serve the needs of the newly formed NPESR Work Group that will construct NPESR during 2017. Highlights of time series demonstrate the progression of 20th Century industrialization and responses of biota to short and long term climate fluctuations.

November 8, 09:30 (S8-11280)

Life rafts on the open sea: Successful long-term transoceanic transport of coastal marine organisms by marine debris

James T. **Carlton**[1], John W. Chapman[2], Jonathan B. Geller[3], Jessica A. Miller[2], Gregory M. Ruiz[4], Deborah A. Carlton[1], Megan A. McCuller[1], Rebecca Barnard[4], Nancy Treneman[5] and Brian Steves[4]

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A vast number of objects from Aomori, Iwate, Miyagi, and Fukushima Prefectures – ranging from small household items to buoys, vessels, and docks – have been arriving on the shores of North America and the Hawaiian Islands since being sent into the North Pacific Ocean by the tsunami of March 11, 2011. Japanese Tsunami Marine Debris (JTMD) objects with living Japanese species are still arriving as of the date of this abstract submission on July 1, 2016. Examination of the biota associated with more than 650 objects (representing what is likely a small fraction of the amount of debris with living biofouling that has in reality come ashore) has revealed 100s of species of protists, invertebrates and algae, as well as two species of entrapped fish, which have successfully been transported from the Western Pacific to the Central and Eastern Pacific Ocean. Mollusks, crustaceans, bryozoans, hydrozoans, and polychaete worms comprise the majority of rafted invertebrate species. Instances of long distance transoceanic dispersal across the North Pacific are apparently so rare that we have no previous scientific records of living coastal species from Asia landing on the shores of North America or Hawaii by means of rafting. To assess the relative novelty of JTMD we compare this vector to other phenomena, including pre-20th century Japanese shipwrecks, historical and modern shipping (including hull fouling, solid ballast, and ballast water), and the 20th century transoceanic commercial trade in Pacific oysters (*Crassostrea gigas*).

November 8, 10:00 (S5-11358)

Making the most of satellite-derived oceanographic data and habitat use models to understand species distributions

Robert M. **Suryan**

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Satellite-based remote sensing and tracking technologies have advanced our knowledge of global oceanographic and atmospheric processes and species distributions to levels previously unimaginable. Integration of these datasets provide powerful tools for understanding species habitat associations over large, continuous spatial and temporal scales. Satellite-based data, of course, are restricted to the surface layer and limited compared to *in situ* sampling. The number of satellite derived metrics, however, continue to grow and are becoming more widely used. The expansion of satellite-based metrics integrated with individual-based tracking data, has led to rapid advances in species-habitat modelling efforts. Species-habitat models, take many forms and can provide much needed insight into environmental variables affecting species distributions, but are also not used to their fullest potential – both applied or theoretically. The majority of satellite derived products are physical metrics, causing challenges in attempts to relate to mid- and upper-trophic level biological processes. In many of our previous studies using remotely sensed metrics, fair to large amounts of unexplained variance remain in understanding habitat selection. Moving forward and making the most of what is available, we could gain additional insight by being creative and including study designs targeting habitat-use (what/where) vs. mechanisms of use (why/how). The latter, particular, has received less attention by those of us studying mid- to upper-trophic level species. Continued advancement in this field of research will come from innovative study design in addition to advanced sensors and novel quantitative approaches.

S5: BIO/MONITOR/MEQ Topic Session: Understanding our Changing Oceans through Species Distributions and Habitat Models based on Remotely Sensed Data

November 8, 10:50 (S5-10990)

Moving towards dynamic ocean management: How well do modeled ocean products predict species distributions?

Elizabeth A. **Becker**[1,2], Karin A. Forney[1], Paul C. Fiedler[3], Jay Barlow[3], Susan J. Chivers[3], Christopher A. Edwards[4], Andrew M. Moore[4] and Jessica V. Redfern[3]

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Species distribution models (SDMs) are now widely used in marine conservation and management to predict the occurrence of protected species. Dynamic habitat variables have commonly included *in situ* and remotely sensed oceanic variables ("measured data"), but now the Regional Ocean Modeling System (ROMS) provides historical estimates and forecast predictions of habitat variables such as temperature, salinity, and mixed layer depth. In this study we compare SDMs based on ROMS data to those based on measured data. Shipboard line-transect surveys during 1991-2009 were used to develop predictive habitat-based models of animal density for 11 cetacean species in the California Current Ecosystem. Four different generalized additive models were compared: two that included a full suite of available predictors for ROMS or measured data, and two that were restricted to variables available from both data sources. Model performance was assessed using the percentage of explained deviance, root mean squared error, observed to predicted density ratios, and visual inspection of predicted and observed distributions. Predicted distribution patterns and quantitative measures of predictive ability were similar for models using ROMS and measured data. Both model types showed good concordance with observed sightings, and model-based abundance estimates for the study area were statistically similar to standard line-transect estimates. Measures of model uncertainty exhibited spatial variability that differed between model types, and deserve careful consideration if model results are used for conservation management. ROMS-based habitat models open new opportunities for dynamic species management because ROMS data are available in near real time and as forecasts.

November 8, 11:10 (S5-11265)

Spatio-temporal patterns of potential fishing zones for Pacific saury in a warming climate

Achmad Fachruddin Syah[1], Sei-Ichi **Saitoh**[2], Irene D. Alabia[2] and Toru Hirawake[3]

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Pacific saury (*Cololabis saira*) is widely distributed in the subtropical and subarctic waters of the western North Pacific. It also constitutes one of the most commercially-important pelagic fisheries in the region and its spatio-temporal distributions are tightly linked to the changes in environmental conditions. In the present study, we predicted changes in the potential fishing zones (PFZ) for Pacific saury in western North Pacific under a warming climate, using future sea surface temperature projections from the Intergovernmental Panel on Climate Change -CMIP5 RCP4.5 scenario. The future PFZ patterns were compared with the present-day distributions derived from habitat model predictions. The habitat models were developed using the Pacific saury presence data from the nighttime visible images (August-December, 2005-2013) and remotely-sensed environmental factors. Our results showed considerable changes in the spatial and temporal PFZ patterns under the warm climate, characterized by an increasing degree of poleward displacement from 2025 to 2100. These projected tendencies in the PFZ of Pacific saury may have consequent socio-economic implications that might be useful for designing fisheries management strategies under global warming.

November 8, 11:30 (S5-11220)

Modeling blue whale movement behavior in relation to environmental conditions in the California Current from satellite tracking and remote sensing

Daniel M. **Palacios**[1], Ladd M. Irvine[1], Bruce R. Mate[1], Elliott L. Hazen[2,3], Karin A. Forney[4], Elizabeth A. Becker[4], Monica L. DeAngelis[5,6], Steven J. Bograd[2] and Helen Bailey[7]

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We investigated the association between movement behavior and environmental conditions for blue whales (*Balaenoptera musculus*) satellite-tracked in the California Current System (CCS), using a long-term (1994-2009) data set including 104 tagged whales. Daily whale locations and behavioral state probability, on a continuous scale from 0 to 1 corresponding to fast, directed movement (i.e. transiting) at one end, and slow, localized movement (i.e., area-restricted searching associated with foraging, ARS) at the other, were estimated for each track using state-space models. Because blue whales depend exclusively upon dense euphausiid (krill) schools for food, we hypothesized that their movement behavior in the CCS reflects the variable, patchy nature of krill aggregations. In the absence of adequate krill data, we used remotely sensed variables at each whale location as proxies for mechanisms favoring krill aggregation. The data were aggregated into a single summer-fall (July-November) seasonal period and were further binned into 0.25° × 0.25° grid cells to reduce autocorrelation. Behavioral state was predicted at each grid cell based on the environmental data using a nonparametric multiplicative regression model. Predictions indicated an increased likelihood of ARS behavior over the continental shelf in association with westward-facing slopes, highlighting the importance of seafloor terrain for blue whale foraging. Oceanographic conditions associated with most intense ARS included low sea-surface height, increased Ekman upwelling, and elevated chlorophyll-*a* concentration. These responses indicate that blue whales optimize foraging behavior along environmental gradients. As such, behavioral state can be a useful measure of ecological performance.

November 8, 11:50 (S5-11323)

Foraging patterns of Laysan Albatross from Guadalupe Island, Mexico and their relation to oceanographic variables from the California Current System

Daniela Y. **Munguía-Cajigas**, Julio César Hernández-Montoya, Evaristo Rojas-Mayoral, Yuliana Bedolla-Guzmán, Federico Méndez-Sánchez and Alfonso Aguirre-Muñoz

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There are few studies that discuss marine foraging areas of seabirds nesting on Baja California Pacific Islands. Therefore, we identified and classified Laysan Albatross (*Phoebastria immutabilis*; LAAL) foraging areas on the Eastern Pacific—California Current region—using Kernel densities from GPS tracks, in combination with different oceanographic variables. GPS devices were attached to 20 LAAL individuals from the Guadalupe Island colony during the January to May 2014 season. Satellite composites of chlorophyll concentration, sea surface temperature maps and the Pacific Environmental Fisheries Laboratory upwelling index were retrieved from January to May 2014. We evaluated and mapped Kernel density estimates from 15 LAAL tracks around the Northeast Pacific Ocean. We also overlaid these tracks with mean chlorophyll concentration and mean sea surface temperature maps. Kernel density maps indicate that 50% of the tracks are being recorded around Guadalupe Island. High chlorophyll concentration, low sea surface temperature, upwelling conditions and zig-zag flights were recorded during the first half of March 2014, off the coast of California, USA, from San Francisco Bay to Santa Barbara Basin, and off the coast of Baja California, Mexico, from San Quintín Basin to Punta Eugenia. Our results reveal a wide spatial distribution of LAAL from Guadalupe Island throughout the Northeast Pacific Ocean, as well as the oceanographic features that encourage their foraging within this region, associated to high productivity waters.

November 8, 12:10 (S5-11217)

Submarine canyons and essential krill habitat: Implications for modeling distribution patterns under climate change

Jarrod A. **Santora**, Jeffrey G. Dorman, Ramona Zeno and William J. Sydeman

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Remote-sensing of physical oceanographic conditions in species distribution models is ushering in new insights on forage species to benefit dynamic habitat management strategies as well as studies of climate impacts. However, aside from including sea depth (or slope), most broad scale (i.e., 1000s km) species distribution models (SDM) for pelagic species ignore the complexity of marine geological features, which are significant and relatively static in comparison with sea surface temperature or Chl-a, variables typically used in SDM. The California Current large marine ecosystem (CCE) is a productive upwelling ecosystem that is studded with complex submarine canyon systems along its extensive shelf-break/slope habitat. Euphausiid crustaceans ('krill') are a linchpin of the pelagic food web and identifying their essential habitat relative to SDM is paramount for forecasting as well as current ecosystem-based management. Using 15 years of acoustic survey spanning the entire CCE and remotely sensed bathymetric features, we investigate krill distribution relative to submarine canyons, specifically size dimensions (length, area, and width), orientation and depth variability (rugosity). Krill aggregations were associated with submarine canyons in CCE, but krill aggregations were not found at all canyons, and there were weak relationships between aggregation size and canyon characteristics. Nonetheless, the importance of these static bathymetric features to krill and perhaps other mesopelagic species must be considered in SDM.

November 8, 14:00 (S5-11219)

Forecasting bycatch and ship strike risk for dynamic ocean management in the California Current

Elliott L. **Hazen**[1,2], Kylie L. Scales[1,2], Dana K. Briscoe[3], Steven J. Bograd[1,2], Larry B. Crowder[3], Rebecca Lewison[4] and Sara Maxwell[5]

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Highly migratory species are inherently difficult to manage as they cross human-imposed jurisdictional boundaries in the open seas. Given that many species undertake seasonal migrations, management approaches require data on changes in their distribution and abundance through time. Top predators face spatially-explicit threats such as ship-strike risk, from which blue whales in the California Current are particularly at risk, and fisheries bycatch. Here we present two tools that integrate data from satellite tags, in situ sightings, and fisheries bycatch records together with Earth Observation remote sensing to develop near-real-time spatial management approaches for threat mitigation. First, we estimate monthly densities of endangered blue whales (*Balaenoptera musculus*) for use in establishing dynamic management areas. These predictions incorporate seasonal changes in habitat, and can be used to minimize overlap with potentially harmful human activities more precisely. Second, we examine fisheries bycatch risk in the California Current for a number of species including sea lions (*Zalophus californianus*), leatherback sea turtles (*Dermochelys coriacea*), blue sharks (*Prionace glauca*), and the target species, swordfish (*Xiphias gladius*). While still in the formative stage, this EcoCast tool uses habitat models and risk weightings to estimate catch / bycatch ratios in near-real-time. These approaches could be applied to other migratory species for which telemetry, survey, or bycatch data are available, and demonstrates the utility of satellite data for marine conservation and management.

November 8, 14:20 (S5-11197)

Seasonal distribution of short-tailed shearwaters and their prey in the Bering and Chukchi seas

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The marine ecosystems of the Bering Sea and adjacent Chukchi Sea are experiencing rapid changes due to reductions in sea-ice. Short-tailed shearwaters *Puffinus tenuirostris* visit this region between the summer and fall during non-breeding season. Understanding the links between seasonal distribution, their prey (i.e., krill) and the marine environment are crucial to predicting ecosystem changes. We tracked the migratory movements of 19 and 24 birds in 2010 and 2011 respectively, using geolocators, and conducted ship-based at-sea surveys including net sampling of krill during September 2012 and July 2013 in the Bering and Chukchi seas. Tracked individuals occupied the southeastern Bering Sea from May to July in both 2010 and 2011. In August–September 2010 68% of individuals moved into the Chukchi Sea but only 38% did in 2011 when SST was 2^{o}C colder. Shearwater's distribution based on survey data showed similar patterns; shearwaters were mainly distributed in the southeastern Bering Sea (60±473 birds km^{-2}) in July 2013 and in the Chukchi Sea (19±91) in September 2012. In the Chukchi Sea, the krill size was greater in September 2012 (9.6±5.0 mm) than in July 2013 (1.9±1.2). Within the Chukchi Sea in September 2012 shearwaters occurred more frequently in 50-km cells where large krill was more abundant with warmer SST. These findings suggest the seasonal northward movement of shearwaters might be associated with the seasonal increase of large krill and SST in the Chukchi Sea. Thus this study indicates the importance of krill as a prey of top-predators in the Arctic ecosystem.

November 8, 14:40 (S5-11283)

Relationships between seabird, tuna, and dolphin foraging aggregations and El Niño-Southern Oscillation in the oceanic eastern tropical Pacific

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An important feature of the eastern tropical Pacific ecosystem is the prevalent association of multispecies seabird feeding aggregations with schools of tunas and dolphins. This association is particularly strong in the Tropical Surface Water Mass (TSW), where feeding aggregation densities exceed mean densities in adjacent equatorial and subtropical surface waters by factors of 3.23 and 4.57, respectively. Changes in the distribution, density, and composition of these feeding aggregations in response to El Niño-Southern Oscillation (ENSO) may provide insights into mechanistic oceanographic drivers of this important feature of the TSW biological community. In this study we developed generalized additive models (GAM) to predict density of feeding aggregations using 8 years of National Oceanographic and Atmospheric Administration transect survey data (1988 – 2006, 1343 days at sea, 3966 feeding aggregations). During positive-phase ENSO events, there was a 54% mean reduction in density of tuna-dolphin associated feeding aggregations within the core geographic area of the eastern Pacific warm pool (delineated using Advanced Very High Resolution Radiometer sea surface temperature remote sensing products). Conversely, the density of these feeding aggregations increased within the typically upwelling-dominated Gulf of Tehuantepec and Costa Rica Dome during positive-phase ENSO events. Tuna play a critical role in mediating these feeding aggregations. Changes in the foraging depth and behavior of tuna in response to vertical displacements of mixed layer depth during ENSO events constitute hypothesized mechanisms for these changes in an important feature of the eastern tropical Pacific ecosystem.

November 8, 15:00 (S5-11110)

Climate change impacts on distribution patterns of boreopacific gonate squid (*Boreoteuthis borealis*) in the Northwest Pacific

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All data including positive and zero catches of the North Pacific highly abundant and widely distributed pelagic squid *Boreoteuthis borealis* were taken from the database "Marine Biology" (TINRO-Center) and Global Biodiversity Information Facility.

Two groups of species distribution models (SDM) were tuned for the squid in the Pacific area between 35°-63°N and 141°-180°E. The first group of SDMs utilized 10 bioclimatic variables (annual mean, range, variance, and extreme values for temperature and salinity) and geophysical variables (bathymetry and its complexity: components of aspect, slope, concavity of the seafloor, and plan and profile curvature, as well as distance from shore) obtained from "MARSPEC" database. The second group of SDMs was designed for forecasting on the basis of future values of sea surface temperature and salinity obtained from A1B, A2, B1 Intergovernmental Panel on Climate Change scenarios for the late 21st century available in "Bio-ORACLE" database.

We compared 5 methods: Maximum Entropy (MaxEnt), Generalized Additive Models, Random Forest, Support Vector Machines and Bayesian SDMs using Gaussian processes. Model performance was estimated using Area Under the receiver operator Curve (AUC) on the 25% out of sample (test) cases. In all test cases, MaxEnt showed the lowest AUC around 0.5; however, the other four SDMs had much higher AUC within 0.8-0.9. Although far from ideal, mean current and future projections from these four SDMs, weighted by AUC, appeared close to known distribution patterns of the squid.

November 8, 15:20 (S5-11327)

Salmon prey assemblages and oceanographic conditions along the California Current shelf ecosystem

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Early ocean entry is a critical life-history period for juvenile Chinook salmon out-migrants whose early survival is known to be affected by the availability of suitable prey on the shelf. We describe the distribution of marine forage assemblages relative to biogeographic and oceanographic conditions in the California Current shelf ecosystem (36'N to 47'N, <200m). Nekton samples were collected during annual mid-water trawls conducted from May-June by the SWFSC and NWFSC, 2011 - 2015. Oceanographic data at the time and location of each sample, as well in monthly time steps up to five months prior to samples, were derived from the Data Assimilative Regional Ocean Modeling System (ROMS) and the U.S. Navy FNMOC surface atmospheric pressure database. We used nonmetric multidimensional scaling to characterize differences in assemblages between samples. Regression-tree analysis of the ordination revealed a set of southern sites that were characterized by high upwelling and shallower depth of the 26.0 isopycnal 4 months prior to the trawl, and stronger transport during the time of the trawl. Northern sites were characterized by weaker upwelling and deeper 26.0 isopycnal 4 months prior to the samples. Our model agrees with prior results showing that early upwelling pre-conditions the system and that transport during sampling relates to retention in the region. Using generalized additive modeling, we found that krill abundance was best explained by regional preconditioning. This work extends prior research to relate oceanographic and biogeographic variables relative to juvenile Chinook salmon forage assemblages along a wider range of the California Current ecosystem.

November 8, 15:40 (S5-11215)

Eastern Bering Sea seabirds shift distributions in response to timing of sea-ice retreat

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In the eastern Bering Sea, the timing of sea-ice retreat varies interannually and provides the opportunity to examine the impacts of a warmer (earlier sea-ice retreat) Bering Sea on its ecosystem. Recent work has shown significant impacts of sea-ice-retreat timing on the recruitment of shelf copepods, euphausiids and walleye pollock (*Gadus chalcogramma*). Here, we contrast the summer distributions of seabirds in the eastern Bering Sea in years with early and late sea-ice retreat. In the southeastern portion of the shelf, where there is considerable variation in the extent and duration of sea ice, we found there was a strong tendency for seabirds that use the Inner Shelf Domain in years with late ice retreat to shift offshore in years with early ice retreat, and for species that forage off the shelf in years with late ice retreat to move toward the shelf, or onto the shelf, in years with early ice retreat. Similarly, on the north central portion of the shelf, between 58º and 61ºN, seabird distributions showed a shift from having concentrations along the 50 m isobath in years with late sea-ice retreat to concentrations along the 100 m isobath in years with early sea-ice retreat. Changes in seabird distributions over the southeastern shelf appear to reflect variability in the abundance and/or availability of large copepods, euphausiids and age-0 pollock; factors underlying the shifts in the northern region are not known.

November 8, 16:20 (S5-10996)

Bioclimatic velocity for walleye pollock in the Bering Sea

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Evaluating the species-specific responses of key fishery resources to environmental changes is essential to marine spatial planning and informed management decisions. In the Bering Sea, walleye pollock (*Gadus chalcogrammus*) is among the most ecologically-important and abundant commercial fish species. Based on 23 years of data from the NOAA summer bottom trawl surveys (1993-2015) and satellite-derived environmental variables, we developed species distribution models to explore the rate at which the suitable habitat distribution of walleye pollock has shifted under recent historical climate change, i.e., its bioclimatic velocity. Our approach accounts for the important element of climate connectivity between past and current habitats by identifying the speed and direction of change in suitable habitat over time. When interpreted within the context of species' exposure and sensitivity to climate change, our results can help inform current conservation and management practices in the region, and improve future predictions of this economically and ecologically important species.

November 8, 16:40 (S5-11142)

Forecasting the flock: Using species distribution models to evaluate the effects of climate change on future seabird foraging aggregations in the California Current System

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Ocean management and conservation in the face of climate change depends on robust understanding of current relationships between species and their environment. This study built spatially-explicit models to identify multispecies seabird foraging aggregations ('hotspots') in the California Current System and assessed how locations may shift due to climate change. Models for 30 species were built and validated using 15 years (1997-2012) of seabird survey data from multiple cruises spanning the California Current combined with predictor variables derived from bathymetric and remotely-sensed oceanographic data as well as climate indices. We predicted species-specific relative densities during February, May, July and October under three scenarios: current conditions and increases of sea surface temperature (SST) by 0.6°C and by 2.0°C, based on ocean warming estimates from the Intergovernmental Panel on Climate Change 5th Assessment. For future scenarios, we assessed current relationships between SST, sea surface height (SSH) and chlorophyll-*a* concentration (Chl-a), and used these relationships to predict future SSH and Chl-a while increasing SST. Predicted relative densities were averaged across years, standardized and, based on predicted sensitivity to SST increases, species were split at the 50th percentile. Species in the upper 50th percentile were split further by foraging ecotype (diving foragers and surface feeders). Standardized predicted means were averaged by foraging ecotype to create scenario-specific multispecies hotspot maps by month. Results suggest suitable foraging habitat will shift offshore and north, diving and surface feeders will be the most sensitive to a changing climate, and some seamounts may retain suitable habitat in the future.

November 8, 17:00 (S5-10967)

Adaptive improvement of habitat suitability index (HSI) model for neon flying squid in central North Pacific by using ocean forecasts and real-time fishery reports

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The neon flying squid (*Ommastrephes bartramii*) has a wide-spread distribution in subtropical and temperate waters in the North Pacific, which plays an important role in the pelagic ecosystem and is one of the major targets in Japanese squid fisheries. We have constructed a habitat suitability index (HSI) model for neon flying squid using the Japanese commercial fishery dataset collected during 1999-2012 and 4D-VAR ocean reanalysis data set FORA. Also, we have developed a 4D-VAR ocean data assimilation system "SKUIDS" (Scalable Kit of Under-sea Information Delivery System) for forecasting ocean environmental changes in the summer fishing ground located in the central North Pacific (35-45N, around the date line). By using the HSI model and SKUIDS, we have produced daily HSI maps of the neon flying squid and provided them to the Japanese commercial vessels in operation. In this study, we developed a method of an adaptive improvement of HSI model by using real-time daily fishery reports provided from the squid fishermen. The HSI model constructed in advance were sequentially modified in operation. We investigate the HSI model performances before and after modification and compare them. The remarkable improvement can be seen in the sequentially modified HSI model in which the information of ocean environments in the actual fishing ground was reflected. The results suggest that the adaptive modification of the HSI model could be practically useful for the accurate estimate of the potential fishing zone.

November 8, 17:20 (S5-11364)

Use of a potential habitat model to reduce uncertainty in surveys of Pacific sardine

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Estimating the abundances of mobile and patchily distributed fish populations requires judicious use of resources. In 2011, a model of the potential habitat of the northern stock of Pacific sardine off the West coast of the US was created to better guide the sampling effort during surveys using acoustic-trawl and daily egg-production methods. Using a 12-year data set of sardine presence and satellite-derived environmental data, the model indicated that sampling efforts could have been better allocated if only regions deemed statistically likely to include sardine were surveyed. Increased sampling effort in areas potentially including sardine reduces both sampling bias and variance. Since 2012, spring surveys for Pacific sardine have been designed with consideration of near real-time potential habitat maps, moving away from the traditional fixed-area approach. Due to the variable environment in the northeast Pacific during 2011-2016, the potential habitat model results motivated the sampling of considerably different survey areas, year-to-year. This strategy was particularly beneficial during this period when the sardine population and its migration contracted. If the survey sampling had not been guided by the results of the potential habitat model, then the population would not have been sampled with the traditional fixed-area design, and the results of the spring 2015 and 2016 surveys would have erroneously indicated undetectable population abundances. We conclude that when sampling highly mobile and patchy populations, habitat-based survey designs mitigate potential bias due to changes in environmentally-driven population distributions. This is especially important when populations are small and sampling resources limited.

November 8, 17:40 (S5-11353)

Integrating species environmental thresholds to explore species interactions and parameterize multi-species models

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Projected climate change will influence the distribution of species, alter competitive and predatory interactions, and shift the volume and configuration of marine environments. Individual species respond in distinct ways that present implications for species interactions. Predicting responses to climate-driven change requires knowledge of habitat associations, resource preferences, and environmental tolerances. This paper presents an approach to estimate climate impacts on the spatial distribution of species and relative volume of distinct marine habitats in the Bering Sea. Our approach extends the habitat envelope approach to evaluate species distributions over cold and warm phases and to develop models that consider the influence of multiple environmental factors on the distribution of dominant fish in the ecosystem. Random forest approaches were used to determine the marginal importance of a suite environmental variables to the abundance of select forage and groundfish. A bootstrapped regression model was then applied to distinguish distinct breakpoints on variable gradients and determine threshold tolerances. Using a ROMS model, we defined habitat volume within distinct temperature tolerance ranges. We then applied covariates of habitat extent, range overlap, and prey availability to multispecies model hindcasts. This was used to evaluate the extent to which inclusion of environmental correlates improve fit and explain recruitment deviates as a function of density dependent constraints and competitive and predatory interactions. Results reinforce the importance of developing Species Distribution Models (SDMs) and demonstrate how integrating results with climate data might better inform shifts in habitat volume and species overlap in ways that improve stock forecasts.

S6: POC/MEQ/MONITOR/BIO Topic Session What Factors make or break Trophic Linkages?

November 8, 10:50 (S6-11058)

Response of commercial fisheries and a top predator to long-term ecosystem fluctuations in the western North Pacific Ocean off northeastern Japan

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An adequate understanding of the ecosystem state with respect to its historical change is important in evaluating the potential impacts of environmental and anthropogenic factors. We analyzed long-term commercial fisheries data and dietary records of northern fur seals (*Callorhinus ursinus*) to better understand the ecosystem changes in the western North Pacific off northeastern Japan. Fisheries in this region are highly diverse, deploying a variety of fishing methods and landing marine species spanning a wide range of trophic levels. Total commercial catches showed two peaks around 1960 and during the 1980s. Species composition of the catches changed over time being affected by many factors including large-scale environmental shifts. The shifts from "mackerel-dominant regime" in the 1970s to "sardine-dominant regime" in the 1980s resulted in large fluctuations in the mean trophic level of the catches. Impacts of fisheries on their ecosystem can be evaluated through the comparison of regional Ecopath models. Northern fur seals prey on pelagic, mesopelagic, and demersal fishes and squids during their winter migration. The standardized occurrence probabilities of fishes and squids in their stomachs revealed changes in prey abundance related to the decadal shifts in oceanographic regimes. Stable isotope analysis of the fur seal tissue samples demonstrated the top predator foraged at a lower trophic level during the "sardine dominant regime", suggesting simplification of the food web and shortening of the food chain. In contrast, prey diversity increased with the switch in fur seal diet from a predominance of pelagic fishes to various mesopelagic micronektons in the 1990s.

November 8, 11:10 (S6-11338)

Trophodynamic drivers of global fisheries catch

Charles A. **Stock**[1], Jasmin G. John[1], Ryan R. Rykaczewski[2], Rebecca G. Asch[3], William W.L. Cheung[4], John P. Dunne[1], Kevin D. Friedland[5], Vicky W.Y. Lam[4], Jorge L. Sarmiento[3] and Reginald A. Watson[6]

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Photosynthesis fuels marine food webs yet differences in fish catch across marine ecosystems far exceed differences in net primary production (NPP). We examine drivers of this contrast by combining global fish catch and fishing effort data with outputs from a prototype high-resolution global Earth System Model (ESM). Stark inter-regional differences in fish catch per unit area can be explained with an energy-based model that a) considers dynamic inter-regional differences in benthic and pelagic energy pathways connecting phytoplankton and fish, b) depresses trophic transfer efficiencies in the tropics, and c) associates elevated trophic transfer efficiencies with benthic-predominant systems. Model catch estimates are generally within a factor of two of values spanning two orders of magnitude. The same mechanisms explaining dramatic regional catch differences in the contemporary ocean amplify projected catch trends relative to NPP, suggesting the potential for large regional catch differences under climate change.

November 8, 11:30 (S6-10947)

Juvenile Pacific Herring (*Clupea pallasi*) trophic linkages in the Strait of Georgia, British Columbia

Jennifer L. **Boldt**[1], Matthew Thompson[1], Chris Rooper[2], Chrys Neville[1], Doug Hay[3], Jake Schweigert[3], Rusty Sweeting[1], Jaclyn Cleary[1] and Marc Trudel[1]

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Pacific Herring (*Clupea pallasi*; herring) are an important prey species for a variety of predators, such as Chinook Salmon (*Oncorhynchus tshawytscha*). Herring are also important to First Nations communities and the commercial fishing industry. Annual recruitment of herring can vary substantially and new recruits can represent a large proportion of the adult population biomass, adding uncertainty to population estimates. Scientific literature provides increasing evidence that survival during early life history stages is important for determining fish survival and recruitment. Biotic factors that may affect juvenile herring abundance and distribution include zooplankton prey availability, abundance of predator and competitor species, and disease. Abiotic factors that may affect spawning times and distribution (advection) of larvae include changes in ocean temperatures, river discharge, and coastal circulation. Understanding how these factors affect herring recruitment and survival might improve forecasts of year class strength and knowledge about their role in the food web. We explored factors that may influence juvenile herring abundance and condition in the Strait of Georgia, British Columbia (BC), which may in turn affect recruitment to the adult herring population and prey availability to predators. Previous analyses indicated that age-0 herring abundance varied inter-annually with high abundances in recent, even-numbered years. Also, there was an increasing trend in fish condition during 1997-2010. We explored potential ecological and trophodynamic linkages between herring, their prey, predators, and the environment. Investigating the dynamics of ecological linkages among pelagic species will improve our understanding of these valuable species in BC's marine ecosystems.

November 8, 11:50 (S6-11168)

Role of small copepod in four genera (*Calocalanus*, *Clausocalanus*, *Farranula* and *Oithona*) in South China Sea fisheries resources conservation

Lianggen **Wang**, Feiyan Du, Xuehui Wang, Jiajia Ning, Yangguang Gu, Yafang Li, Xingxia Wang and Yuanyuan Zheng

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Small plegic copepod(<1mm in length) are the important diets of larval fish and some carnivorous or omnivorous macro-zooplankton. The relationships between four genera(*Calocalanus*, *Clausocalanus*, *Farranula* and *Oithona*) and larval fish, hyperiid and krill were analyzed on the net data obtained during seasons of 2013 and 2014. Four genera were 22.5% of zooplankton in individual number. The first dominant species of every genera were *Calocalanus styliremis, Clausocalanus furcatus, F. gibbula and O. plumifera* with high dominant index more than 33.6%. The abundance distribution of four genera and hyperiid, krill and larval fish were similar. The seasonal abundance distributions changed along with the surface current driven by monsoon reversal. The community structure of the four genera was affected by larvae of hyperiid, krill and fish. The result of GAM analysis showed that the abundance of larval fish was affected by *F. gibbula, C. styliremis*, *O. plumifera, O. tenuis* and *Clausocalanus minor*; the abundance of larval hyperiid was affected by *C. furcatus, C. laticeps, C. minor* and *C. arcuicornis*; the abundance of larval krill was affected by *C. furcatus, C. laticeps, C. minor*, *C. styliremis* and *O. plumifera*. The abundance of larval fish, larval hyperiid and larval krill could be predicted by those species in the four genera. It is concluded that the four genera would provide some food for some larval fish in South China Sea. The relationship between small copepod and hyperiid (krill) need future research.

November 8, 12:10 (S6-10981)

A comparison of trophic linkages across the PICES region, based on Continuous Plankton Recorder data

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The CPR Survey samples lower trophic levels at large spatial scales, with at least seasonal resolution. The time series is in its seventeenth year and long enough to compare with longer lived, higher trophic levels. Here we show examples of linkages between plankton and fish/seabirds and explore the role of ocean climate variability:

1. In the Aleutian Islands region between 2000 and 2012 the abundance of diatoms and large copepods have odd/even year cycles that demonstrate top down control by pink salmon. In years with a high pink salmon density, large copepods are significantly less abundant (presumably consumed by salmon) reducing the grazing pressure on diatoms which are consequently more abundant. The relationship between salmon and plankton appears to break down after 2012.

2. There are strong correlations between Cassin's auklet chick growth rates and zooplankton density near the breeding colony of the planktivorous seabird in northwestern BC. Timing and abundance of the larger lipid-rich copepods are influenced by SST, with variability in the time series between cold years such as 2008 (high chick growth), and warm years (influenced by El Nino or the Blob) such as 2005, 2010 and 2015 (low chick growth).

3. The abundance of small zooplankton and diatoms explains patterns of interannual variability in first year Pacific herring growth on the Alaskan shelf. Shifts in prey seasonality between warm and cold years suggest that young-of-the-year herring may grow better in warm years because the timing of key prey is a better match for their first feeding.

November 8, 14:00 (S6-11129)

Linear and non-linear responses of marine and coastal fish populations to physics and habitat: A view from the virtual world

Kenneth A. **Rose**

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Many issues related to effective management of marine and coastal areas require understanding of how physical dynamics (physics and habitat) can directly and indirectly (through lower trophic levels) affect the dynamics of fish and other consumers. Examples include climate patterns, spatial restrictions on harvest, and ecosystem restoration. The types of questions being asked increasingly require full life cycle (multi-generational) predictions and explicit consideration of spatial variation; indeed, the theory seems to be lagging the management demands. I review several modeling analyses that simulated population responses to changes in physics and habitat: sardine and anchovy in the California Current, delta smelt in the San Francisco Estuary, shrimp in coastal Louisiana, herring around the North Pacific, and spiny lobster in Florida Bay. The mix of types of perturbations and linear and non-linear responses will be synthesized to look for generalities. One generality already identified is the importance of knowing the movement cues and patterns of these consumers. Individuals respond by altering their movement, thereby making indirect effects resulting from the changed physics and habitat very important. Differences in movement responses greatly affect the magnitude and predictability of the population-level responses. Hopefully, by the time of the conference, my synthesis of these various modeling methods and results will enable discussion of some general conclusions, and I will also offer some ideas on the emerging field of "movement ecology" and its important role in assessing physics and habitat changes on fish and shellfish populations.

November 8, 14:20 (S6-10872)

Effects of freshwater discharge and tidal currents on zooplankton aggregations in the coastal Sea of Okhotsk

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The Sea of Okhotsk hydrography is changing as the result of rapid regional warming and freshening. Academy Bay and the Shantar Archipelago in the northwestern Sea of Okhotsk are well known feeding grounds for bowhead whales. We studied the physical and biological oceanographic characteristics that make this Bay a lucrative feeding ground. Here we use CTD casts, Argos drifters and mooring data collected in 2003, 2004 and 2013 to examine the relationship between hydrography and the aggregation of the dominant zooplankton species (copepods *Calanus glacialis* and pteropods *Limacina helicina*), focusing on a significant hydrological freshening event that occurred in 2013 coastally in the Sea of Okhotsk. Variation in tidal and subtidal advection of Okhotsk Sea shelf water with high salinity (density) that contained copepod and pteropod aggregations was the most important process influencing variation in plankton concentrations. Cross-isobaths compression of copepods coupled with the maintenance of their vertical position due to sinking is proposed as the main mechanism that results in zooplankton accumulation on the bottom slope. Data collected in 2013 indicate that the upper layer of the Okhotsk Sea was ~ 4–5 psu fresher than in 2004, and this was associated with a major freshwater discharge event in 2013. Here we show that this reduction of salinity is accompanied by a significant decrease in abundance of copepods and pteropods in the Bay. We surmise that freshening and strengthening of the coastal circulation is the major cause of the reduction of zooplankton abundance.

November 8, 14:40 (S6-11284)

Cryptic trophic connections to juvenile salmon survival are revealed by a zooplankton time series

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A copepod community time series from the Strait of Juan de Fuca (between the U.S.A. and Canada) shows strong, linear correlations with survival of coho salmon (*Oncorhynchus kisutch*) that return to Puget Sound, Washington. The correlations are of interest to fisheries managers, but the mechanisms driving the copepod community variance and their link to coho survival are not clear. Mysteriously, an important component of the correlation is an even-odd or "see-saw" pattern in the copepod community composition and in coho salmon survival (higher in even years) that is not related to any known physical or chemical change in the environment. That pattern seems to be controlled by competition and predation within the trophic web, and is not likely a direct link from the copepods to the salmon since copepods are not a primary component of juvenile coho diets. Instead, the relationship may indicate an indirect link that is controlled by the abundance of other fish in the system, and their selective feeding on components of the zooplankton community. The relative abundance of juvenile herring from the Strait of Georgia (Canada) also shows a see-saw pattern, suggesting that multiple fish species may be linked to the copepod time series through dietary overlap and/or direct predation. In this presentation, we will explore the patterns and linkages among the trophic levels in an attempt to draw a mechanistic connection between the copepod time series and salmon survival.

November 8, 15:00 (S6-11123)

New insights on the trophic diversity of pelagic "forage species" in the central North Pacific and Northern California Current ecosystems

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Determining and ranking the importance of predator-prey interactions to characterize the overall flow of biomass and energy within a system is a central tenet of ecosystem-based fisheries management. Managers and ecologists are increasingly challenged by this task for vast pelagic ecosystems from which a large global majority of marine fish species are commercially harvested. Traditionally, pelagic forage species have been identified using a combination of gut content analyses and midwater trawling inventories. Both of these approaches favor the inclusion of structurally robust organisms or those with remnant hard parts (e.g., otoliths, vertebrate, beaks) such as fishes and squids. Here, we take a relatively novel approach to monitor important trophic linkages within two important Pacific Ocean pelagic ecosystems. In the central North Pacific (waters around Hawaii), we use the abundant midwater predator, longnose lancetfish (*Alepisaurus ferox*), as a high-resolution, multi-year biological sampler of midwater communities. In the northern California Current (waters of Monterey Bay), midwater community survey and collection methods center on multi-decadal, remotely operated vehicle video operations. Combining key findings from both approaches, we evaluate the long-term stability of the pelagic forage base by linking to other subtropical Pacific ecosystem work, and along the way expand traditional ideas of important pelagic "forage species" to include commonly overlooked soft-bodied dominants such as siphonophores, tunicates, medusae, polychaetes, among others. Before reaching a holistic understanding of how large pelagic ecosystems respond to climate variability and anthropogenic forcing, a more detailed understanding of the overall trophic structure is needed.

November 8, 15:20 (S6-11264)

Modeling recruitment variability of Pacific saury (*Cololabis saira*) using an individual-based model

Hitomi **Oyaizu**[1], Satoshi Suyama[2], Shin-ichi Ito[1], Daisuke Ambe[3], Takahiko Kameda[3], Takeshi Terui[4], Michio J. Kishi[5] and Sachihiko Itoh[1]

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Pacific saury (*Cololabis saira*) is a commercially and ecologically important pelagic fish in the North Pacific. Fishing pressure from countries along the western North Pacific is recently increasing and thought to influence the stock abundance. However, the variability in stock abundance cannot be explained solely by fisheries catch. The recruitment rate shows marked interannual fluctuations, which are likely related to the environmental variability in both the spawning and feeding grounds. In the present study, an individual-based model combining a bioenergetics model and migration model is used to examine the recruitment variability of Pacific saury. We parameterize the mortality rate with the length, weight, condition factor and instantaneous growth rate and test the performance of each parameterization by comparing the model and observation results. The growth-rate frequency distribution of the high-growth-rate group and their growth trajectories in the model are generally consistent with those estimated from the field samples. In the presentation, we will show how the recruitment variability is explained by each parameterization and compare the model results with existing hypotheses on saury recruitment.

November 8, 15:40 (S6-11119)

A comparison of Bering Sea ecosystem energy pathways in warm versus cold years

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In the Bering Sea, variability in ecosystem energy pathways is strongly influenced by interannual variability in physical factors such as temperature and stratification. In particular, earlier sea ice retreat coupled with warmer waters leads to later phytoplankton blooms that favor pelagic energy pathways over benthic ones. Here, we look more closely at the mechanistic linkages connecting physical factors to primary and secondary production, and to growth and recruitment of forage fishes in the Bering Sea. We do so using a set of coupled models: the Bering 10K ROMS domain, which simulates physical dynamics using a 10-km-resolved regional ocean model; the BESTNPZ (Bering Ecosystem Study NPZ) biogeochemical model, which simulates nutrient and energy exchange between primary producers, detrital and benthic pools, and zooplankton; and the FEAST (Forage and Euphausiids in Space and Time) model, which simulates the bioenergetics, predator/prey interactions, and fisheries losses for several forage fish species. The Bering10K-BESTNPZ-FEAST complex is run for two one-year simulations, representing a warm year (2005) and a cold year (2009), with a focus on comparing the magnitude and timing of primary production and propagation of that production to higher trophic levels.

November 8, 16:20 (S6-10974)

Caught in the middle: Top-down impact of seabirds on Chinook salmon (*Oncorhynchus tshawytscha*) is dependent on bottom-up mechanisms

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Many marine predators are capable of switching prey or foraging areas in response to changes in available forage. For waters of coastal central California from 1983-2012, we related time series of environmental conditions, forage species availability, juvenile Chinook salmon (*Oncorhynchus tshawytscha*) survivorship, and the abundance of a predator, common murre (*Uria aalge*), to show that prey switching can have significant consequences to salmon. 85% of common murre prey by number is young-of-the year rockfishes (*Sebastes* spp.) and adult northern anchovy (*Engaulis mordax*) and there is dramatic switching between the two (r = -0.94) when regional oceanographic conditions transition to less productive respectively. During less productive oceanographic conditions (e.g., weak upwelling), common murre foraged closer inshore and in larger aggregations, where they preyed predominantly on adult northern anchovy but as a consequence consumed juvenile salmon at a rate as great as 9%. Thus, out-migrating juvenile salmon on the shelf during such years were subject to significantly increased predation rates and significantly reduced population survival. These results support earlier findings that show timing and strength of upwelling, and the resultant forage assemblage, is related to Chinook salmon recruitment variability in the CCE, but here we demonstrate the significant top-down impacts associated with these bottom-up dynamics. We also provide valuable insights into connections between the physical environment in marine and freshwater systems and the CCE food web, which can be used to parameterize ecosystem models and develop benchmarks and thresholds to evaluate likely outcomes of ecosystem-based management options.

November 8, 16:40 (S6-10969)

Shoreward intrusions of Kuroshio waters may influence the recruitment of a top predator in river ecosystems

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Top predators play vital roles in ecosystems. The Japanese eel, *Anguilla japonica*, is considered to be one of these predators in river ecosystems of Japan and is of economic importance in East Asian fisheries. In early life stages, they are transported near coastal habitats by the Kuroshio. Mechanisms involved in the recruitment of juveniles (glass eels) from this current remain unknown. Shoreward migration of the early life stages of marine fish species reportedly occurs with warm water intrusions from the Kuroshio, although clear relationships have not been demonstrated. This study therefore aimed to elucidate the relationship between recruitment of *A. japonica* glass eels and shoreward intrusions of Kuroshio current waters. As a proxy for the recruitment of glass eels, catches in Lake Hamana, which is an estuary on the southern coast of Japan, from the 1965-2014 fishing seasons (December-April) were used. When a westward intrusion of Kuroshio water occurs coastally, it raises the water temperature at Shirahama, located east of Lake Hamana, and consequently increases the water temperature difference between Shirahama and Lake Hamana. As a proxy for the intrusions of Kuroshio waters, the mean water temperature differences between these sites during fishing seasons were used. The catch of glass eels tended to be greater when the mean water temperature difference was greater, suggesting detrainment and shoreward migration of glass eels from the Kuroshio through the warm water intrusions. The shoreward intrusions of Kuroshio waters may thus influence river ecosystems by supplying juvenile top predators into coastal and estuarine waters.

November 8, 17:00 (S6-11078)

Temporal variability of net primary production drives global patterns of structure and function across multiple marine ecosystems

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Primary productivity is generally considered to be an important driver of ecosystem structure and function. To investigate this relationship, we derived ecosystem-wide estimates of net primary production (NPP) from satellite data and compared them to estimates of biomass, a measure of ecosystem-level structure and function, for these same ecosystems based on trophic models of energy inputs and storages (Ecopath). Our analysis was based on 42 ecosystems across all oceans of the world, spanning 130˚ of latitude, and including multiple ecosystem types (reefs, upwelling, estuaries, shelfs, open ocean). Contrary to expectations that average NPP plays a dominant role in driving ecosystem dynamics, biomass showed a weak positive relationship with average NPP (R^2 = .18), but stronger unimodal relationships with interannual (R^2 = 0.27) and seasonal variability (R^2 = 0.4) in NPP, peaking at intermediate levels. These patterns suggest that temporal variability of NPP affects ecosystem structure and function in a way that is independent and potentially more important than average NPP. Results also indicate that there are universal energetic principles that drive ecosystem structure and function despite major environmental differences between systems. We used three earth system models to derive measures of oceanic NPP along with a three-dimensional model calculated from the combined relationships between biomass, and interannual and seasonal variability (R^2 = 0.46) to estimate global distributions of biomass. The predictive model was applied to future emissions scenarios to predict spatial patterns in biomass trends over the next century. These models predict large-scale ecosystem change in the Arctic, north Atlantic, equatorial Pacific, and Indian oceans.

November 8, 17:20 (S6-11175)

Suboptimal thermal conditions and spatial mismatch between predators and prey and may limit walleye pollock growth under climate change.

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Taxonomically disparate, non-linear relationships among physical conditions and marine species, ecosystem structure, and productivity portends dynamic and complex responses to future climate conditions, particularly in arctic and subarctic systems where climate change is expected to have the strongest effects. Because species exhibit differential response to changing conditions, climate change has the potential to induce mismatch between predators and prey production rates. We used multiple future projections of physical conditions and lower trophic level productivity in the Bering Sea (AK) under climate change to evaluate the bioenergetic scope for growth of juvenile walleye pollock (*Gadus chalcogrammus)*. While net production of zooplankton prey was high under future conditions, our projections portend marked reductions in future growth potential over the next 50-100 years due to (1) suboptimal thermal conditions for pollock growth and (2) spatial mismatch between hotspots of zooplankton prey and focal areas of pollock growth. In contrast, hindcasts of physical conditions and prey exhibit reveal multiple years of widespread pollock growth potential across the Bering Sea shelf. These results highlight the potential for phenological and spatial mismatch between marine consumers and lower trophic production under climate change.

November 8, 17:40 (S6-11302)

Comparing the roles of physical context and food web structure among continental shelf ecosystems using intermediate complexity end-to-end models

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A major feature distinguishing the dynamics of different shelf ecosystems is the physical context and its role in regulating the productivity and resilience of trophic guilds. Physical fluxes determine nutrient input rates, export of plankton and detritus production, water residence times, and regulate nutrient recycling. How important is consideration of physical context relative to food web structure (composition and connectivity between trophic guilds) to understanding ecosystem dynamics and resilience? We apply a general physically coupled, intermediate complexity end-to-end model platform to study the dynamics of four representative continental shelf ecosystems: an eastern boundary upwelling system (Northern California Current), a coastal downwelling system (Coastal Gulf of Alaska), a shallow offshore system (Georges Bank), and a semi-enclosed system (North Sea). Each differs in food web structure and the rates and relative importance of advection and mixing exchange within and across ecosystem boundaries. A common trophic guild definition was applied to each food web, from independently published sources, to allow direct comparisons. We tested the null hypothesis that within similar physical environments there are no significant differences among ecosystems with respect to the productivity of trophic guilds nor response to physical perturbation. We find that under set assumptions of detritus recycling and zooplankton migration, rates of physical flux of nutrients into and plankton export from each ecosystem have large consequences for productivity across all trophic levels and the resilience of whole ecosystems. Simulations also indicate that food web structural differences do play a role in trophic guild response to alternate physical settings.

S7: POC/TCODE/MEQ Topic Session New Stage of Ocean Acidification Studies: Responses of Oceanic Ecosystem including Fisheries Resources

November 8, 10:55 (S7-11383)

Ocean acidification: What can species responses tell us about ecosystem consequences?

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As carbon dioxide (CO_2) enters the oceans it reacts with seawater driving a series of chemical changes; reduced pH (acidification), increased levels of dissolved CO_2 (hypercapnia) and reduced carbonate saturation states. These changes, collectively known as “Ocean Acidification” or OA, have accelerated as atmospheric CO_2 levels have increased. Once these long-term changes in marine carbonate chemistry were recognised, their potential impacts on marine organisms became the focus of international research. It is now clear that OA can impact significantly upon the health and function of many marine organisms. In particular, biological processes such as acid-base balance, calcification, growth, reproduction and immune function have been shown to be strongly affected. All of which could have a significant impact on the functioning of individuals and the long-term sustainability of populations. In addition to these direct effects, there is growing evidence that ocean acidification can affect the biological processes which control animal behaviour and the interactions that occur between predators and prey. It is clear that these changes could also lead to significant changes in the structure and function of marine communities and ecosystems. This has prompted new efforts to scale up this wealth of information on individual species or processes to predict the impacts of OA on whole ecosystems. This presentation will introduce some of the experimental and modelling approaches now being employed to try and achieve this scaling up.

November 8, 11:25 (S7-11170)

Coastal zone acidification and bivalves: Carbonate chemistry complexity, high frequency variability, and organism interactions, oh my!

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Acidification in the coastal zone continues to receive growing attention due to the reliance of many marine resources on the near-shore and complexity in understanding biological-chemical interactions. While some disagreement remains about the importance of acidification in some systems, failure to embark upon the research challenges presented by this global effect acting locally will put critical resources at risk. In this talk I will present three brief examples of work within my group addressing the challenges of understanding the effects of an increasing baseline of anthropogenic carbon in estuarine environments. First, the immediate challenges with interpreting biocalcification responses to experimental manipulations will be presented. By re-interpreting existing experimental data I will differentiate responses of biocalcification to saturation state with respect to calcium carbonate and the substrate-inhibitor ratio, SIR (or $[HCO_3^-]/[H^+]$). These two values are typically perfectly correlated due to the thermodynamics of the marine carbonate system. Initial analysis of existing data suggests, in bivalves, saturation state and not SIR is controlling calcification rates. Next, a model we have termed OASIS (Ocean Acidification Stress Index for Shellfish) will be presented that predicts survival of Pacific oyster (*Crassostrea gigas*) larvae in a hatchery setting exposed to naturally variable conditions. The potential applicability of model application to high-frequency monitoring data will be discussed. Finally, field data of high-frequency P_{CO2} measurements within and outside seagrass beds, and concurrent growth experiments with juvenile Pacific oysters will be presented that illustrates the positive benefits of seagrass on oyster growth and complex P_{CO2} dynamics within these habitats.

November 8, 11:55 (S7-11146)

Effects of ocean acidification on temperate coastal marine ecosystems and fisheries in the Northeast Pacific

Rowan Haigh[1], Debby Ianson[2], Carrie A. **Holt**[1], Holly E. Neate[1,3] and Andrew M. Edwards[1,3]

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The northeast Pacific Ocean has naturally relatively acidic waters due to ocean circulation, and so may be particularly vulnerable to ocean acidification (OA). Fisheries in this region play key economic and cultural roles and provide significant employment, especially in rural areas. Although direct impacts on a variety of commercially important species have been assessed extensively, the indirect impacts across trophic levels have not been synthesized. We analyzed available data up to 2014 to provide a description of the marine ecosystem, focusing on vertical distributions of commercially harvested groups in the context of local carbon and pH conditions. We then evaluated the potential impact of OA on this temperate marine system using available studies. Our results highlight significant knowledge gaps. Above trophic levels 2–3 (where most local fishery-income is generated), little is known about the direct impact of OA, and more importantly about the combined impact of multi-stressors, like temperature, that also varies as our climate changes. There is evidence that OA may have indirect negative impacts on finfish through changes on lower trophic levels and habitats, and through increasing the prevalence of fish-killing algal blooms that can affect the lucrative salmon aquaculture industry. On the other hand, some species of locally farmed shellfish have been well-studied and exhibit significant negative direct impacts associated with OA, especially at the larval stage. We summarize the direct and indirect impacts of OA on all groups of marine organisms in this region and provide conclusions, ordered by immediacy and certainty.

November 8, 14:00 (S7-11279)

The 2016 NOAA west coast ocean acidification cruise

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The NOAA Ocean Acidification Program (OAP) West Coast Cruise, conducted along the west coast of North America during the spring of 2016, revealed oceanographic conditions that varied significantly from our previous NOAA ocean acidification cruises. Starting in late 2013, open-ocean surface waters in the northeast Pacific began to warm up by as much as 2–3 °C above normal due to the lack of strong storms and subsequent cooling. This warm pool, commonly known as "the Blob," lasted throughout all of 2015 and into early 2016. Within the Blob open-ocean pCO_2 values were generally about 40–50 µatm higher than normal. In the coastal region, the sea-surface temperature (SST) values were generally lower in the latter half of 2013 and early 2014 due to coastal upwelling, but that changed in the late summer and fall of 2014 when the coastal waters also had anomalously high SST values as a result of the Blob moving onshore and warming the subsurface waters. By spring of 2016, the very high SST anomalies had dissipated but the surface and subsurface waters generally remain warmer than normal by 1-2°C. Corrosive waters off California were shallower than 75 m in all near-shore waters north of Monterey Bay. However, corrosive, low pH waters (Ω_{ar} < 0.9; pH < 7.7) reached the surface at the innermost station near the entrance to San Francisco Bay due to strong winds favorable to upwelling. On our OAP cruises, this is the furthest south we have observed corrosive waters at the surface.

November 8, 14:20 (S7-11108)

Respiration and enhanced ocean acidification in the hypoxic zone off the Changjiang estuary

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This study examines the interplay between the respiration and ocean acidification in a hypoxic zone off the Changjiang estuary in the East China Sea. Based on five cruises conducted off the Changjiang estuary in April, June, July, August and October 2011, with the strategy of better defining the evolution of the hypoxia, we observed seasonal variations in both dissolved oxygen (DO) and pH_T (total scale, 25°C) in the subsurface water. The hypoxic (or low DO) center was located at 123°E, 31°N with its bottom DO of 2.07 mg L^{-1} in August, which was a big contrast to the DO level of 8.34 mg L^{-1} in April. Accompanied with the hypoxia was the decrease of the bottom pH_T from 8.08 in April to 7.68 in August. Both the variations in DO and pH_T were closely related to the aerobic respiration of organic material. Indeed, the subsurface community respiration rate increased from 0.3-1.0 μmolO_2 L^{-1} day^{-1} (in April) to 1.4-6.5 μmolO_2 L^{-1} day^{-1} (in August) around the hypoxic (or low DO) center. In order to examine in a quantitative way how the respiration affects ocean acidification, or pH_T decrease, a simple pH_T-DO simulation model under pre-industrial, present and future CO_2 scenarios was adopted. The results suggested pH_T decrease induced by the uptake of anthropogenic CO_2 was 0.138 units from pre-industrial era to present day, which would further increase to 0.230 units by the year 2100. In the DO-depleted scenarios, the maximal pH_T-drops mediated by aerobic respiration were 0.336 to 0.402 and to 0.489 units for pre-industrial era, present day and year 2100 respectively. If we considered the stimulation of elevated temperature on respiration (Q_{10}=3) and assumed that DO would not be depleted due to limited water residence time (40 days), the subsurface pH_T would drop by another 0.21 units due to respiration in the future compared with the present. These results suggest that in the future, more pH_T-drops would be caused by elevated aerobic respiration activity and high CO_2 levels. The coastal water off Changjiang estuary will become more vulnerable to hypoxia and ocean acidification in the future.

November 8, 14:40 (S7-11228)

Ocean acidification and increased temperatures reduce young-of-the-year red king crab (*Paralithodes camtschaticus*) survival, but not growth or morphology

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Multiple stressor studies are needed to better understand the effects of oceanic changes on marine organisms. To determine the effects of near-future ocean acidification and warming temperature on young-of-the-year red king crab (*Paralithodes camtschaticus*) survival, growth, and morphology, we conducted a long-term (184 d) fully crossed experiment with two pHs and three temperatures: ambient pH (~7.99), pH 7.8, ambient temperature, ambient +2ºC, and ambient +4ºC, for a total of 6 treatments. Mortality increased with both reduced pH and by higher temperatures, but interpretation of the multistressor effects is not straightforward as a clear trend was not observed. A synergetic effect was observed; the pH 7.8 and ambient +4°C temperature treatment had the lowest survival, with only 3% surviving to the end of the experiment. However, antagonistic effects were observed in the pH 7.8 ambient +2°C temperature treatment; the mortality in this treatment was less than the mortality of each of the stressors individually. Despite the effects on mortality, neither decreased pH nor increased temperature had an effect on growth or morphology. The results of this study combined with other studies suggest that ocean acidification and warming may have profound negative effects on red king crab populations in the upcoming decades unless the species is able to quickly adapt or acclimate to changing conditions.

November 8, 15:00 (S7-10998)

Interactive effects of ocean acidification and ocean warming on Pacific herring (*Clupea pallasi*) early life stages

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The synergy of ocean acidification and warming may lead to negative marine organism responses not apparent under single climate change stressors. While adult fish are effective acid-base regulators and presumed to be less affected by environmental stressors, early developmental stages may be more susceptible. Pacific herring are ecologically and economically important forage fish native to the U.S. Pacific Northwest. My study focused on the combined effects of ocean acidification and ocean warming on Pacific herring embryo and larval development. Pacific herring embryos were incubated under temperature (13°C, 19°C) and ambient (~ 400 ppm), moderate (~ 800 ppm), and high (~ 1600 ppm) pCO_2 treatments. Development was monitored during a two-week period and hatched larvae were preserved to determine length and weight measurements. The combination of high pCO_2 and high temperature may reveal greater developmental aberrations previously not observable under single stressors. Preliminary observations indicate herring reared under high pCO_2, for both temperature treatments, experienced delayed hatching compared to herring reared in the ambient and moderate pCO_2 treatments. This study will further aid our understanding in how interactive environmental stressors affect Pacific herring embryology and future herring populations.

November 8, 15:20 (S7-10934)

Nutritional and ocean acidification effects on larval growth of a North Pacific flatfish

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Multiple aspects of climate change are expected to co-occur such that ocean acidification will take place in conjunction with warming and a range of trophic changes. Previous studies have demonstrated that nutritional condition plays a significant role in the responses of invertebrates to ocean acidification, but similar studies have yet to be conducted with marine fishes. In this study, we examined the potential interactive effects of elevated CO_2 levels and nutritional stress on the growth and development of northern rock sole (*Lepidopsetta polyxystra*). Separate experiments examined the effects of these two environmental stressors during the pre-flexion (3-31 days) and post-flexion (31-87 days) larval stages. In both stages, larval feeding regime has a much larger impact on growth rates than did CO_2 level, and there was no observed interaction between stressors. By 31 days post-hatch, larvae in the high feeding treatment were 84.2% heavier than the fish in the low feeding treatments, but there was no significant effect of CO_2 level on body size or condition. While overall growth rates were faster during the pre-flexion stage, the effects of food limitation were greater for post-flexion larvae undergoing metamorphosis, with high feeding treatment fish being 3.3 times as heavy as fish in the low feeding treatments. These results have important implications for understanding the impacts of the multi-faceted nature of climate change on population productivity of commercial fish species in the North Pacific.

November 8, 15:40 (S7-11068)

Identifying potential ecosystem effects of ocean acidification using size structured food web models

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In the last decade progress made in terms of quantifying the effects of ocean acidification (OA) on individual-level parameters (e.g., body growth and survival rates), but modeling approaches are needed to scale empirical results up to populations and food webs and to evaluate potential changes in the ecosystem services they provide. Here, we use a model of intermediate complexity, a multispecies size-spectrum model, to evaluate the effects of OA on one of the most productive shelf systems in the world, the Eastern Bering Sea. Size spectrum models are based on the observation that marine predators generally consume smaller sized prey. Importantly, system dynamics emerge from individual-level processes (growth, predation, survival, reproduction) that are determined by a small set of parameters that can be tuned to reflect OA scenarios. The models offer a strong conceptual framework for linking OA impacts on individual-level parameters to food web-level consequences. We formulated three sets of OA hypotheses to examine using the model: OA will (1) alter phytoplankton productivity and size structure; (2) reduce the productivity of zooplankton and benthic invertebrates with calcifying body parts; and (3) exact higher metabolic demands on certain fish species. We show the individual and interactive effects of the hypotheses on emergent properties of the food web (e.g., community size structure, species diversity) and on the harvest of economically important flatfishes and gadoids. Predicting OA impacts on food webs remains a daunting challenge, but size-based models offer promising strategic tools that may aid decision making under future climate conditions.

November 8, 16:20 (S7-11412)

Ocean acidification research in the United Kingdom: Scaling from chemistry to commercial fisheries

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Scientific work on ocean acidification is being carried out by a wide range of UK research centres, university groups, and government bodies. In 2010 most of that effort was brought together under the UK Ocean Acidification (UKOA) research programme, a £12.4 million, five-year initiative funded by Defra, DECC and NERC. In this invited talk, we review the main outputs from this integrated programme as well as subsequent work (the PLACID initiative) that has aimed to sustain monitoring programmes and to investigate consequences for commercial shellfish.

Both observations and modelling show that seawater CO_2 levels vary over an annual cycle between 200 – 450 ppm and collated measurements seem to suggest a long-term decline in pH over the past 30 years, whereby North Sea pH has decreased at a rate of around 0.0035 pH units per year. A coupled physical-ecosystem model was used to project future values for pH and aragonite saturation state for the North Western European Shelf and this suggests that surface waters will start to become under-saturated gradually from around 2030 and more rapidly from 2080. Laboratory experiments have been conducted on a wide variety of commercial shellfish species (lobsters, scallops, cockles, whelks) to determine possible vulnerabilities. This has revealed that some commercial species seem highly sensitive whereas other are robust. This talk will conclude with a description of recent modelling activities that have aimed to ‘scale up’ from laboratory experiments to consequences for populations, food-webs and fisheries. We provide estimates of regional and national economic impacts for the UK aquaculture and fisheries sectors.

November 8, 16:50 (S7-11239)

Effects of ocean acidification on growth of juvenile Japanese surf clam *Pseudocardium sachalinense*

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Many previous studies have reported that ocean acidification could give negative influence on marine calcifiers. However, the influences of ocean acidification on edible marine species, especially on cold-water species, are poorly understood. We therefore studied the effects of five levels of pCO_2 (400, 600, 800, 1,000, and 1,200 µatm) during 20 weeks on stable isotope compositions of shell and growth in juvenile Japanese surf clam. The clam is important in local fisheries and inhabits on the upper subtidal sandy bottom in northern Japan. Stable carbon isotope composition (δ13C) of the shells collected from the external margin of the outer shell layer showed significant positive correlations with pH ($R = 0.56$, $p < 0.05$). The regression slope of the relationship between shell δ13C and pH was roughly the same as that between δ13C of dissolved inorganic carbon (DIC) of seawater and pH, and calcification of the experimental specimens might strongly affected by acidified seawater. Thus, by measuring δ13C of molluscan shell and DIC of seawater, it might be possible to estimate the contribution of acidified seawater to calcification. We found no significant effect of elevated CO_2 on weight (whole body, shell, and soft tissue), shell length, shell width, and shell height during experiments. However, shell thickness at a region that grew during experiments thinned in a pCO_2-dependent manner. These results suggest that Japanese surf clam with thinner shells likely to be more vulnerable to fracture under ocean acidification and predation. Therefore reduction of the clam population in the future is concerned.

November 8, 17:10 (S7-11235)

Sustainability of crab fisheries with ocean acidification uncertainty in Alaska

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The long term sustainability of commercial crab stocks is uncertain as environmental variability in the eastern Bering Sea is expected to increase specifically due to climate change and ocean acidification. A multi-year laboratory study was conducted to assess the physiological response of southern Tanner crab (*Chionoecetes bairdi*) during early developmental stages to changes in pCO_2 (+440 µatm [-0.3 pH units] and +1,260 µatm [-0.6 pH units] from ambient) based on long term climate predictions. Response variables included embryological development; larval and juvenile survival, morphology, growth, and calcium content; and adult calcium content and hemocyte function. Most embryos failed to hatch in the second year of the study when exposure began during oocyte development. Similarly, larval survival decreased when the oocyte developmental stage was exposed to corrosive conditions. Growth, calcification, and survival were reduced at the juvenile stage. In adults, changes in hemocyte pH suggested increases in energetic costs associated with immune functions. Laboratory survival results were subsequently used to inform stock assessment and bioeconomic models to predict effects on biological and economic reference points. Low juvenile survival led to decreased estimates of mature biomass and a >50% decrease in catch and profits within 20 years after ocean acidification reaches levels that may affect natural mortality in the Bering Sea. Measuring basic physiological responses is necessary for predicting the sustainability of crab stocks and coastal fisheries as climate and ocean acidification changes increase in the North Pacific.

November 8, 17:30 (S7-11273)

Anticipated impacts of ocean acidification on local societies in Japan

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Ocean acidification has recently been shown to affect marine ecosystem services and human activities such as fisheries, aquaculture, tourism and recreation. However, the impacts are expected to differ between sites in Japan. For example, most of coral reefs exist in Okinawa Prefecture in which tourism is a major local industry. On one hand, around 50% of marine calcifiers and 60% of shellfish in Japan are caught or cultured in Hokkaido Prefecture where fisheries is one of the main industries. Thus ocean acidification may widen regional gaps of economic conditions and pose a social security threat in future by damaging specific local industries. Things might be further complicated because suitable habitats for the calcifiers are projected to become sandwiched between migrating northern and southern limits regulated by global warming and ocean acidification, respectively. To alleviate the anticipated impacts on local societies, community-based adaptive strategies as well as global mitigations are required,. These strategies will only be achieved after consensus building among various stakeholders including citizens, policy makers and both natural and social scientists.

S8: MoE/MEQ/TCODE Topic Session
The Effect of Marine Debris caused by the Great Tsunami of 2011

November 8, 16:25 (S8-10866)

Responding to the debris generated by the Great Tsunami of 2011

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The Great Tsunami of 2011 in Japan washed an unprecedented amount of debris into the Pacific Ocean. In the months after the tsunami, there was a growing concern about the impacts of the debris on North American shorelines. The NOAA Marine Debris Program led the coordination efforts in those early months and the following years to address those impacts. Federal, state, and local agencies as well as non-governmental partners and academia came together and made great strides to limit the effects on sensitive ecosystems from the debris as it arrived. Efforts focused on detection, modeling, monitoring, response planning, removal of debris and communication activities. The effort was greatly supported by the generous monetary gift from the Government of Japan. Important lessons were learned through about how to respond to significant debris events in the future. This work was the pre-cursor to the PICES project ADRIFT Funded by the Ministry of Environment of Japan.

November 8, 16:40 (S8-11193)

Drift simulation of Japan Tsunami Marine Debris (JTMD) as an application of data assimilation

Masafumi **Kamachi**[1], Hideyuki Kawamura[2], Yoichi Ishikawa[1] and Norihisa Usui[3]

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A drift simulation on the movement of the marine debris has been conducted by a Japan Modeling Group (JAMSTEC, JAEA, MRI) in order to examine the positions in the North Pacific, landing positions, and landing date on the coast after the Great East Japan Earthquake occurred on March 11, 2011. The simulation has been done under the Japan National Project and the MoE-PICES ADRIFT Project. The potential locations of the marine debris were determined using numerical simulations with an ocean data assimilation system MOVE/MRI.COM-WNP and –NP, a coupled atmosphere-ocean data assimilation system K7, and an ocean dispersion model SEA-GEARN. Data assimilation and dispersion methods, current and wind fields, effects of windage, and comparison with sighting observation will be reported.

November 8, 17:00 (S8-11242)

Modeling the drift of marine debris generated by the 2011 tsunami in Japan

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3 Japan Agency for Marine-Earth Science and Technology, Yokohama, Japan

More than five years after the 2011 Great Tohoku Earthquake in Japan, marine debris generated by the tsunami (JTMD) continues washing on shorelines of North America and Hawaii. A team of oceanographers at the University of Hawaii, US National Oceanic and Atmospheric Administration (NOAA) and Japan agencies (Meteorological Research Institute (MRI), Japan Agency for Marine-Earth Science and Technology (*JAMSTEC*) and Japan Atomic Energy Agency (*JAEA*)), supported by the Japan Ministry of Environment through a PICES project, used a suite of numerical models to interpret observational reports of JTMD boats, skiffs and small ships. By the end of 2014 the dataset included 277 reports from multiple sources at sea as well as from the coastlines of Japan, Canada and the United States. The core of the study comprised 79 boats that landed on the US/Canada west coast between 40 and 51N and were used to calibrate/validate three numerical models. By optimizing model parameters, we were able to successfully reproduce all major peaks of boats arrivals in the North American shores. This excellent correspondence between the models and observations allowed us to calibrate model solutions and estimate that approximately 1000 boats were lost at a time of the tsunami, out of which 60-70% were still floating in the ocean (mainly in the "garbage patch" area). Given a good condition of found boats, they will likely continue washing ashore for many future years. Also, new techniques developed in the project allowed us to estimate probable pathways of individual JTMD items.

November 8, 17:20 (S8-11073)

The NOAA Marine Debris Monitoring and Assessment Project: Four years of effort in the U.S. Pacific States

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The Marine Debris Monitoring and Assessment Project (MDMAP) is a citizen monitoring initiative that engages National Oceanic and Atmospheric Administration Marine Debris Program (MDP) partners and volunteers across the nation to report on the amount and types of marine debris on shorelines. Over four years of surveys following the earthquake and tsunami in Japan (March 2012 – February 2016), a total of 211,709 debris items were recorded at 91 sites on U.S. Pacific shorelines. Items that appear in the top ten list for surveys across all states include plastic rope and net, bottle/container caps, food wrappers, and plastic beverage bottles. On a per-survey basis, the greatest number of items was recorded on shorelines in Hawai'i compared to the other states. At 100-m accumulation survey sites, 862 items were recorded per survey in Hawai'i, roughly ten times more debris than West Coast sites and five times more than Alaska. In Alaska, California, and Oregon, plastic consumer items were at least twice as common as plastic fishing-related items. In Hawai'i, plastic fishing items were slightly more common than plastic consumer items, whereas in Washington there was an equal split between the two user categories. The MDP recently launched a "Get Started Toolbox" (https://marinedebris.noaa.gov/research/monitoring-toolbox) to assist volunteers with training, provide access to resources, and encourage the sharing of results. Programs such as MDMAP are useful for detecting the influx of debris from acute events, identifying targets for prevention, assessing the effectiveness of existing mitigation efforts, and as experiential outreach and education programs.

November 8, 17:40 (S8-10952)

The influx of marine debris to North American shorelines after the Great Tsunami of 2011

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Marine debris is one of the leading threats to the ocean and the Great Tsunami of 2011 washed away an estimated 5 million tons of debris in a single, tragic event. Anecdotal evidence suggests that there was a significant increase in debris landings to North American and Hawaiian shorelines. Here we used shoreline monitoring surveys, disaster debris reports and oceanographic modeling to investigate the timeline of tsunami marine debris. The increase in debris influx to surveyed North American and Hawaiian shorelines was substantial and significant, representing a ten-fold increase over the baseline at sites in Northern Washington State where a long term dataset was available. British Columbia, Canada and the Hawaiian Islands had the highest documented debris influx in the years after the tsunami. The cumulative debris influx at sites where monitoring and cleanup occurs represents more than 100,000 debris items over a three-year period. The tsunami event brought different types of debris along the coast, with high-windage items dominant in Alaska and British Columbia and large, medium-windage items in Washington State and Oregon. The peaks in measured shoreline debris match the predictions made by the oceanographic models. The impacts of Japan tsunami marine debris are unknown and long-term monitoring of coastal waters is required to detect changes resulting from the influx of debris itself and the nonindigenous species potentially introduced by the debris.

S11: POC Topic Session (Day 1)
Advances in Understanding and Modeling of Physical Processes in the North Pacific in the Past 25 Years of PICES and Future Directions

November 8, 10:50 (S11-11238)

Ocean mixing processes: Impact on biogeochemistry, climate and ecosystems

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Western north Pacific is one of most abundant ecosystem areas such as the largest biological CO_2 drawdown in the western subarctic Pacific and nursery grounds of many kinds of fish in the Kuroshio. Hypotheses have been proposed: vertical mixing in localized areas uplifts nutrients such as iron in the Kuril Straits and nitrate in the Tokara Strait and maintains the abundant ecosystems. Furthermore, bi-decadal variability of ocean, climate and ecosystem are beginning to be noticed to be related with 18.6-year period tide-induced vertical mixing variability. Ocean vertical mixing is the important physical process which controls vertical transports of heat, nutrients and carbonate materials and circulations of ocean and biogeochemistry and thus ecosystems. However, observations of vertical mixing are still quite limited. We need efficient observational system and develop numerical models with vertical mixing process and variability, and explore links between vertical mixing and various unresolved phenomena. Overview is presented for the 5-year Japanese project 'Ocean mixing processes: impact on biogeochemistry, climate and ecosystem (OMIX)' which are launched in July 2015.

November 8, 11:15 (S11-10991)

Oceanographic conditions facilitating the formation and propagation of a novel coccolithophore bloom in the Santa Barbara Channel

Paul G. Matson[1], Chris Gotschalk[2], Tanika M. Ladd[1], David A. Siegel[3], Libe Washburn[3] and M. Debora **Iglesias-Rodriguez**[1]

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The NE Pacific warming anomaly of 2014/2015, commonly referred to as "the blob", caused significant alterations in the marine environment along the western coast of the US. Specifically, a warming anomaly of up to +5 ºC, appears to be responsible for shifts in species composition and changes in ecosystem structure in the California Current. Following a harmful algal bloom, an unprecedented coccolithophore bloom with cell densities of up to ~6 $x10^6$ cells L^{-1} was observed within the Santa Barbara Channel (SBC) in early summer of 2015, causing striking changes in ocean color that were also detected by satellite-based remote sensing. This bloom was dominated by the most ecologically important coccolithophore - *Emiliania huxleyi*, a species that forms seasonal blooms that can occupy surface areas exceeding 100,000 square km, thus representing a significant global source of biogenic calcite. However, while typical of high latitudes both in the Atlantic and Pacific Oceans, these blooms have never been reported in the SBC or in coastal ecosystems along the California Current. This talk will discuss the likely causes of the SBC coccolithophore bloom and explore the role of circulation on the spatial and temporal propagation of this bloom using a combination of remote sensing, ocean moorings, high-frequency radar, microscopy, and flow cytometry.

November 8, 11:35 (S11-10971)

Long-term sea level variation in the Japan/East Sea from two decades of altimetry data

Olga **Trusenkova** and Dmitry Kaplunenko

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Long-term sea level variation in the Japan/East Sea (JES) is revisited using Ssalto/Duacs 0.25°-gridded sea level anomalies (SLA) for 1993-2013. To remove short-period variability, SLA were low-pass pre-filtered, with cut-off period of 1.2 years. The leading Empirical Orthogonal Function (EOF) mode derived from the low-frequency SLA accounts for ~50% of the total variance and captures simultaneous quasibiennial (QB) oscillations in the entire JES. Linear SLA trends estimated in every grid point are equal to 5-7 mm/year in the southern JES but only to 2-3 mm/year in the northern JES. They should be attributed to steric effects, mostly from warm water entering the Korea Strait. However, trends from EOF 1 are equal to 4.3, 2.0, 0.4, and 0.6 mm/year for 1993-1999, 1993-2004, 1993-2009, and 1993-2013, respectively. To separate variability time scales, intrinsic mode functions (IMF) are computed for EOF 1, using the Hilbert-Huang transform. IMF 1 captures the QB oscillations, IMF 2 shows weak variability before 2006 and the 5-year oscillation after 2006, and IMF 3 and the residual term together capture secular variation. Sea level in the entire JES increased at the rates of 5.7 and 4.5 mm/year in 1993–1998 and 2009−2013, respectively, but no trend was detected in 1999–2008. This pattern is different from the global mean increasing trend of 3.38 mm/year (http://www.aviso.altimetry.fr). Simultaneous SLA in the entire JES are caused by transport imbalance through the straits, which is non-uniform throughout the two decades, depending on variability of large-scale wind stress curl and sea level difference between the subtropical and subarctic Pacific.

November 8, 11:55 (S11-10965)

Long-term variability of surface nutrient concentrations in the North Pacific

Sayaka **Yasunaka**[1], Tsuneo Ono[2], Yukihiro Nojiri[3,4], Frank A. Whitney[5], Chisato Wada[4], Akihiko Murata[1], Shin-ichiro Nakaoka[4] and Shigeki Hosoda[1]

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We present spatial distributions and temporal changes of the long-term variability of surface nutrient concentrations in the North Pacific by using nutrient samples collected by volunteer ships and research vessels from 1961 to 2012. Nutrient samples are optimally interpolated onto 1° × 1° monthly grid boxes. When the Pacific Decadal Oscillation is in its positive phase, nutrient concentrations in the western North Pacific are significantly higher than the climatological means, and those in the eastern North Pacific are significantly lower. When the North Pacific Gyre Oscillation is in its positive phase, nutrient concentrations in the subarctic are significantly higher than the climatological means. The trends of phosphate and silicate averaged over the North Pacific are −0.012 ± 0.005 μmol/l/decade and −0.38 ± 0.13 μmol/l/decade, whereas the nitrate trend is not significant (0.01 ± 0.13 μmol/ll/decade).

November 8, 12:15 (S11-11022)

Mechanism of warming the Okhotsk Sea Intermediate Water, from consideration on the seasonal cycle

Makoto **Kashiwai**

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A 50-year warming trend was detected at the intermediate isopycnal surfaces of the western subarctic Pacific, which is strongest in the Sea of Okhotsk at the surface 26.9σ_0 and weakening though enough to be significant down to 27.4σ_0 (Nakanowatari *et al*., 2007). The cause of this trend was attributed to the decrease of dense shelf water production by anthropogenic warming. But this fails to explain an associated salinity increase to keep density at the same level. In this study, a new method was developed to identify forcing factors for watermass T/S changes using a ΔTS-diagram which illustrates a relationship among the time change vector of focal watermass and the T/S difference vectors between the focal watermass and the other interacting watermasses. This method was applied to the seasonal cycle of the Okhotsk Sea Intermediate Water (OKIW) ($\sigma_0 = 26.4$−27.1), identified as a physical entity using TσV analyses on WOA13 seasonal data. The major forcing factor for the T/S time change in summer, having the same direction as the interannual trend, was the mixing with Deep Water ($\sigma_0 \geq 27.1$). This result indicates that the upwelling Deep Water is mixing into the OKIW by vertical mixing at the entrance straits, and coincides with the results of Macdonald *et al*. (2009) that the downwelling and upwelling around the Sea of Okhotsk meet at the surface 27.5σ_0. At the Kuril Straits, the Deep Water is strongly mixed vertically with the Intermediate Water by tidal mixing (Nakamura *et al*., 2000), and is also affected by the sill-effect (Freeland *et al*., 1998; Wong et al., 1998), which is modulated by seasonal change in the isopycnals depth caused by spin-up/-down of the Subarctic Gyre. Associated with the winter monsoon weakening around the Sea of Okhotsk (Glebova *et al*., 2009) and the weakening trend in the southern part of Western Subarctic Circulation (Carton *et al*., 2005), the warming trend of the OKIW may be a reflection of the weakening of the Western Subarctic Gyre, through strong tidal mixing and the sill-effect at the Kuril Straits, to the formation of OKIW.

November 8, 14:00 (S11-11344)

Recent advances and future perspectives in the understanding of mesoscale water dynamics in the Japan/East Sea

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Significant progress in the understanding of physical and biogeochemical processes in the Japan/East Sea (JES) has been achieved over last two decades due to the development of international research programs. Soon after the successful beginning of the CREAMS (Circulation Research of East Asian Marginal Seas) program, initiated by Japanese, Korean and Russian scientists in 1993, PICES established a working group (WG 10) to clarify circulation and ventilation in the JES. Its activity led to closer connections with CREAMS and the launch of a large multinational program, CREAMS-II, having an extensive field observation component during 1999-2001. To maintain international collaboration in the East Asian Marginal Seas in the PICES area and to facilitate the establishment of permanent observation and data exchange networks in this region, an Advisory Panel for a CREAMS/PICES Program in East Asian Marginal Seas was established in 2005. Since then, the AP has been facilitating international collaborative research in the JES including joint cruises, development of observing systems, numerical modeling and time series analysis. Most recent research has focused on the ventilation system of the JES and its changes in response to modern climate tendencies, open sea and slope convection processes, anticyclonic eddies found to control water mass transformation at various regions of the sea, the upwelling system along the Korean and Russian coasts, and subduction and advection at the subarctic front. The dynamics of all these processes include strong mesoscale and sub-mesoscale components. Recent advances in understanding and modeling of these phenomena, as well as future perspectives, are discussed in this presentation.

November 8, 14:25 (S11-11259)

Mesoscale-eddy-induced variability of flow through the Kerama Gap between the East China Sea and the western North Pacific

Hanna **Na**[1], Jae-Hun Park[2], Mark Wimbush[3], Hirohiko Nakamura[4], Ayako Nishina[4] and Xiao-Hua Zhu[5]

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The Kerama Gap (KG) is the deepest channel (sill depth 1050 m) along the Ryukyu Island chain connecting the East China Sea (ECS) to the western North Pacific. The observed mean flow through the KG from June 2009 to June 2011 is 2.0±0.7 Sv into the ECS. A 23-year (1993 to 2015) time series of the KG volume transport is obtained based on a good correlation between satellite altimeter-measured sea-level difference across the KG and 2-year-long in situ-measured volume transport. Comparison of the KG volume transport time series with satellite-measured sea-level anomaly maps reveals that KG transport fluctuations at 40- to 200-day periods are strongly affected by mesoscale eddies near the KG. Consequently, interannual to decadal amplitude changes in KG transports are associated with interannual to decadal eddy field changes to the east of the Ryukyu Island chain in the western North Pacific. The mesoscale-eddy-induced variability results in time-varying correlations between the KG throughflow and the Ryukyu Current volume transport south of Okinawa. Additionally, the relationship of the KG throughflow with the Kuroshio east of Taiwan and the Kuroshio in the ECS is discussed based on the changes in the eddy field.

November 8, 14:45 (S11-10913)

Studies on mesoscale eddies in the subarctic North Pacific

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Mesoscale eddies in the subarctic North Pacific have a significant impact on water (heat, freshwater, macro- and micro-nutrients and biota) exchanges between shelf and offshore regions and thus play an important role in the marine ecosystem of the offshore region. Mesoscale eddies also have a significant impact on vertical water exchange between surface and subsurface layers. In this talk, we review the studies on mesoscale eddies in the subarctic North Pacific and discuss what should be studied in the near future for the better understanding of the marine ecosystem in the region from the view point of mesoscale and sub-mesoscale eddies.

November 8, 15:05 (S11-11150)

Mesoscale eddies of the Northeast Pacific Ocean

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Many of the features of anticyclonic eddies of the Gulf of Alaska were discovered in the past 25 years: formation along the west coast of North America, westward propagation, stimulation of local phytoplankton blooms, lifetimes of several years, and their impact on exchange of biota between deep-sea and coastal waters. These eddies are observed from British Columbia to the western Aleutian Islands, and their nature changes if they propagate along the continental slope. Although they carry nutrients into deep-sea waters, the impacts of these macro- and micro-nutrients at the ocean surface vary with the age of eddies, their location, and even the season. The features of these eddies are generally opposite to those of cyclonic eddies that form off California. I will show that despite progress in understanding these features, we need more information on their propagation, how they mix with surrounding waters, and their impacts on higher trophic levels.

November 8, 15:25 (S11-11339)

The effect of mesoscale circulation on biological production and carbon export in the North Pacific

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The subarctic North Pacific and the Kuroshio Extension are hotspots of both regional biological production and carbon export in models and observations. Here we present results comparing runs of the CESM-BEC earth system model, resolved globally at both 1º and 0.1º, forced with the CORE-I normal year atmospheric data set. Resolving the mesoscale circulation allows the formation of long filamental structures and eddies. These are assessed with a dynamical systems metric, the finite-time Lyapunov exponent, ridges of which form the skeleton of filamentation and demarcate eddy boundaries. The mesoscale coherent features limit and control the distribution of the coastal iron input flux, constraining the spatial structure of the spring bloom and the resulting carbon export signal. The organization of production and export into filaments in the subarctic limits both the horizontal extent of production and its magnitude so that export is over-estimated at 1º model for this high-export region. Additionally, synoptic atmospheric forcing events in the Kuroshio extension trigger production and export events, modulated by the mesoscale features. These results suggest the need for observational campaigns to constrain the validity of coupled biogeochemical-physical models in resolving mesoscale processes controlling carbon export.

November 8, 15:45 (S11-11221)

Reconciling perspectives of upwelling system dynamics and basin-scale drivers on shelf water variability in the Pacific Northwest coastal ocean

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The Northern California Current System experiences highly variable upwelling in addition to larger basin-scale variability. A ROMS hindcast model of this region (2003–2009, 43°N–50°N, 1.5 km resolution over the shelf and slope) makes possible a study of interannual variability on both of these spatial scales. Analysis of salinity/ temperature

fields and intensive particle tracking within the model were used to assess the relative importance of 1) local and remote wind forcing, 2) depth and composition of the

California Undercurrent (CUC), and 3) north-south origin of water on the slope and shelf, in explaining interannual variability in mid-shelf bottom water and water over the slope.

Slope water properties varied only one-tenth as much as shelf bottom water. Thus, slope water and shelf water composition are not significantly correlated. However, Lagrangian

analysis of slope and shelf water shows that both are affected by large-scale advection of water from the northern and southern boundaries, and are closely linked through large- scale advection processes north and south (R^2 = 0.36; excluding 44°N). Additionally, results show that together, interannual variability in both local and remote alongshore wind stress and in depth of the CUC account for more than half of the interannual variability in shelf bottom water salinity (R^2 = 0.56). Overall, this analysis suggests that variability in dissolved oxygen and pH are driven by both variability of the upwelling system and basin-scale drivers.

November 9

Session 8 (Day-2)
The Effect of Marine Debris caused by the Great Tsunami of 2011

Session 9 (Day-1)
Resilience, Transitions and Adaptation in Marine Ecosystems under a Changing Climate

Session 11 (Day-2)
Advances in Understanding and Modeling of Physical Processes in the North Pacific in the Past 25 Years of PICES and Future Directions

Session 13
Understanding the Changing Coastal Ocean: Advances and Challenges in Multi-parameter Observations

S8: MoE/MEQ/TCODE Topic Session (DAY 2)
The Effect of Marine Debris caused by the Great Tsunami of 2011

November 9, 09:05 (S8-10936)

Sequential monitoring of marine debris washed ashore on a western US beach using a webcam system

Shin'ichiro **Kako**[1], Tomoya Kataoka[2], Kei Yufu[3], Atsuhiko Isobe[3], Charlie Plybon[4], Thomas A. Murphy[5] and Nir Barnea[6]

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We attempt to quantify the amount of marine debris that has continuously washed ashore on a US beach using a webcam system. As a part of ADRIFT (Assessing the Debris-Related Impact of Tsunami) project, we have installed a webcam on a beach in Newport, Oregon, US, to sequentially and automatically take photographs of marine debris, which might include tsunami debris. The hourly photographs of the beach have been taken during the daytime from April 2015 to the present (and now ongoing), to elucidate the temporal variation of debris quantity (counted by numbers) and its possible cause(s). We found that the quantity of marine debris varies largely in time with a period shorter than one month or less superimposed on seasonality. To investigate the possible cause(s) for this temporal variability, the time series was compared with that of satellite-derived wind speeds and sea surface dynamic height off the Oregon coast. In summer, it is found that the quantity of marine debris on the webcam site decreased when the northerly winds prevailed. This is because the coastal upwelling (hence, offshore-ward Ekman flow) induced by the northerly wind prevents marine debris from being washed ashore on the beach. In winter, the marine debris rapidly decreased especially when westerly (onshore-ward) winds prevailed at spring tides. In these periods, the high-tide line on the beach moved toward the land and thus, the re-drifting of debris into the ocean was likely to occur.

November 9, 09:25 (S8-10951)

Accumulation of beach litter in Vancouver Island, Canada

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We attempt to quantify the abundance of marine debris washed ashore on the exposed beaches of Vancouver Island, Canada by applying an image analysis to aerial photographs. As a part of the Assessing the Debris-Related Impact of Tsunami (ADRIFT) project, aerial photographs have been taken along the coast of British Columbia, Canada from October 2014 to March 2015, to monitor Japanese Tsunami Marine Debris (JTMD) induced by the Great Tohoku Earthquake. First, the projective transformation method was applied to the aerial photographs to remove the geometric distortion of the photographs. Thereafter, we calculated ratios between areas with and without marine debris (hereinafter, "percent covers") on the beaches by extracting the pixels of marine debris from the processed images. This image analysis enables us to quantify the abundance of marine debris on beaches because the percent covers calculated from the aerial photographs were consistent with the densities of marine debris measured by shoreline cleanup surveys. The estimated percent covers were significantly related to the cross-shore direction of the beach, and in particular, marine debris accumulated on the south- and southeast-facing beaches of Vancouver Island. The accumulation of marine debris was likely to depend on the ocean currents west of Vancouver Island (that is, the northward and northwestward Alaska Current). This indicates that the amount of beach litter tends to become large on the beach where the alongshore direction is perpendicular to the predominant currents in the offshore region, and also that these beaches could be prioritized for cleanup and removal activities.

November 9, 09:45 (S8-11198)

An estimate of the tsunami-debris quantity washed ashore on the US and Canadian beaches, based on a webcam monitoring and a particle tracking model experiment

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Particle tracking models (PTMs) are capable of computing debris motion in the ocean circulation. However, it is difficult to determine by the PTMs alone if modeled particles in the ocean are washed ashore onto the land, because the stranding must be dependent on nearshore processes that might not be resolved in modeled ocean currents (hence, PTMs) sufficiently. Also, re-drifting processes of stranded particles into the ocean should be incorporated into the PTM; otherwise the estimate of debris quantity on beaches remains unreliable. The webcam monitoring on a beach in Newport, OR provides us with a simple scenario of stranding/re-drifting processes: the debris on the beach increased during the downwelling-favoring winds, and rapidly decreased under the onshore-winds at spring tides by re-drifting. The PTM in the present study consists of two models: one is a PTM to reproduce the tsunami-debris motion in the North Pacific using an ocean reanalysis product (ocean circulation) and satellite-derived winds (leeway drift), and the other is a "sub-model" to give the criterion whether the modeled particles are washed ashore on the neighboring land grid cell, and whether they return to the oceanic domain from the land. The satellite-derived winds on the grid cells neighboring the land boundary were used for the criterion in the sub-model. An attempt in the present study is to evaluate the abundance of the modeled particles (which can be approximately converted to tsunami-debris weight) washed ashore on the land during the past five years.

November 9, 10:05 (S8-11365)

Crustaceans adrift: Multiyear observations of Asian marine amphipods, isopods, and tanaids arriving in North American shores on open ocean drift objects generated by the 2011 Japanese Tsunami

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The frequencies of transoceanic colonizations of species on passively drifting objects have been a widely invoked but unobserved explanation of marine species distributions spanning oceans and continents. Diverse reproductive non-native marine species of peracaridan crustaceans (including gammarid and caprellid amphipods, isopods, and tanaids) arrived in western North America commencing in 2012 on drifting objects generated by the Great Japanese Tsunami of 2011. These species survived multi-year open ocean crossings by replacement of multiple generations rather than by individual survival. Given the relatively short life of natural objects (such as wood) on long-distance ocean voyages, successful ocean crossings by short-lived species in modern times may be predominately on artificial, anthropogenic material, leaving natural ocean crossings in prehistoric times in doubt.

November 9, 10:50 (S8-10922)

Genetic diversity and biogeography of the macroalgal species associated with the Japanese tsunami marine debris

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Recognizable debris from the 2011 Great Tohoku Earthquake and Tsunami (JTMD) was carried across the North Pacific on currents from Japan, and has been arriving on Northeastern Pacific shores since 2012. Often healthy marine macroalgae are attached on JTMD, and there is a threat that they may become introduced to the coasts and disturb their ecosystems. In the PICES ADRIFT project sponsored by the Ministry of Environment, Japan, we have monitored the macroalgae on JTMD, and identified them by morphology and by using genetic markers. We have identified ca. 70 macroalgal species on JTMD, genetically analyzed the specimens using multiple genetic markers, and compared them with those from natural habitats in Tohoku and NW America. We have genetically examined following taxa: *Ulva* spp. (*U. compressa*, *U. lactuca*, *U. linza*, etc.), *Blidingia* spp. [Ulvophyceae]; *Feldmannia mitchelliae*, *Ectocarpus* spp., *Kuckuckia* sp., *Desmarestia* spp. *(D. japonica*, *D. viridis*, etc.), *Petalonia fascia*, *P. zosterifolia*, *Saccharina japonica*, *Scytosiphon lomentaria, S. gracilis* [Phaeophyceae]; *Chondrus giganteus, C. yendoi*, *Grateloupia turuturu*, *Palmaria palmata* and *P. mollis* [Rhodophyceae]. We have further analyzed the geographical distributions of representative haplotypes (genetic types) of the following taxa: *Ulva pertusa, Blidingia* spp., *Petalonia fascia*, *Desmarestia* spp. *Ectocarpus* spp., *Palmaria palmata*/*P. mollis*. These analyses suggest that although half of the species on JTMD have already been reported to occur in the NE Pacific, many of the debris specimens are genetically distinct from NW and NE Pacific populations, and their introductions to NE Pacific coasts may cause genetic disturbance to the local populations.

November 9, 11:10 (S8-10944)

The fate of wood at sea: shipworms (Bivalvia: Teredinidae) in woody debris from the 2011 Japanese tsunami

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The Tohoku tsunami of March 2011 ejected a vast amount of debris into the Pacific Ocean. Lumber and other Tohoku-sourced wood began appearing on Eastern and Central Pacific (Hawaii) beaches in 2013 and 2014 respectively. Wood boring mollusks (Teredinidae) settled on this debris, offering a unique opportunity to study shipworm diversity in rafted wood of a known origin and time of ocean entry. Diversity and abundance were determined by extracting tissue and hard calcareous structures (pallets and shells) for genetic and morphological analyses from 120 pieces of Japanese Tsunami Marine Debris (JTMD) consisting of construction beams, trees, milled logs and wood from vessels or maritime structures. Seven species were found: *Bankia carinata, Teredothyra smithi, Bankia bipennata, Lyrodus takanoshimensis*, *Teredo navalis, Teredora princesae* and a new species belonging to *Psiloteredo*. The first three are warm-temperate to subtropical species. *T. navalis* and *L. takanoshimensis* are typically cooler water species. *T. princesae* is a pelagic species generally observed in subtropical and Indo-Pacific driftwood. *Psiloteredo* sp*.,* to be described in a forthcoming paper, is genetically distinct (COI-5P sequences) yet morphologically identical to *Psiloteredo megotara*, a cold water species reported from the North Atlantic and the continental shelf off northern Japan. *Psiloteredo* was found in over 90% (and was the sole species in 43%) of the items examined. Up to six species were found in any one wooden object. Species diversity, abundance, morphological variation, correlations with type of debris, immersion time, possible circulation pathways, and stranding latitude were explored.

November 9, 11:30 (S8-11147)

DNA barcoding of potential Japanese tsunami marine debris-associated invaders of U.S. and Canadian waters

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The Great East Japan Earthquake of March 11, 2011 ejected uncounted tons of debris into the Pacific Ocean that has served as substrate for rafting by coastal Japanese marine organisms. Japanese Tsunami Marine Debris (JTMD) carrying Japanese plants and animals was first observed in North America and Hawaii in 2012 and continues to arrive. Examination of over 600 objects has revealed more than 300 species, many not known previously in North America nor Hawaii but presenting potential to establish as invasive species. Identification and surveillance of JTMD associated species can be assisted by detection of diagnostic DNA sequences (DNA barcodes). Toward this end, we have used conventional and next-generation sequencing methods to sequence a portion of mitochondrial Cytochrome c oxidase subunit I (COI) from specimens collected on JTMD or in the fouling communities of Japan. Early detection of potential JTMD invaders will require extensive surveys over a large geographic area that would be difficult to perform with traditional methods. Metagenetics, the sequencing of environmental samples, is a faster and cost-effective alternative. We have sequenced COI from biomass collected from JTMD objects, plankton, and settling plates collected in North America, and used an introduced species database to create species lists; representative examples are presented here.

November 9, 11:50 (S8-11148)

The invasion risk of invertebrate species associated with Japanese tsunami marine debris in North America and Hawaii

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Marine debris from the 2011 Great Japan Tsunami is a novel transport vector for Japanese species to reach Pacific North America and Hawaii. Over 600 debris items attributed to the tsunami have been intercepted thus far and over 330 species of algae, invertebrates and fish have been identified associated with this Japanese tsunami marine debris (JTMD). Some of these species are well-known global invaders, such as the shore crab *Hemigrapsus sanguineus*, the bryozoan *Tricellaria inopinata*, and the anemone *Diadumene lineata*. Most of the species encountered are native to Japan, not currently present in North America or Hawaii, and their invasion risk is unknown. Thus, it is important to characterize the risk their introduction may pose to North American and Hawaiian ecosystems. Risk assessments are an important tool that can inform policy and management decisions about potential invasive species. Here we characterize the risk of individual invertebrate species associated with JTMD using an established screening-level risk assessment tool – the Canadian Marine Invasive Screening Tool (CMIST). This tool scores both the probability and consequences (impacts) of an invasion for receiving ecosystems, to generate an overall risk score that encompasses assessor uncertainty. This approach allows us to generate a list of higher-risk invertebrate invaders for different ecoregions on the Pacific coast of North American and Hawaii, providing key information that can be used to inform monitoring activities and raise awareness with stakeholders and the public.

November 9, 12:10 (S8-11282)

Detection of non-native species in North America: Effects of the large-scale arrival of biota on Japanese tsunami marine debris (JTMD)?

Gregory M. **Ruiz**[1], Jonathan B. Geller[2], Linda McCann[1], Kristen Larson[1], Lina Ceballos[1], Michelle Marraffini[1], Briana Tracy[1], Stacey Havard[1], Katherine Newcomer[1], Brian Steves[1], Andrew Chang[1], Ruth Di Maria[1], Katrina Lohan[1], Rebecca Barnard[1], Paul Fofonoff[1], Jessica A. Miller[3], John Chapman[3], Cathryn Clarke Murray[4], Thomas W. Therriault[5] and James T. Carlton[6]

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The Great Japan Tsunami of 2011 resulted in a massive and unprecedented dispersal event of marine biota from Asian coastal waters to the shores of North America. While significant effort has focused on characterizing the spatial and temporal patterns of biota arriving to North America, the fate of these organisms and the extent of new invasions is poorly resolved. We report here the synthesis of existing data and new surveys to evaluate (detect) the presence of non-native marine species in western North America, from California to Alaska, including free-living marine invertebrates and parasites reported on Japanese tsunami marine debris (JTMD). These data provide important baseline measures (benchmarks) for the species pool present in North America before and during the JTMD dispersal event. We explore the inferences that can be drawn from this baseline and its application to evaluate invasions associated with JTMD, while also considering the potential for both lag-times in detection and other mechanisms (vectors) of introduction of biota from the northwestern Pacific.

S9: FIS/TCODE Topic Session (DAY-1)
Resilience, Transitions and Adaptation in Marine Ecosystems under a Changing Climate

November 9, 09:00 (S9-10881)

Marine ecosystem resilience, what is it and how can we measure it?

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The term resilience is broadly understood as "*the ability of a system to absorb disturbance and maintain structure and function*". Three features can contribute to the resilience of a system: resistance, flexibility and reorganisation. Resistance implies low sensitivity to external pressures. Flexibility refers to the capacity of a system to return to its original configuration after being exposed to a perturbation. Reorganisation defines the capacity of a system to constantly reconfigure itself in order to maintain its functions in the presence of perturbations. For marine systems, resilience can be defined at different levels of biological organisation, from individuals to populations, communities or the ecosystem as a whole. High resilience at one level does not necessarily derive from or result in high resilience at other levels. During the 'Barents Sea Ecosystem Resilience' project, structural aspects of ecosystem resilience were investigated by quantifying ecosystem diversity (specific, functional and trophic), redundancy (trophic and functional) and modularity (in food webs). In addition, dynamic aspects of resilience were investigated by time-series analyses of multivariate-multidecadal patterns in ecosystem structure. In both analyses (structural and dynamic) a key issue remained the definition of 'reference' states, against which empirical observations may be compared. The development of 'null' ecosystem models in which simple hypotheses are used to generate expected patterns of resilience has been essential to compare historical patterns of ecosystem variations in the Barents Sea (e.g. regime shifts, decadal shifts in top-down/bottom up controls) to 'expected' ones.

November 9, 09:30 (S9-11081)

Early warning signals of declining resilience and abrupt transitions in ocean ecosystems

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Ecological regime shifts are an important source of uncertainty that affect our ability to successfully manage marine resources. A rapidly developing area of ecological research proposes that characteristic statistical signals (e.g., rising variance and autocorrelation) should provide early warning of declining resilience and an increased chance of an ecological transition. While these Early Warning Signals (EWS) began as strictly theoretical predictions, some research demonstrates that they may have utility in predicting abrupt change in real ecosystems. However, empirical studies to date have produced mixed outcomes; some show evidence supporting the predictions of EWS theory while others do not. The goal of our study is to identify the factors distinguishing successful and unsuccessful real-world applications of EWS. To do this, we conducted a review and meta-analysis of EWS research as well as a new, comparative analysis of eight northeast Pacific Ocean time series. Here we present the results of these analyses, which demonstrate the importance of nonlinearity or hysteresis for the successful application of EWS in empirical systems. There is little expectation for the presence of EWS if a system is best described by models of linear relationships between the biological response and environmental drivers. In addition, we make recommendations for future empirical research on EWS and propose ways in which EWS could be incorporated into ecosystem-based fisheries management given the current state of knowledge.

November 9, 09:50 (S9-11087)

Status and trend of four commercially important coastal cephalopods in China Seas: An overview with implications for climate change

Yongjun **Tian**, Yumeng Pang, Yanli Tang, Yiping Ren and Rong Wan

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Increasing evidence indicates a worldwide proliferation of cephalopods with global warming, however there is little information on coastal cephalopods in Chinese waters. Coastal cephalopods, including squids, cuttlefish and octopus, play a vital part in Chinese catch composition in spite of over-exploitation in China Seas and their high turnover rates have important ecosystem effect. Here we review the status and trend of four commercially-important coastal cephalopods with different life history strategies in China Seas and adjacent areas using historical fisheries and survey data. Four typical species of coastal cephalopods, the golden cuttlefish (*Sepia esculenta Hoyle*), Japanese loligo squid (*Loligo japonica*), common Chinese cuttlefish (*Sepiella maindroni*) and swordtip squid (*Uroteuthis edulis*), have been exploited over six decades in the coastal area of China. Even though distributions of these four species partly overlap, their life history strategies such as spawning seasons, migration and growth are diverse, which allows their populations to respond differently to climate change and to maintain stability. Catch trends illustrate decadal variation patterns with significant declines and increases around 1980 and in the late 1990s, indicating strong effects of ENSO events and regime shifts. Different responses to climate change among these four species may be attributed to their intrinsic biological traits and different life history strategies. Our results open a window to the climate impact on Chinese coastal cephalopods. For the coastal cephalopods in an over-exploited ecosystem such as China Seas, high fishing pressure would not be the sole reason of population decline and environmental variability such as regime shifts should be considered in the context of ecosystem-based fishery management.

November 9, 10:10 (S9-11230)

Effects of high-CO_2 and temperature on the dynamics of plankton communities in the subarctic Pacific

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Increases in ocean acidity and temperature are induced by an increase in atmospheric CO_2 levels. These environmental perturbations may impact marine organisms in a variety of ways, but the knowledge of interactive effects on marine phytoplankton is still very limited. We conducted CO_2 and temperature manipulation experiments at three stations in the subarctic Pacific to investigate the interactive effects of these factors on the dynamics of marine phytoplankton. Stations are located at 41°53'N 145°50'E, 47°01'N 160°01'E, and 47°00'N 148°02'W, and experiments were conducted in April 2015, August 2014, and August 2014, respectively. Net phytoplankton growth rate based on chlorophyll-*a* was enhanced by the increase in temperature in two of the three experiments, whereas it slightly decreased by the increase in CO_2 levels. In two of the three experiments, the magnitude of decreasing net growth rate in the high CO_2 condition was smaller under higher temperature conditions. The growth of cyanobacteria and pico-sized eukaryotic phytoplankton were often enhanced by either increasing temperature, CO_2, or both. Diatom growth was negatively affected by the high-CO_2 conditions only in the April-2015 experiment. We found that the negative impact of high CO_2 condition is ameliorated by the high temperature conditions because of the positive response in the growth of pico-sized phytoplankton in the high CO_2 treatment. These results suggest that future high-CO_2 and temperature conditions could shift the phytoplankton community to fast growth rates with small cell size, which may negatively affect the trophic transfer efficiency and biological carbon pump in the ocean.

November 9, 10:50 (S9-10883)

A model simulation of the adaptive evolution through mutation of the coccolithophore *Emiliania huxleyi* based on a published laboratory study

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Phytoplankton and other microbes, with generation times of days or less, experience hundreds of generations each year, allowing the possibility for favorable mutations (i.e., those that produce organisms with fitness maxima nearer to the environmental conditions at that time) to dominate existing genotypes and survive in a changing climate. Several laboratories have grown phytoplankton cultures for hundreds to thousands of generations and demonstrated that they have changed genetic makeup. In particular Schlüter et al (2014) grew replicates derived from a single cell of *Emiliania huxleyi*, a coccolithophorid with broad geographical and thermal range, for 3 years (~1000 generations) at 15°C, and then for a year at 26.3°C, near their upper thermal limit. During the last year the intrinsic growth rate increased more or less linearly, which the authors attribute to genetic mutation. Here I simulate genetic mutation of a single trait (intrinsic growth rate), both for the control phase and the warm phase of their study. I consider sensitivities to frequency of mutation, changes with temperature in intrinsic growth rate, and use the experimental setup and results to place constraints on the way mutations occur. In particular, all numerical experiments with mutation result in a lag time of order 100 generations before a significant increase in realized growth rate occurs. A numerical experiment that includes a simple plastic response formulation shows that plasticity could remove this lag and yield results more in agreement with those observed in the laboratory study.

November 9, 11:10 (S9-10909)

Detection of a geographically fixed center of high abundance of macroinvertebrates along the west coast of Baja California

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One expected consequence of ocean warming is the potential poleward shift of species geographic distribution ranges. Small-scale benthic fisheries are especially at risk because of their limited mobility, and difficulty to track resource changes by moving to different locations. We conducted a large scale survey of subtidal benthic invertebrates along the Baja California west coast. We report 60 species of mollusks, 33 species of echinoderms, and three species and eight operational taxonomic units of crustaceans. A Cluster analysis with Bray-Curtis similarity coefficient shows four coherent latitudinal regions for the invertebrates community (north, central, south and Islands), with the highest diversity and abundances at the central region. The historical comparison of abalone densities suggest a decrease in both species for all regions, but with the highest densities remaining at the central regions in both periods and species. Our findings indicate the presence of a fixed center of high abundance of benthic macroinvertebrates at the central region off Baja California, a pattern already documented for the pelagic realm. Implications are that at least for this type of systems, the expected impacts of climate change may not be evidenced in latitudinal shifts of the abundance centers and fishing grounds.

November 9, 11:30 (S9-11162)

Identifying climatically resilient or sensitive locations in the Northern California Current using partitioned beta-diversity

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Patterns of beta diversity lead to an improved understanding of the spatial and temporal organization of marine fish and invertebrate communities and their responses to environmental change at a variety of scales. We assess the long-term beta-diversity trends of the pelagic fish and invertebrate community in the Northern California Current yearly between 1999 and 2015. We partition beta-diversity into two components: turnover and nestedness. To determine the relationship between partitioned beta-diversity patterns with the local environment as well as basin-scale variables through time we used variable coefficient generalized additive models as well as Spearman's rank correlations. Turnover and nestedness were correlated with the change in station depth and temperature. Spatially, the southern and most offshore stations were generally the most correlated with PDO and MEI. Overall, no decrease or increase was observed in the turnover and nestedness components of the pelagic community's beta diversity during the inspected time series, instead they fluctuated around a long-term mean. These results suggest that while the region as a whole may be largely resilient in the available species pool, some localities are more stable than others and vary as a function of basin scale fluctuations. We discuss the possible implications for management and conservation, as well as a need for continued monitoring.

November 9, 11:50 (S9-10976)

Climate vulnerability analysis of eastern Bering Sea fish and invertebrate stocks

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Vulnerability analyses of stocks to climate change have been identified as a priority action in the U.S. National Oceanic and Atmospheric Administration Climate Change Strategy. We are conducting a vulnerability assessment that uses stock sensitivity (i.e., biological attributes that are predictive of an ability/inability to respond to potential environmental change) and exposure (i.e., an overlap between a species distribution and the magnitude of expected environmental change) to determine relative vulnerabilities of stocks. Stock sensitivity reflects both resilience (i.e., capacity to absorb disturbances) and adaptive capacity (i.e., biological responses that mitigate exposure or sensitivity). Stock sensitivity scores were assessed for 36 eastern Bering Sea (EBS) stocks encompassing a wide range of taxonomic groups. Evaluation of climate exposure used existing projections for the EBS from three downscaled global climate models that represent a range of projected future warming. The relative change in environmental conditions is indicated by comparing projected future (2030-2039) conditions to "current" (2003-2012) conditions. Stocks with low population growth rates (i.e., rockfish), complex spawning cycles (i.e., salmon), or sensitivity to ocean acidification (i.e., crabs) generally had high stock sensitivity scores. The final results will include evaluation of uncertainty, as indicated by data quality scores and bootstrap analyses. The EBS vulnerability analysis will provide a rapid, semi-quantitative indication of the relative vulnerability of stocks to climate change, which can assist in evaluating research priorities and options for human adaptation.

November 9, 12:10 (S9-11251)

Resilience and adaptation of marine ecosystems in Vanina Bay, Sea of Japan: Past, present and scenarios for the future

Ekaterina P. **Kurilova** and Sergey E. Kulbachnyi

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The results of ecological monitoring in Vanina Bay (Sea of Japan) over the last decade are presented. Changes in the abundance of fish, invertebrates, plankton and other organisms under increasing anthropogenic influence are shown.

Anthropogenic impacts on marine ecosystems in the area as a result of Vanino sea port activity have occurred since 1943. Unfortunately, underdeveloped technological processes caused heavy damage to marine ecosystems. We discovered changes in the bottom structure, and loss of abundance and biomass in fish and plankton.

At the same time, taking into account continuance and force of anthropogenic influence, we can say that an irreversible tipping point associated with the loss of essential structure and function has not been reached. Resilience and adaptation of marine ecosystems to changing environmental conditions was detected.

Ecological monitoring results in elaboration of the criteria for assessment of resilience of marine organisms to impacts, and scenarios of marine ecosystems adaptive capacity to different stressors. On the basis of these data, specialists work out recommendations for improvement of Vanino sea port technological processes in order to reduce negative anthropological influence and increase marine ecosystem capacity to adapt to changing conditions.

S11: POC Topic Session (Day 2)
Advances in Understanding and Modeling of Physical Processes in the North Pacific in the Past 25 Years of PICES and Future Directions

November 9, 09:00 (S11-10977)

Linking technological and POC advances over the past 25 years

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Many advances in climate and physical/chemical oceanographic research over the past twenty-five years were greatly facilitated by corresponding advances in technology. In this presentation we will give examples of how observations from "recent" technologies such as satellite altimetry and autonomous platforms, and complex model simulations made possible by the development of more powerful computers have produced important Physical Oceanography and Climate Committee (POC) research relevant to the central goal of PICES, namely understanding and projecting trends and variability in North Pacific marine ecosystems. Future technological advances, and their possible impact on POC research over the next twenty-five years, will also be discussed.

November 9, 09:25 (S11-11378)

Wave turbulence interaction induced vertical mixing and its effects in ocean and climate models

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Heated from above, the oceans are stably stratified. Therefore, the performance of general ocean circulation and climate studies through coupled atmosphere-ocean models depend critically on vertical mixing of energy and momentum in the water column. Many of the traditional general circulation models are based on total kinetic energy (TKE) in which the roles of waves are averaged out. Although theoretical calculations suggest that waves could greatly enhance coexisting turbulence, no field measurements on turbulence have ever validated this mechanism directly. To address this problem, a specially designed field experiment has been conducted. The experimental results indicate that an enhancement of the background turbulence due to wave-turbulence interaction is indeed the predominant mechanism for turbulence generation and enhancement. Based on this understanding, we propose a new parameterization for vertical mixing as an additive part to the traditional TKE approach. This new result has reconfirmed the past theoretical model that was tested and validated in numerical model experiments and field observations. It firmly establishes the critical role of wave-turbulence interaction effects in both the general ocean circulation models and atmosphere-ocean coupled models, which could greatly improve an understanding of the sea surface temperature and water column property distributions, and hence the model-based climate forecasting capability.

November 9, 09:45 (S11-11125)

Distribution of near-inertial waves in the mixed and deep layers of the East/Japan Sea using a high-resolution wind-forced ocean model

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Previous observations of deep near-inertial waves in the East/Japan Sea showed that they were more energetic in the southern region than in the northern region. The significant variation of surface currents in the southern region was suggested to be the cause of this meridionally asymmetric distribution of near-inertial waves, but no clear dynamic explanations were provided. In this study, we investigate the characteristics of near-inertial wave energy distribution in the East/Japan Sea using high-resolution wind-forced ocean model outputs. This model reproduces realistic circulation and stratification through a nudging assimilation of in-situ hydrocasts, satellite measurements, and throughflow observations in the Korea Strait. In addition, the model is forced with hourly wind forcing calculated from a 5-km resolution weather forecast model. Analyses of model outputs at hourly intervals from November 2012 to September 2015 reveal that the near-inertial wave energy distributions in the surface mixed layer are much different from those in the deep layers. The near-inertial wave energy in the mixed layer is stronger and is distributed dominantly in the northern side of the subpolar front during winter months when the wind is strong and the mixed layer develops well. In the deep layers, energetic near-inertial wave patches are found at the southern part of the East/Japan Sea even during winter months, which is consistent with previous observations. Comparisons with background circulation patterns suggest that the distribution of near-inertial waves in the deep layers is highly correlated with anticyclonic mesoscale eddy fields due to their trapping inside those eddies.

November 9, 10:05 (S11-11121)

Synoptic variability of wintertime wind-driven circulation in the Bohai, Yellow and East China seas

Daji **Huang** and Zhiyuan Li

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A high resolution three-dimensional numerical model was used to investigate the response of the sea surface height (SSH) and circulation in the Bohai, Yellow and East China seas (BYES) to synoptic wind in winter. The simulated currents agreed well with previous studies and in-situ observation. Complex Empirical Orthogonal Function analysis captured two leading modes of coastal-trapped waves (CTWs). Both modes propagate counterclockwise in the entire region with a period of 2-5 days. The first mode has one amphidromic point of SSH. The second mode has three amphidromic points of SSH. A significant meso-scale eddy with synoptic variation in the northern East China Sea was revealed. The momentum balance analysis indicates that the along-shelf current is in geostrophic balance with the cross-shelf pressure gradient and is accelerated by the along-shelf pressure gradient. The evolutionary mechanism the CTWs is also investigated with vorticity balance analysis. The first CTW mode dominates the entire region, particularly the Bohai and Yellow seas. The second CTW mode is more important in the East China Sea.

November 9, 10:50 (S11-11115)

Regional and climate forcing on forage fish and apex predators in the California Current: New insights from a fully coupled ecosystem model

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A fully coupled ecosystem model is used to describe the impact of regional and climate variability on changes in abundance and distribution of forage fish and apex predators in the California Current Large Marine Ecosystem. The ecosystem model consists of a biogeochemical submodel (NEMURO) embedded in a regional ocean circulation submodel (ROMS), and both coupled with a multi-species individual-based submodel for two forage fish species (sardine and anchovy) and one apex predator (California sea lion). Sardine and anchovy are specifically included in the model as they exhibit significant interannual and decadal variability in population abundances, and are commonly found in the diet of California sea lions. Output from the model demonstrates how regional-scale (i.e., upwelling intensity) and basin-scale (i.e., PDO and ENSO signals) physical processes control species distributions and predator-prey interactions on interannual time scales. The results also illustrate how variability in environmental conditions leads to the formation of seasonal hotspots where prey and predator spatially overlap. While specifically focused on sardine, anchovy and sea lions, the modeling framework presented here can provide new insights into the physical and biological mechanisms controlling trophic interactions in the California Current, or other regions where similar end-to-end ecosystem models may be implemented.

November 9, 11:15 (S11-11013)

Macro-scale patterns in upwelling/downwelling activity along the North American west coast

Romeo **Saldívar-Lucio**[1], Emanuele Di Lorenzo[2], Miguel Nakamura[3], Héctor Villalobos[1], Daniel Lluch-Cota[4] and Pablo Del Monte-Luna[1]

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The seasonal and interannual variability of vertical transport (upwelling/downwelling) has been relatively well studied, mainly for the California Current System, including low-frequency changes and latitudinal hetereogeneity. The aim of this work was to identify potentially predictable patterns in upwelling/downwelling activity along the North American west coast and discuss their plausible mechanisms. To this purpose we applied the min/max Autocorrelation Factor technique and time series analysis. We found that spatial co-variation of seawater vertical movements present three dominant low-frequency signals in the range of 33, 19 and 11 years, resembling periodicities of: atmospheric circulation, nodal moon tides and solar activity. Those periodicities might be related to the variability of vertical transport through their influence on dominant wind patterns, the position/intensity of pressure centers and the strength of atmospheric circulation cells. The low-frequency signals identified in upwelling/downwelling are coherent with temporal patterns previously reported at the study region: sea surface temperature along the Pacific coast of North America, catch fluctuations of anchovy *Engraulis mordax* and sardine *Sardinops sagax*, the Pacific Decadal Oscillation, changes in abundance and distribution of salmon populations, and variations in the position and intensity of the Aleutian low. Since the vertical transport is an oceanographic process with strong biological relevance, the recognition of their spatio-temporal patterns might allow for some reasonable forecasting capacity, potentially useful for marine resources management of the region.

November 9, 11:35 (S11-10910)

The seasonal and interannual variability of circulation in the eastern and western Okhotsk Sea and its impact on plankton biomass

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The seasonal and interannual variability of circulation in the eastern and western Okhotsk Sea has been investigated using AVISO velocity field and oceanographic data for the period from 1993 to 2015. Year-to-year changes of the Alaskan Stream surface flow, forming the northern boundary of the western subarctic gyre in Pacific Ocean, impact the dynamics of water and plankton biomass in the eastern Okhotsk Sea. An intensification/weakening of the Alaskan Stream leads to increased/decreased fluxes in the areas of the Krusenstern and Fourth Kuril Strait connecting the Okhotsk Sea with the Pacific Ocean. Enhancement of the Alaskan Stream flux is accompanied by an increase in water temperature and biomass of small- and medium-sized zooplankton, and decreasing ice area and biomass of large-sized zooplankton in the eastern Okhotsk Sea. In the East-Sakhalin Current region, the coastal upwelling forced by northward winds and positive wind stress curl along the Sakhalin coast in summer lead to a mesoscale cyclone formation. An inflow of low salinity waters from the Sakhalin Bay driven by southward winds and negative wind stress curl along the Sakhalin coast during fall and winter results in the generation of a mesoscale anticyclone. Mesoscale cyclones support the high biological productivity at the eastern Sakhalin shelf in July-August.

November 9, 11:55 (S11-10992)

The response of Northeast Pacific Ocean circulation to recent atmospheric forcing

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Strongly positive temperature anomalies developed in the Northeast Pacific Ocean during the winter of 2013-14 and have persisted, with considerable evolution in magnitude and pattern, well into 2016. It is evident that highly anomalous atmospheric forcing is the primary cause of this warm event. In particular, a strong and persistent ridge of higher than normal sea-level pressure (SLP) resulted in reduced seasonal cooling of the upper ocean during the winter of 2013-14. The following two winters featured a relatively deep Aleutian low and a SLP pattern favoring low-level winds from the south, and abnormally warm air temperatures in the eastern part of the basin, leading to positive temperature anomalies in a wide strip along the west coast of North America. It is not evident, however, the extent to which the upper ocean large-scale circulation (i.e., the mean currents) in the Northeast Pacific ridge has responded to climate forcing during the last 3 years. The present study uses monthly mean data from NOAA's Global Ocean Data Assimilation System (GODAS) to address this issue. GODAS is based on a numerical ocean model that incorporates available oceanographic observations, including data from Argo profiling floats, and hence provides a dynamically-consistent representation of large-scale ocean structure and processes. A focus of the present analysis concerns the lag between the atmospheric forcing and the upper ocean circulation response, and ultimately the implications for predictability on time scales of months to seasons from a marine ecosystem perspective.

November 9, 12:15 (S11-11293)

Anomalous oceanic conditions along the US West Coast in 2014: Inferences from a high resolution regional ocean model

Alexander **Kurapov**

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A 2-km resolution ocean circulation model of the Northeast Pacific region has been run with realistic atmospheric forcing and boundary conditions for a period of 2009-2014, and fields are saved daily. These fields are utilized to estimate an annual cycle and anomalies in atmospheric forcing, surface oceanic fields, and continental slope properties in the area from 24°N to 55°N. In particular, analyses focus on the year 2014 which was influenced by a warm anomaly developed in the Gulf of Alaska in winter, wide-spread warming over the California Current System and the shelf in summer, and subsurface anomalies along the continental slope associated with the emergence of El Niño. Based on the model analyses, anomalies were found in the properties on the 26.5 isopycnal surface over the continental slope in summer 2014, including lower depth of placement (all along the coast), stronger along-slope poleward undercurrent, and warmer temperatures and lower potential vorticity north of the Mendocino Escarpment. These were forced by lowering isopycnal surfaces at the south boundary of our domain (at 24°N), inferred from a global model. At the surface, the winter SST anomaly developed offshore was not directly associated with the heat flux anomaly, but was possibly a result of horizontal eddy transport from the south. Anomalously large short-wave radiation and increased negative latent flux were found in an area over the North Pacific Current bifurcation point, California Current System, and the continental shelf.

S13 MONITOR/TCODE Topic Session
Understanding the Changing Coastal Ocean: Advances and Challenges in Multi-parameter Observations

November 9, 09:05 (S13-11132)

Coastal observation systems to monitor physical, chemical and biological parameters

Hidekatsu **Yamazaki**[1], Eiji Masunaga[2], Scott Gallager[3], Mamoru Tanaka[1], Marika Takeuchi[1], Kazuo Amakasu[1], Kunihisa Yamaguchi[4] and Hayato Kondo[1]

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We have developed a free-fall multi-parameter profiler (YODA Profiler) to measure various physical and biological parameters in coastal ocean. We found internal bores create a strong mixing event. Sediment resupension is asscociated with the mixing event and also AZFP detected fish school at the front of bore.

We have deployed a cable observatory system (Oshima Coastal Environment data Acquisition Network System, OCEANS) in a coastal area to monitor coastal ecosystem continuously. OCEANS can measure various physical, chemical and biological parameters simultaneously, and operates a plankton imaging system (Continuous Plankton Imaging and Classification System, CPICS). Based on acquired images of phytoplankton and zooplankton we are investigating how planktonic biodiversity is affected by multi-scale physical processes, such as Kuroshio and internal waves. We are developing a technique to predict the biodiversity of plankton from three-dimensional hydrodymanic model using a newly developed plankton ecosystem model.

We are also developing a AUV (MEMO-pen) that carries CPICS as well as microstructure profiler (TurboMAP) in order to simultatnously observe turbulence and plankton. We will introduce the most recent results from these observation systems.

November 9, 09:30 (S13-11052)

Introduction to the Ocean Research Stations (ORSs) in Korea and application activities

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Large-scale and long-term environmental changes have been reported in the Yellow Sea and East China Sea (YECS) during the last couple of decades. Many important meteorological and oceanic processes occurring in the YECS are changing their environment. From the early 2000s, several ocean research stations (ORSs) have been planned in Korea as a part of the ‘Integrated Coastal Monitoring System’ program. The Ieodo ORS (IORS) is the first open-ocean research tower station in Korea. The IORS is located in the northeastern part of the East China Sea and more than half of the typhoons which affect the Korean peninsula pass over the IORS area. Equipped with more than 30 different types of instruments, the IORS is observing more than 40 different variables of the ocean and atmosphere (wind, wave, temperature and salinity, air-sea fluxes, etc). Constructions of 2 more ORSs, the Gageocho and Socheongcho ORSs, were completed in 2009 and 2014, respectively. Currently (March 2016) there are about 20 on-going research programs utilizing the ORSs to investigate typhoons, air-sea interactions, transportations of air pollutant particles, sea-fog formations, changes of the biological eco-environment, etc. Scientists can use the ORSs to attach/integrate their own sensors, and conduct process studies on or nearby the station (staying for days). The ORSs could serve as one of the reference stations for monitoring global climate change. This paper will introduce some of the noticeable accomplishments from the ORSs and the future plans for international cooperative works for enhancing and expanding the functions and applications part of the ORSs.

November 9, 09:50 (S13-11333)

Recording extreme events in the multi-parameter Central and Northern California Ocean Observing System (CeNCOOS)

CeNCOOS Investigators, David M. **Anderson**

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Several locations in California coastal waters experienced record-warm temperatures in 2015, and unprecedented levels of domoic acid during the summer 2015 harmful algal bloom. Salinities in estuaries remain elevated as the California drought enters its fifth year. These and other extreme events are recorded by the Central and Northern California Ocean Observing System. CeNCOOS supports an array of 14 continuously streaming multi-parameter shore stations, 27 current-sensing high frequency radars, and two autonomous gliders that traverse the California Current to 500km offshore. Data aquisition at periods ranging from minutes to hours produces a high-velocity stream useful in a range of applications including mobile apps and assimilation into coastal models. Ninety percent of CeNCOOS' observations are in the surface layer, underscoring the challenge of siting, maintaining, and telemetering observations from multiple depths. CeNCOOS is one of eleven regional ocean observing system (IOOS) regional associations that maintain real-time, multi-parameter observing systems. IOOS data are made available in a variety of formats, served to distributed catalogs, and contributed to long-term archives. Best practices are documented in quality assurance manuals and reports, enabled by the use of existing standards, and further developed in test-beds and exploratory programs.

November 9, 10:10 (S13-10887)

Probing multi-scale oceanic signals from the coast

Hyun Sup Soh, Jang Gon Yoo and Sung Yong **Kim**

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This paper presents feasibility and capability of integrated coastal ocean observations to monitor multiscale oceanic geophysical signals and variability in open ocean and coastal regions. As a part of geophysical signals, sea surface heights (or sea surface elevations) obtained from satellite altimetry, tide gauges, and coastal radar-derived surface currents are cross-compared. The oceanic variability between open ocean and coastal areas is investigated with temperature and salinity profiles sampled by Argo floats, long-term hydrographic surveys (e.g., CalCOFI), and shore station CTD casts. This work can be aligned with the enhanced awareness and matured efforts to examine the physical view on the ocean ecosystem-related issues.

November 9, 10:50 (S13-11250)

Using multiple platforms to assess a potential link between the North Pacific warm anomaly (the 'Blob') and anomalous conditions in the Salish Sea during 2015

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The NE Pacific warm anomaly (the 'warm Blob') was first identified offshore in the Gulf of Alaska in late 2013/ early 2014, following limited fall/winter cooling and downwelling associated with a weak Aleutian Low. More typical downwelling conditions returned during the 2014/2015 fall-winter period and transported some of the warm surface waters onto the West coast of North America. Both the strength of seasonal downwelling and the arrival of anomalously warm waters onto the shelf of Vancouver Island were recorded by a cabled sea-floor instrument platform at Folger Passage (97 m; Ocean Networks Canada). Subsequent to the inshore arrival of the 'Blob', mid- and deep-basin conditions recorded by cabled instruments in the Strait of Georgia were indicative of limited deep-water renewal (i.e. anomalously low deep-water dissolved oxygen conditions). Limited deep-water renewal may be attributed to the inability of low-density (warm) waters entering the basin from Juan de Fuca Strait to penetrate deep into the basin. Both the Strait of Georgia and Saanich Inlet (inshore fjord) experienced little-to-no winter cooling during the 2015/2016 winter season. Here we take advantage of a number of publicly-available high-resolution time-series measurements (fixed and mobile platforms) to assess whether anomalous deep-water conditions inshore can be directly attributed to an inshore incursion of the 'blob' or if warmer than average local conditions promoted surface warming which limiting deep-water renewal into both the Strait of Georgia and Saanich Inlet.

November 9, 11:10 (S13-11352)

From marine terrestrial interactions to the "warm blob": Integrating land-ocean-atmospheric research in a coastal observatory framework

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Coastal margins are dynamic zones at the interface between land and ocean that support complex and highly productive ecosystems, and a range of essential ecosystem services. The Pacific Coastal Temperate Rainforest (PCTR), stretching from Oregon to Alaska, is a coastal margins hotspot. The PCTR is the world's largest coastal temperate rainforest and contributes massive seasonal discharge of freshwater, micro- and macronutrients to the north east Pacific coastal ocean. The timing, quantity, and composition of these terrestrial inputs is strongly effected by climate and land use practice, yet the role of terrestrial contributions in these coastal marine ecosystems remains poorly understood. Additionally, the physics, chemistry and productivity of coastal oceans are driven by ocean-climate systems, seasonally (e.g., upwelling / downwelling cycles; spring transition timing), inter-annually (ENSO, PDO), and in the long-term (e.g., warming; increasing CO_2). Understanding the dynamics of coastal ecosystems, and their response to climate and anthropogenic impacts, therefore requires an integrated approach that considers interacting effects over a range of spatial and temporal scales. The Hakai Institute's Coastal Observatories combine high frequency field sampling with autonomous instrumentation to measure the interacting effects of land-ocean-atmospheric forcing on marine ecosystems on the coast of British Columbia (central PCTR). Here we outline the observatory framework through the presentation of two case studies: 1) The role of terrestrial carbon in marine food webs – integrating stream discharge, oceanography, and biochemistry, stable isotope analysis; and 2) Ecosystem level response to the "warm blob" in 2014/2015 - integrating oceanography with micro and macrobiological observation.

November 9, 11:30 (S13-11354)

Water quality comparison and ecological environment assessment during major and minor tides in near sea area of Fujian Province

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In order to evaluate the potential ecological risks of nearshore area of Fujian Province, four surveys on water quality, marine sediments and marine biological quality at 20 monitoring sites were carried out during the spring and neap tides in the autumn of 2010 and the spring of 2012. Diversity index (H′), uniformity (J′), abundance (d) and dominance (Y) were measured. The results showed that the background values of heavy metals in the waters were generally low, but eutrophication was obvious. Eutrophication in the autumn was more severe than in the spring. The indices of inorganic nitrogen and active phosphate at all monitoring sites in autumn exceeded the quality standard for sea water. The average primary productivity of the sea area in the spring was 877.3 $mgC \cdot m^{-2} \cdot d^{-1}$, which was higher than that in the autumn (26.60 $mgC \cdot m^{-2} \cdot d^{-1}$). In the research area, there were 4 phyla, 97 species of phytoplankton in the sea water in spring. The composition of dominant species was diversified. The average diversity index H' in the two seasons was 3.28 and 1.52, respectively. The average abundance d was 0.87 and 0.41, respectively. The community structure of phytoplankton in the spring was unstable, and the marine environment in the autumn was more suitable for the growth of a variety of phytoplankton.

November 9, 11:50 (S13-11076)

Multi-parameter observations of whales, zooplankton and hydrography on the west coast of Vancouver Island using ocean gliders

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Whales are an important component of the coastal ocean; they are integral to marine ecosystems, exerting pressure as top predators and planktivores, as well as cycling nutrients and sediments as they feed. They are also cultural icons that drive much of the ecotourism industry in western Canada. Their presence and abundance vary on both large and small temporal and spatial scales, driven largely by variation in their habitat. As whale habitat is defined by diverse biological and environmental factors, sustained multi-parameter observations that also include fine scale examinations over space and time are required. We are addressing this need using ocean gliders, a mobile autonomous data-collection platform, and will report on the first of several deployments on the west coast of Vancouver Island being undertaken as part of the MEOPAR-WHaLE project. The ocean gliders are equipped with passive acoustics for whale detection and soundscape assessment, active acoustics to observe backscattering from their zooplankton prey and hydrographic sensors to observe their physical oceanographic environment. This is a first look at coastal and across-shelf processes that may drive whale habitat use in the Northwest Pacific, and comes at a time of altered oceanic regimes and increasing anthropogenic input to coastal systems. Additionally, this experiment uses the mobile passive acoustics data to identify large baleen whale species in real time, with the dual goals of managing ship strike risk and determining the location and timing of whale hotspots to anchor planning for marine protected areas and endangered species management.

November 9, 12:10 (S13-11372)

Advances in the science and technology underlying measurement of survival of juvenile fish in the ocean

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Major scientific progress often results from engineering advances allowing new scientific questions to be answered. We present an example. Acoustic telemetry arrays provided the first direct measurements of early-marine survival and migratory behavior for acoustic-tagged juvenile salmon. However, the large size of tags limited studies to only the larger smolts (≥140 mm fork length until 2007, then ≥125mm FL starting in 2007). Very small acoustic tags have recently become available, which allows implantation into smaller (≥100 mm) smolts, but at a cost: the tags have shorter range (<100 m). Because larger tags have detection ranges of 300m or 400m, to monitor the same area of the ocean and achieve the same detection performance and statistical precision implies that 16-25 times more receivers would be needed in each monitoring subarray. In 2015 we developed and field-trialed a new subarray geometry. Using only twice the density of receivers previously used resulted in detection performance for free-ranging salmon smolts (74%, SE=10%) equivalent to that previously achieved for larger smolts. It is now technically feasible to directly measure movements and survival in the coastal ocean for fish >100mm. The way is now open to directly test scientific theories concerning the claimed impact of fish farms on wild salmon smolt survival, as well as to quantify the movement biology of a host of other species in unprecedented detail. We outline these results and review the tradeoffs between array design, tag detection efficiency, cost, and the accuracy and precision of the resulting survival estimates.

November 10

Plenary Session

Session 2
Early Life History Stages as Indicators and Predictors of Climate Variability and Ecosystem Change

Session 3
Source, Transport and Fate of Hydrocarbons in the Marine Environment

Session 4
Climate Variability, Climate Change and the Reproductive Ecology of Marine Populations

Session 9
Resilience, Transitions and Adaptation in Marine Ecosystems under a Changing Climate

Session 10
The Response of Marine Ecosystems to Natural and Anthropogenic Forcing: Past, Present and Future

Session 12
Causes and Consequences of 25 Years of Variability in Ocean Conditions on the Ecosystems of the North Pacific

Session 10
The Response of Marine Ecosystems to Natural and Anthropogenic Forcing: Past, Present and Future

November 10, 09:00 (S10-11067)

Influence of phytoplankton-bacterial coupling on the export of biogenic carbon in the ocean: Insights from iron enrichment experiments

Richard B. **Rivkin**[1], M. Robin Anderson[2] and Michelle Hale[3]

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Marine heterotrophic and autotrophic microbes have a pivotal role in the marine biogeochemical cycle of carbon and climate active gasses and nutrients. Generally more than half of the phytoplankton production (PP) is channeled through heterotrophic microbes, mainly bacterioplankton. Most of the PP is respired (R) by heterotrophic microbes and the remainder is incorporated into food webs, i.e. zooplankton (Z) or renewable marine resources (F), or exported (E) below the euphotic zone. At steady state Z and F is channeled toward R or E, hence PP = E + R. In about 35% of the World Ocean, phytoplankton biomass is low and mesoscale Fe fertilization experiments demonstrate that the low Fe concentrations in these areas limit phytoplankton production and growth. Studies in these regions are potentially important for understanding paleoclimate processes as during the last glacial maximum, wind-borne dust carried iron to Fe-limited regions of the ocean, stimulating PP and eventually leading to the removal of CO_2 from the atmosphere and its export to depth. However, export requires that PP must escape microbial-mediated solubilisation and remineralization before carbon is then sequestered. Although the influence of Fe enrichment on phytoplankton has been well studied, there is less information on the response of bacteria and especially the degree of trophic coupling that leads to the retention *vs.* export of CO_2 and biogenic carbon in the upper ocean. Here, the trophic coupling of phytoplankton and bacteria is examined for all mesoscale Fe fertilization experiments and the role of heterotrophic microbes in modulating E is assessed.

November 10, 09:20 (S10-11335)

The Response of Fisheries Production to Natural and Anthropogenic Forcing: Past, present and future

Colleen M. **Petrik**[1], Charles Stock[1], Ken Andersen[2], James Watson[3] and Jorge Sarmiento[1]

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Many empirical relationships between commercial fish recruitment and population biomass with the environment exist, however the mechanisms behind these relationships are rarer. These mechanisms are often region-specific and can dissolve over time. We seek a mechanistic understanding of the variability of commercial fish recruitment and population biomass with respect to natural and anthropogenic forcing, both historically and with future climate change. To do so, we have developed a global stage- and size-based mechanistic model that represents the immature and mature stages of forage fishes, large pelagic fishes, and large demersal fishes. In this talk we will present preliminary results of fish biomass under (1) pristine non-anthropogenic historical forcing (no anthropogenic CO_2, no fishing), (2) historical climate without fishing, (3) historical climate with fishing, (4) and projected business-as-usual climate and fishing. The stepwise addition of forcings in simulations 1-3 separate the effects of each, while simulation 4 forecasts the potential fish biomass response to integrated natural and anthropogenic forcings of climate and fishing. Specific attention will be paid to North Pacific ecosystems.

November 10, 09:40 (S10-11218)

Non-analogue ecosystem states in the Gulf of Alaska

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For much of the 20th Century, winter sea surface temperature in the Gulf of Alaska (GOA) was correlated with population status for a wide variety of fish and crustacean taxa. However, these temperature-biology relationships abruptly deteriorated after 1988/89. Correlations between temperature and other ecologically important climate parameters (freshwater discharge, upwelling intensity, salinity at depth) also changed sign in 1988/89. We propose that the GOA made a switch between non-analogue climate states in 1988/89. Non-analogue climate states are distinct patterns of covariation among individual climate parameters that are symptomatic of nonstationary relationships among fundamental climate processes. Specifically, we hypothesize that changing temperature-biology relationships are related to nonstationary relationships among GOA climate parameters resulting from reorganization of basin-scale climate as NPGO variability replaced PDO variability. We use a combination of statistical ecological modeling and numerical ocean models to test this hypothesis. Observations of ecological responses to non-analogue climate states are extremely rare. However, non-analogue climate states are well known from paleoecology, and are predicted as a widespread outcome of anthropogenic climate change. Non-analogue states in the GOA imply that observations from one ecosystem state may not be useful for making inferences about climate-biology links in another state. This has obvious implications for predicting ecological responses to future climate change. Understanding of non-analogue ecosystem states also suggests a new framework for assessing the ecological importance of ongoing climate perturbations, such as the recent Warm Blob/El Niño event.

November 10, 10:00 (S10-11260)

Applications of downscaled regional ocean biophysical models: Forecasting indicators and fish habitat

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We use model output from downscaled climate forecast simulations for the Bering Sea to evaluate future effects of climate change on selected ecosystem indicators and fish habitat. The forecasts (2002-2039) used forcing files from multiple general circulation models that were part of the Coupled Inter-comparison Project 3 and 5 (CMIP3, CMIP5) from the Intergovernmental Panel on Climate Change (IPCC). The selected general circulation models were chosen based on their ability to capture key features of the eastern Bering Sea: decadal variability and sea ice dynamics. Prior work on ecosystem assessment and essential fish habitat (EFH) identified three key ecosystem indicators (cold pool extent, sea ice retreat, and mean zooplankton biomass), and developed habitat models for economically important groundfish in the eastern Bering Sea. We use walleye pollock as a case study, as it is the main commercial groundfish in the US with total annual catches in excess of one million tons. These applications range from non-spatial time series suitable for use as forcing functions in other models, to geographically explicit weekly, annual or decadal averages suitable to address changes in weekly climatologies or geographical distributions. We emphasize the importance of evaluating the performance of the general circulation models for the region of interest as well as the performance of the downscaled regional model to capture the chosen indicators and relevant features. While downscaled forecast ensemble means provide general trends, the evaluation of a variety of forecasts captures some of the range in the variability of future outcomes and their implications for management.

S2: BIO/TCODE/FIS Topic Session
Early Life History Stages as Indicators and Predictors of Climate Variability and Ecosystem Change

November 10, 10:50 (S2-11356)

Climate change, stock identification, and the distribution of early life stages

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Defining stock boundaries is a fundamental step in fishery stock assessments. These spatial boundaries determine the area over which biological and fishery data is aggregated for use in the assessment. Population structure – a biological attribute – does not directly equate to stock structure – an assessment and management construct – but in general stocks should not spilt a population without explicit consideration of management of one population as multiple stocks. Climate change and long-term climate variability is resulting in changes in species distributions and stock boundaries should be reconsidered in light of these distribution changes. Study of early life stages provides a component of the interdisciplinary approach to stock identification. Distribution patterns reveal information about spawning locations. Distinct spawning locations in time and space are a prerequisite, but not determinative, of population structure, as a species' seasonal and age-based migrations can complicate interpretation of spawning locations. Changes in climate (long-term change or multi-decadal variability) can affect early life stage distributions through shifts in spawning locations, changes in larval dispersal, and changes in larval survival. These various factors will be examined in an analysis of larval distributions and stock structure for species inhabiting the Northeast U.S. Shelf. The utility of early life stages in informing stock structure and understanding population structure will also be reviewed.

November 10, 11:15 (S2-10930)

Climate-driven growth potential affects recruitment signals in coastal age-0 cod surveys from the Atlantic and Pacific

Benjamin J. **Laurel**[1], David Cote[2], Robert S. Gregory[3], Lauren Rogers[4,5], Halvor Knutsen[4,6,7] and Esben Moland Olsen[4,6,7]

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Climate-driven impacts in cod fisheries will likely be manifested in regions where early ontogenetic stages are exposed to thermal stress. Both age-0 Atlantic cod (*Gadus morhua*) and Pacific cod (*Gadus macrocephalus*) use coastal nursery habitats with high seasonal and annual temperature variation, but time series data from these regions is sparse compared to offshore regions where adult populations are typically assessed. In this study, we compiled coastal time-series of beach seine data from the Gulf of Alaska, Newfoundland and Norway to test the hypothesis that recruitment signals are stronger when assessed under thermal conditions that provide high juvenile growth potential. We selected these coastal regions because they: 1) have direct measures of abundance for age-0 and age-1 gadid life stages, and 2) reflect the broad marine environmental characteristics of 'Sub-Arctic' (NE Newfoundland) 'North Temperate' (SE Norway) and 'Boreal' (Gulf of Alaska) ecosystems. Both the statistical and mechanistic growth models supported the hypothesis; weaker recruitment signals were associated with low growth potential from cold winters (Newfoundland) and recent warmer summers (Norway). We conclude that: 1) temperature-dependent growth strongly influences the ability to forecast recruitment among regions, and 2) temporal changes in growth potential (e.g., via climate change) will likely affect recruitment signals by way of changes in juvenile mortality or spatial shifts to more favorable thermal habitats.

November 10, 11:35 (S2-11000)

Decadal-scale changes in larval fish abundance and composition in the Strait of Georgia (British Columbia, Canada)

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The Strait of Georgia (SoG) is an important nursery ground for commercially valuable fish species on the west coast of Canada. Prior to our study, very little was known about either the status or possible changes of the ichthyoplankton community in this coastal basin. Mining of historical data repositories has found that spatially intensive sampling of ichthyoplankton had occurred in the SoG during the late 1960s (1966-1969) and the early 1980s (1980 and 1981) in addition to our sampling in the late 2000s (2007, 2009 and 2010). Comparing the three eras, it can be seen that lingcod (*Ophinodon elongates*) and Eulachon (*Thaleichthys pacificus*), which are now endangered species under the Species at Risk Act (Canada), were in high abundance in larval fish assemblages in the late 1960s compared to the decades that followed. The average concentration of dominant species in the 1980s, *Merluccius productus*, *Theragra chalcogramma*, *Leuroglossus schmidti*, and *Sebastes* spp., had declined by the late 2000s. In contrast, the absolute concentration and proportion of Pleuronectidae and several demersal fish taxa had increased in the spring larval assemblage by the 2000s. Examination of the associations between larval fish assemblages and environmental fluctuations suggests that large-scale climate processes are potential contributors to variations in overall larval concentrations of the dominant taxa and assemblage composition in the SoG. In addition to the field surveys, development of time-series estimates of larval fish productivity by using acoustic technique (parallel transects followed by mark-identification multinet sampling) has been explored in the SoG pelagic ecosystem.

November 10, 11:55 (S2-11177)

The spring spawning habitats of small pelagic fish in northwestern Mexico

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Small pelagic fishes are a shared fishery resource in the California Current System. The shifts in ocean conditions over seasonal and interannual changes result in displacement in geographic distribution and availability of stocks. We evaluated the favorable to unfavorable spawning habitat of sardine, anchovy and both mackerel species and their relations with large-scale fluctuations in the wind field. Data were collected by CUFES and their habitat conditions were evaluated during spring of 2000 to 2005 using thermohaline data. Results showed shifts in the Pacific high-pressure system that causes a direct response in the northwesterly winds and the offshore Ekman transport. The physicochemical characteristics of the habitat occupied by pelagic fishes are modified by changes in the width of the coastal zone and the position of the upwelling front. These conditions may be illustrated by contrasting the conditions observed during 2002 and 2003. In 2002, an enhanced high pressure forcing consistent with increased alongshore equatorward winds produced more upwelling along the coast that in turn extended the distribution of eggs of all species offshore. In contrast, winds during 2003 weakened and produced a relaxation of the coastal sea surface height gradient. The oligotrophic region moved onshore, driven mainly by wind-stress curl, and significant increased abundances of jack mackerel eggs compared to the other species were observed. Although the wind field continuously induced changes in the ocean conditions, habitat selection by these different species provides a natural system of organization for their separation into units that are managed as fishery stocks.

November 10, 12:15 (S2-11222)

Variability, collapse, and recovery of forage fish populations

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We use a unique combination of a 500-year paleorecord and a 60 year survey off southern California to determine intrinsic variability, collapse frequency, cross-correlation, persistence and return times of exploited forage fish populations. We find no evidence that commercial fishing increased the variability of forage fishes beyond the intrinsic natural variability. The paleorecord shows that "collapse" (defined as < 10% of the mean peak biomass) is a normal state repeatedly experienced by anchovy, hake and sardine which were collapsed 29 − 40% of the time, prior to commercial fishing exploitation. Mean (±SD) persistence of 1/3 mean peak biomass from the paleorecord was 19±18, 15 ± 17, and 12 ± 7 years for anchovy, hake, and sardine. Mean return times to the same biomass was 8 years for anchovy, but 22 years for sardine and hake. Further, we find that the current paradigm of sardine-anchovy alternations is incorrect, and that sardine and anchovy are positively correlated on the 500-year time scale, consistent with coherent declines of both species off California. Persistence and return times, combined with positive sardine-anchovy correlation indicates that on average 1−2 decades of fishable biomass will be followed by 1−2 decades of low forage. Forage populations are resilient on the 500-year time scale, but their collapse and recovery cycle is fitted to pulsed exploitation strategies.

November 10, 13:55 (S2-11343)

Decadal changes in abundance and distribution of early life stages of fish in the Kuroshio Current system

Akinori **Takasuka**[1], Hiroshi Kuroda[2], Takeshi Okunishi[3], Michio Yoneda[4], Chiyuki Sassa[5], Motomitsu Takahashi[5], Patricia Ayón[6] and Yoshioki Oozeki[7]

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We firstly review long-term monitoring programs for ichtyoplankton in the Kuroshio Current system, along with some examples taken from other current systems. Then, we introduce our studies on early life stages of fish based on data from egg and larval surveys off the Pacific coast of Japan. Small pelagic fish have exhibited cyclic and dramatic patterns in response to climate changes at large spatial and temporal scales. A prominent example is the out-of-phase population oscillations between anchovy and sardine (species alternations). The pooled data set allowed us to extract representative patterns of spawning responses to environmental factors (temperature, salinity, zooplankton volume, and chlorophyll-*a* concentration) for multiple species of small pelagic fish. A series of interspecific and intersystem comparisons revealed that the spawning responses to environmental factors are species-specific rather than genus-specific, which we consider is key to understanding biological mechanisms behind climate impacts on species alternations and the synchronous patterns of species alternations across the Pacific. The decadal changes in egg and larval abundance well reflected the patterns of species alternations responding to climate changes in the Kuroshio Current system. However, there were more or less discrepancies between egg and larval abundance and adult stock biomass in the long term. The processes of discrepancies need to be understood for early life stages to be used as indicators and predictors of climate variability and ecosystem change. We interpret such discrepancies in the context of maternal effects and survival variability during the early life stages.

November 10, 14:20 (S2-11189)

Two walleye pollock stocks around Japan under different recruitment control mechanism

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Strong year classes (SYCs) of two walleye pollock stocks around Japan, Japanese Pacific stock (JPS) and northern Japan Sea stock (JSS), show some contrasting characteristics. For example, SYCs of JPS are characterized by large body size and early hatching period of larvae and juveniles, and no relationship is observed between numbers of JPS larvae/juveniles and recruitment. In contrast, SYCs of JSS are marked by small body size and late hatching period of juveniles, and a strong positive relationship is recognized between numbers of JSS juveniles and recruitment. It is likely that different predation pressure and larval food availability between the two stocks causes these contrasting traits. For JPS, predation pressure is high mainly due to strong cannibalism, implying that large body size (i.e. high capability to escape) is more important to become a SYC than high abundance at early life stages. This probably results in no relationship between number of larvae/juveniles and recruitment, and early hatching period is profitable for large body size. On the other hand, for JSS, predation pressure is low because of habitat separation between juveniles and adults, but larval food availability is also low. Therefore, high larval survival until the spring bloom is more important for a SYC than large body size. Late hatching period is beneficial for high numbers of survivors, because the larval period under poor food condition is shortened. In addition, the number of survivors may result in positive relationships between numbers of juveniles and recruitment. There is a possibility that recruitment of JPS follows the “bigger is better” theory, whereas that of JSS follows the “match-mismatch” theory.

November 10, 14:40 (S2-11043)

Specific gravity measurements on mackerel eggs and larvae and implications for interannual variability in recruitment

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Based on earlier measurements on the specific gravity of Pacific mackerel (*Scomber japonicus*) eggs in Korean waters, we extended our experiments to the larval stage, because the vertical distribution of fish eggs and larvae are crucial components for determining spatial distribution patterns as well as recruitment variability. The specific gravity of artificially-fertilized eggs and larvae was measured in a density-gradient water column during the spring of 2014-2015. The egg specific gravity during the early egg stage ranged from 1.0203-1.0211, but a sudden increase to 1.0249 occurred just before hatching. However, during experiments conducted in 2014 and 2015, the specific gravity of hatching larvae was very low (1.0195), and tended to increase (1.0233-1.0315) continuously from 4 to 16 days after hatching. For 6 days, especially for 4- to 9-day old larvae, specific gravity measurement showed a diel pattern: the specific gravity observed was highest in the evening while it was lowest at dawn. Diel variation in stomach fullness of larvae was speculated for the observed differences in specific gravity. The changing pattern of specific gravity within a diel period might be an explanation for how mackerel larvae could occupy the surface during night, and inhabit deeper layers during the day through evening hours. Interannual variability in the seawater density of mackerel habitats resulted in different vertical distribution and advection processes, and may consequently affect recruitment variability of mackerel stocks in Korean waters.

November 10, 15:00 (S2-11106)

Comparative larval growth and mortality of mesopelagic fishes and their predatory impact on zooplankton in the Kuroshio waters

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Extensive larval fish sampling has been conducted in the world's oceans to examine the recruitment processes of commercially valuable species. Although the larvae of non-commercial mesopelagic fishes usually dominate the larval fish assemblage, detailed investigations of their ecology are limited to those essential for assessing ecosystem structure and dynamics. Here, we examined the growth and mortality of six numerically dominant mesopelagic fish larvae and their predatory impact on zooplankton in the Kuroshio waters off southern Japan during late winter where spawning grounds of various commercially valuable pelagic fish and squid are formed. The weight-specific instantaneous growth coefficient (G_W) ranged from 0.076 (*Sigmops gracilis*) to 0.156 day^{-1} (*Vinciguerria nimbaria*), while the instantaneous daily mortality coefficient (M) ranged from 0.064 (*S. gracilis*) to 0.143 day^{-1} (*Myctophum asperum*). The ratio G_W/M, an index of stage-specific survival of the larvae, was from 0.89 (*Notoscopelus japonicus*) to 1.25 (*V. nimbaria*), without a significant difference from a value of 1 in all species, indicating that growth and mortality are well-balanced in each species. Based on the reported relationships between G_W and ingestion rate of the marine fish larvae, the daily ration of each species was calculated to be 32.1–57.2% of dry body weight day^{-1}, and mean and 95% confidential interval of prey consumption of the larvae was 3.10 ± 0.85 mg dry weight m^{-2} day^{-1}. Predatory impact of the mesopelagic fish larvae on biomass and production rate of the available prey was estimated to be approximately 1 and 5% day^{-1}, respectively, implying that the larvae have some effect on zooplankton production in the oligotrophic Kuroshio waters.

November 10, 15:20 (S2-11381)

Effects of global warming and ocean acidification on population recruitment and growth of marine economic species

Qinzeng Xu, Zongxing Wang, Xuelei **Zhang** and Shiliang Fan

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Global warming and ocean acidification (OA) are among the major challenges to marine ecosystems. Seawater temperature increases may affect the generation succession and population recruitment of marine organisms. OA also affects the growth of many species, especially those in cultivation. Effective Accumulated Temperature (EAC) for gonad and embryos of common cultured species in China were calculated. The results show that different kinds of species had different EAC. The larval development of cephalopods needed more temperature acclimation. The meta-analysis was also conducted on the OA's impact on the main culture species. Different groups of organisms had different growth responses to OA.

November 10, 15:40 (S2-11145)

Effects of temperature and prey abundances on larval growth rates of Carangid fishes in the East China Sea

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We examined relationships between instantaneous growth rate five days prior to the collection of Carangid fishes, jack mackerel *Trachurus japonicus* and yellowtail *Seriola quinqueradiata*, and environmental conditions measured at the fish collection sites during 2005-2010 in the East China Sea. Since the instantaneous growth rate changed with somatic growth, individual growth rate was standardized based on the mean and the standard deviation of 1 mm size classes as individual relative growth. Ambient temperature for *T. japonicus* and *S. quinqeradiata* were represented by water temperature at 20 m and at the sea surface, respectively. Prey abundance was represented by abundances of Oncaeidae and Paracalanidae copepodites for both species. Mean relative growth of *T. japonicus* was a positive function of temperature at 20 m and abundance of both prey organisms, while mean relative growth of *S. quinqeradiata* was a positive function of temperature but not of prey abundances. Mean relative growth of *T. japonicus* increased from 2005 to 2008 and then gradually decreased after 2009, and it showed comparative trends in prey abundances. Meanwhile, mean relative growth of *S. quinqeradiata* fluctuated interannually, which was comparative with temperature but not with prey abundances. This indicates that interannual variability in larval growth of *T. japonicus* is determined more strongly by prey abundance rather than ambient temperature, while larval growth of *S. quinqeradiata* is affected more strongly by ambient temperature rather than prey abundance. Thus, environmental variables affecting larval growth is species-specific for Carangid fishes in the East China Sea.

November 10, 16:20 (S2-11292)

Examining ichthyoplankton across spatial and temporal scales as an approach to promote understanding and management of fisheries across Large Marine Ecosystems

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Changing climate and oceanographic conditions have sparked significant concern for cascading biological consequences that can impact the overall structure and functioning of large marine ecosystems. In particular, climate impacts to marine fisheries have received considerable focus due to the potential ramifications for communities and stakeholders who depend on the sound, sustainable management of natural resources. The processes that shape fisheries dynamics are complex and non-linear, occurring across a range of spatial, temporal, and organizational scales (individual, population, species, community, ecosystem). One approach to macro-scale fishery management is to develop scale-dependent, tiered management strategies that, taken together, offer a comprehensive approach to addressing a problem that is inherently cross-scale. We illustrate this tiered approach using studies based on ichthyoplankton time series data collected along the US west coast from southern California to Alaska. These data result from long-term monitoring programs supported by the National Oceanic and Atmospheric Administration's National Marine Fisheries Service. We showcase how directed studies at selected scales can inform comprehensive Ecosystem Based Fishery Management, and can be used to develop sensitivity metrics to forecast future perturbations from the individual to the ecosystem level.

November 10, 16:45 (S2-11096)

The influence of climate on the biodiversity and community structure of fishes in the southern California Current, 1969 – 2011

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Previous analyses of CalCOFI ichthyoplankton time series indicated dramatic changes in the abundance of fish populations of the southern California Current System (CCS): a decline by >60% of ~24 midwater fish taxa in response to reduced oxygen concentrations at midwater depths, and a decline by ~70% of key CCS endemics and cool-water affinity taxa since 1969. We show here these abundance changes are associated with changes in the diversity of the CCS fish community. Species richness was positively associated with relatively high midwater oxygen concentration, the warm phase of the Pacific Decadal Oscillation, the Multivariate ENSO Index, and warm near-surface temperatures. On the other hand, the decline of CCS endemics and cool-water affinity taxa was not associated with a change in species richness. However, the markedly reduced abundance of several dominant taxa significantly enhanced the evenness of the fish community. Community structure overall, however, changed relatively little, although regional warming led to the appearance of several rare warm-water affinity taxa and a modest shift toward increasing dominance of the main warm-water affinity taxa. However, there was little change in the rank order of the most abundant taxa, and the list of the 15 most abundant taxa remained virtually unchanged between periods of high and low species richness and evenness. Overall, fish community structure in the CCS has remained stable in recent decades, despite marked changes in abundance of entire suites of species and significant change in several biological diversity indices.

November 10, 17:05 (S2-11237)

Patterns and processes: Spatial and temporal variability in ichthyoplankton assemblages across the Gulf of Alaska

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Understanding the drivers of spatial and temporal patterns in ichthyoplankton distributions is critical to predicting fish community responses to ecosystem processes and climate variability. The Gulf of Alaska (GOA) is an important habitat for a diversity of commercial fisheries species, however, the eastern and western GOA are likely influenced by differing biogeographic patterns, habitat, and oceanographic conditions, and thus may support distinct sub-regional species assemblages. The objectives of this study are to determine the biological and physical processes that influence spatial and temporal patterns of ichthyoplankton communities, transport, and the scenarios that promote connections or divergences in fish assemblages across the GOA. To address patterns and changes in fish assemblages, we utilized six years of ichthyoplankton collections from the eastern and western GOA in conjunction with physical oceanographic data including temperature, salinity, and oceanographic currents measured by drifters. Additionally, we compared sub-regional species assemblages to determine the influence of life-history characteristics on ichthyoplankton community composition. The interactions between oceanographic and biological processes ultimately determine variability in species assemblages across the GOA. Such patterns can provide information to predict juvenile recruitment and to estimate adult population sizes that are critical to the management of fisheries and marine ecosystems.

November 10, 17:25 (S2-11276)

Basin-scale ichthyoplankton response to environmental change in the northeastern Pacific Ocean

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Many studies have linked local changes in ichthyoplankton abundance to climate forcing. We examine five ichthyoplankton time series spanning 35 degrees of latitude in the eastern North Pacific Ocean, and note similarities and differences in their temporal response to local and basin-scale forcing from the species to the community level. Whereas the dominant patterns of community change along the west coast of North American are often correlated with indices of basin-scale climate, such as the PDO, individual species with wide-spread distribution often differ in their response to local variables with latitude, presumably as local conditions change relative to their evolutionary niche.

November 10, 17:45 (S2-11341)

Changes in the ichthyoplankton in the northern California Current during the 2015-16 warm ‘blob’ and El Niño phenomena

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Anomalously warm ocean conditions occurring in the northeastern Pacific Ocean from late 2014 to early 2015, commonly referred to as the ‘blob’, were followed by the strongest El Niño event ever recorded, that lasted into late-spring 2016. To investigate the effects of these phenomena on the ichthyoplankton community in the region, we examined biweekly, nearshore (1-25 nm offshore) larval fish samples collected off the Newport Hydrographic (NH) line along the central Oregon coast in winter (January-March) 2015 and 2016, and compared them to similar collections in 1998-2014. Total larval concentrations in winter 2015 and 2016 were higher than in any of the other comparative years. Larvae of northern anchovy (*Engraulis mordax*), a normally summer spawning species, were found in high concentrations throughout the winter of 2015 and 2016, as were Pacific sardine (*Sardinops sagax*) larvae, which are normally spawned south of our region in summer, and have never before been collected in the northern California Current (NCC) as early in the year. After examining additional samples, we found northern anchovy present in the ichthyoplankton as late as mid-October 2015 and as early as early-January 2016. Also, we found high concentrations of larval Pacific hake (*Merluccius productus*), which are normally spawned south of our region during spring, in samples collected 35-105 nm offshore along the NH line in February 2016. These findings suggest that the phenology of several important fish species in the NCC dramatically and rapidly changed in response to the warming conditions occurring from fall 2014 through spring 2016.

S3: MEQ Topic Session
Source, Transport and Fate of Hydrocarbons in the Marine Environment

November 10, 15:10 (S3-11366)

Sources, behaviour and environmental impacts of petroleum hydrocarbons released into the marine environment

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Petroleum hydrocarbons remain as a primary fuel source for global transportation and a vital material resource for industrialized nations. The world at large consumes 30 billion barrels (4.8 km³) of crude oil per year. To meet both domestic and international demand, oil must be transported from where it is recovered, including offshore reserves, to where it will be refined and ultimately, used. As recent events have demonstrated, accidental releases of petroleum hydrocarbons (e.g., oil spills from offshore platforms, ships, and pipelines) into the marine environment will continue to occur, despite advances in technologies and safety protocols.

Do we have sufficient knowledge about how crude oils and its refined products behave when released into our oceans, to develop effective strategies for spill preparedness, spill response and remediation? In addition to the "catastrophic oil spills" reported by the media, do we fully understand the ecological impacts associated with natural (e.g., oil seeps) and operational waste discharges (e.g., produced water disposal from offshore platforms) of petroleum hydrocarbons?

Studies have demonstrated that the unique chemical properties of various types of oil, including non-conventional products such as diluted-bitumen, influence their transport, fate, and potential impacts on aquatic organisms. Based on a review of published case studies, it has been concluded that the overall impact of an oil spill, including the effectiveness of an oil spill response, depends mainly on site specific environmental conditions and the time lost before remedial operations. Limitations in the availability of pre-spill baseline data and information on the efficacy of spill response tools have impeded the selection of optimal spill response plans and our ability to monitor and predict the long-term effects. Based on the identification of knowledge gaps, recommendations are given on how we should optimize the outcome of multi-disciplinary research programs to improve future policies, regulations and practices to ensure the protection of our oceans and their living resources.

November 10, 15:40 (S3-10885)

Physiological responses of marine phytoplankton to oil exposure in the context of the 2015 oil spill in the Santa Barbara Channel

Tanika M. **Ladd**, Jessica A. Bullington, Andrea Valdez-Schulz, Paul G. Matson and M. Debora Iglesias-Rodriguez

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On May 19, 2015 an onshore pipeline about 20 miles west of Santa Barbara (California, U.S.A.) leaked between 101,000 and 140,000 gallons of crude oil with an estimated 21,000 gallons entering the ocean. The timing of this spill coincided with the spring phytoplankton bloom in the Santa Barbara Channel. Throughout May 2015, the toxin (domoic acid) forming diatom, *Pseudo-nitzschia* spp., was abundant and, in early June, an unprecedented coccolithophore bloom, largely represented by *Emiliania huxleyi*, was observed. Although relatively understudied in the context of oil spills, the responses of individual phytoplankton groups and phytoplankton communities to oil exposure in previous experiments have shown high variability likely due to species-specific sensitivity to oil, initial community composition, and the type and amount of oil used. We conducted laboratory experiments in order to assess physiological impacts of the oil spill on two important phytoplankton species, *Pseudo-nitzschia australis* and *Emiliania huxleyi*, present in the local environment at the time of the spill. Batch cultures of phytoplankton were grown in nutrient-supplemented media with or without oil to determine how growth, photosynthetic health, domoic acid production (only in *P. australis*), calcification (only in *E. huxleyi*), and transparent exopolymer production are altered in the presence of this contaminant. This talk will discuss the results of these experiments in the context of the Santa Barbara Channel environmental conditions at the time of the oil spill and the implications for the local ecosystem and human health.

November 10, 16:20 (S3-11034)

Photo-oxidation of crude fuel and its toxicity to marine amphipods

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To simulate one of the weathering processes of spilled crude fuel in the marine environment, we conducted a laboratory-scale experiment of sunlight-irradiation of a fuel patch on seawater. A drastic decline of the aromatic fraction in the crude fuel by sunlight-irradiation was observed. Dissolved organic carbon (DOC) concentration as well as ultra-violet (UV) absorbance in seawater were found to linearly increase with the duration of sunlight-irradiation, while no intensive increases in DOC and UV absorbance was observed in the dark control. The seawater under the sunlight-irradiated fuel patch was withdrawn and subjected to acute toxicity test by using an amphipods, *Hyale barbicornis*, which showed significant increase in mortality of tested amphipods with duration of sunlight-irradiation, while no significant increase in mortality was observed in the dark control. Water-soluble compounds formed by photo-oxidation of the crude fuel were subjected to gas chromatography equipped with a mass spectrometer after solid phase extraction. Some ketones were detected from the sweater under sunlight-irradiated crude fuel, and some analogous aromatic ketones such as acetophenone and their alkylated-homologues were individually subjected to the amphipods toxicity test. These ketones showed toxicities to amphipods and the increment of the number of methyl group bonded to acetophenone contributed to the increase in toxicity. However, these ketone compounds were unlikely to cover whole toxicity exerted by the seawater under sunlight-irradiated fuel.

November 10, 16:40 (S3-11195)

In situ formation of oil-suspended particulate matter aggregate during flushing activities

Andrew **Loh**[1,2], Un Hyuk Yim[1,2], Sung Yong Ha[1] and Joon Geon An[1]

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After the collision of the Singapore-registered oil tanker, *Wu Yi San* into the oil terminal of Yeosu port, approximately 800 tons of oil mixture was released from the ruptured pipelines. Emergency oil spill responses were performed to recover and clean the spilled oil in a short period of time. However, considerable amounts of residual oils were found along a beach located 2 km from the accident site during a monitoring program a year after the spill. In an attempt to remediate the residual oil, the beach was subject to consecutive flushing: seawater under high pressure was repeatedly applied over residual oil-sediment mixtures. Resuspended residual oils were collected through snares and adsorption pads. During the flushing operation, large amounts of suspended particulate matters (SPM) were also resuspended, which promoted oil-SPM interactions, providing favorable conditions for formation of oil-SPM aggregate (OSA). *In situ* formation of OSA was identified by microscopic and chemical analysis. Large size multiple droplet type OSA was dominant. Mass balance of resuspended oil in various forms was estimated by laboratory OSA simulation using natural seawater and spilled oil. The percentage of surface oil slick, neutral buoyancy OSA, and negative buoyancy OSA were calculated as 52.2±10.7, 32.2±9.8, and 15.6±3.5%, respectively. The neutral buoyancy OSA remained stable for more than 3 months, which might be sufficient time for biodegradation. Flushing activities in turbid environments were found to increase the availability of re-suspended SPM, which (1) minimized oil recoalescence and/or adhesion to the shoreline, (2) increased oil dispersion, and (3) enhanced natural biodegradations.

November 10, 17:00 (S3-11208)

How far will it go? The estimation of oil spill extents from surface drifter data

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Oil spill response planning and risk assessments are generally based on numerical modelling studies, which are driven by output from ocean circulation models. This approach is well-established, and very useful where operational circulation models of the study area exist. But what if this is not the case? Establishing a new circulation model capable of accurately resolving the complex dynamics of the upper few meters of the ocean is an arduous task, especially in coastal areas. In this talk, we present an observation-based statistical model of oil spill extents that is complementary to the numerical modelling process. Starting in 2014, 232 surface drifters of a novel design have been released in the Douglas Channel area of British Columbia. The behaviour of these drifters closely mimics that of oil, as we have confirmed by comparing the drifter tracks to observations from a previous oil spill in the area. By analysing the data from these drifters, we establish a simple statistical model for predicting the evolution of an oil spill's extent through time.

November 10, 17:20 (S3-11216)

A framework to assess vulnerability of biological components to oil spilled in the marine environment

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In support of the development of oil spill response planning, we have developed a framework for identifying biological components which may be most affected by oil. The framework uses a set of criteria which allows for a structured approach to guide the selection of the biological components most sensitive to oil. Criteria are divided in three categories: Exposure, Sensitivity and Recovery, each encompassing several criteria. Criteria are applied to species groupings, which in this top-down approach eliminates requirements for assembling species lists at the onset of the process. Criteria are envisaged to be consistent and broad enough to be usable in a variety of environments. Criteria scoring and a screening process produce the primary outcome of the framework: a list of species sub-groups identified as being most vulnerable to spilled oil. Another important outcome of this work is the identification of knowledge gaps to prioritise future research. This framework is currently being piloted in four different locations on the East and West coasts of Canada (Salish Sea, St. Lawrence, Port Hawkesbury, Bay of Fundy). A full application of this framework has been completed for the Salish Sea and will be presented. We anticipate this framework will be useful for identification of biological components most affected by oil in any marine environment.

S4: FIS Topic Session
Climate Variability, Climate Change and the Reproductive Ecology of Marine Populations

November 10, 10:50 (S4-10973)

Crucial factors affecting reproductive investment of marine fishes in a changing climate

Olav Sigurd **Kjesbu**[1,2]

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Reproduction, especially the spawning stage, is a critical part of the life cycle of oviparous teleosts facing climate change. Generally, for this category of animals, studies regarding reproductive investment (RI) as a function of environmental drivers are limited to either variation in egg size (and quality) or fecundity, and consequently, pairwise, individual data sets of this type are rare. However, RI dynamics can provide insight for the timing when the reproductive organ requires optimal conditions for development, and hence its sensitivity to environmental fluctuations. Furthermore, parallel comparisons between variation in egg size, egg quality and fecundity can provide information about which trait is more dynamic (or critical) and thereby indicate where future research should be focused. Usually, egg characteristics or fecundity measurements are related directly to biotic or abiotic information, however this excludes past influences on the expression of these reproductive traits. The longer history might be more important for fecundity than for egg size, as the latter is normally determined just before, or during, spawning. Studying the underlying processes that ultimately define fecundity is challenging because of the methodological challenges in quantifying oogonia and the smallest oocytes. In this presentation, attention will be given to recent methodological advancements to address the reproductive ecology of Atlantic herring and cod in light of climate variability and change. The latter is expected to be particularly pronounced in northern high latitudes. The reproductive information presented will then be placed within the framework of recruitment dynamics – currently a key area for discussion.

November 10, 11:20 (S4-11077)

Fish responses to climate variation along a capital-income breeding continuum

Richard S. **McBride**

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Fish will adapt, and not simply move, in response to environmental variability. Predicting responses can be informed by examining fish reproductive diversity. Some species spawn and feed in separate areas, during different seasons, by storing energy and drawing on it later for reproduction (i.e. capital breeding). Other species spawn using energy acquired locally, throughout a prolonged spawning season, allocating energy directly to reproduction (i.e. income breeding). There are advantages to both strategies. The spawning period for capital breeders can occur during energetically unfavorable periods for the adult or favorable periods for their propagule survival. Income breeding allows small fish to overcome allometric constraints of egg production. Income breeders also recover quickly when good feeding conditions are re-established. Many species exhibit mixed capital- and income breeding patterns, which has not been well recognized until now. If change creates poor-feeding environments, this can lead to delayed maturation, skipped spawning, fewer spawning events per season or fewer eggs produced per event. These flexible processes allow females to prioritize their own condition over their propagules' condition at any given spawning opportunity, thereby investing energy cautiously to maximize lifetime reproductive value. However, although this flexibility maintains individual resiliency, if such conditions are sustained, it reduces population reproductive potential and can change the phenotypic structure of economically important fish stocks. As capital breeders are common at boreal latitudes, where temperature change rates are highest, they will be affected first or most dramatically early on, but change will not be limited to this type of breeder.

November 10, 11:50 (S4-11047)

Temperature-related variability in the resource allocation to egg production in Japanese anchovy *Engraulis japonicus* as revealed by stable isotope approach

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Temporal relationship between resource acquisition and allocation to reproductive output (e.g., continuum between capital and income breeding) has been discussed for many marine fish species. However, the processes by which environmental variability affects the capital–income continuum of a given species has not well been studied. This study explores the impacts of water temperature on the resource allocation tactics of the Japanese anchovy *Engraulis japonicus*, through diet-switching experiments using carbon and nitrogen stable isotope ratios (SIRs) as quantitative indicators. To monitor the changes in the SIRs in eggs during the spawning season, under ad libitum food availability low SIRs feed was provided initially, then was switched to feed with high SIRs. In all cases, both carbon and nitrogen SIRs in eggs increased and converged at specific values after the diet-switch, suggesting the evidence of income breeding. However, the estimated transfer rates of income food intake to eggs varied along with the degree of prevailing temperature (the higher the temperature, the faster the rate). Also, mixed income and capital breeding was suggested for one case with a low temperature regime. These variations may be caused by a physiological response to thermal conditions as temperature strongly affects certain reproductive tactics of this species (e.g., batch interval, size of eggs). Further studies on the possibility of environmental-related variability on the capital–income continuum could assist in understanding the impact of climate change on reproductive output of marine fish species.

November 10, 12:10 (S4-11332)

Female reproductive potential of eastern Bering Sea snow crab (*Chionoecetes opilio*)

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Commercially-important eastern Bering Sea snow crab (EBSSC) are managed with a large-male only harvest strategy based primarily on estimates of mature male biomass. We conducted research on female reproductive potential to improve understanding of population dynamics and fishery sustainability. Environmental factors, especially temperature, are known to mediate life history traits of EBSSC with implications for female reproductive success, including female size at maturity, reproductive tempo (annual or biennial duration of egg development), ontogenetic migration, and distribution patterns. We found that most primiparous females received sufficient sperm to fertilize their first clutch (based on evaluation of egg viability); however, remaining low levels of stored sperm indicated many females would need to re-mate to produce subsequent fertilized clutches. Multiparous crab had higher mean sperm reserves (as weight of spermathecae contents) than primiparous crab, indicating most females participated in another mating season after producing their first clutch. The highest levels of sperm reserves were observed in the southeastern Bering Sea, where warmer bottom temperatures and larger females predominate, and the lowest levels occurred in the northwest, where temperatures are cooler and smaller females prevail. Ongoing research is addressing the confounded relationships between sperm reserves, female body size, latitude, and temperature as well as details associated with the second year of a female's biennial reproductive cycle, including location and inferred history of participation in multiple mating seasons. We will discuss how temperature interacts with life history to shape female mating success and possible directions for accounting for these dynamics in stock assessment and fishery management.

November 10, 14:00 (S4-11199)

Size dependent energy allocation to reproductive output of short-lived multiple-batch-spawning Japanese anchovy *Engraulis japonicus*

Michio **Yoneda**[1], Satoshi Katayama[2], Naoaki Kono[3], Masayuki Yamamoto[4], Tatsuo Tsuzaki[1] and Hiroshige Tanaka[5]

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This study explored the possible flexibility of energy allocation to reproductive output between small (offspring, F1) and large (mother, P) individuals of Japanese anchovy using carbon and nitrogen stable isotope ratios (SIRs) as quantitative indicators. Initially, feed with high SIRs was provided and then switched to feed with low SIRs for monitoring the changes in the SIRs of muscles and ovaries over the study period. The increases in growth rates were evident in F1 while the body size of P remained constant over the experiment. The SIRs of muscles in F1 decreased faster than those in P, suggesting that F1 could allocate more income resources to muscles than P. There was a significant difference in reproductive output between F1 and P; P produced more and heavier eggs than F1. The SIRs of ovaries in both P and F1 decreased after the diet-switch, but the slopes of F1 were significantly higher than those of P. These results suggest that F1 could be largely income breeding while P may invest mixed income and capital resources to reproductive output. In Japanese anchovy, increasing temperature leads to shortening of batch intervals under *ad libitum* food availability, but insufficient income resources could lead to prolonged batch intervals. This implies that, in terms of reproductive potential, smaller mature individuals might be more vulnerable to fluctuating prey availability. With warming sea temperature, even in short-lived multiple-batch-spawning fishes, larger mature individuals may have the advantage of bet-hedging strategies that help fostering stock productivity and stability.

November 10, 14:20 (S4-11213)

Variability in spawning omission and the productivity of deepwater rockfish in the North Pacific Ocean

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Recent examination of the maturity of three deepwater rockfish species (shortraker rockfish, *Sebastes borealis*, rougheye rockfish, *S. aleutianus*, and blackspotted rockfish, *S. melanostictus*) in the Gulf of Alaska revealed a high proportion of non-spawning mature fish, or skip spawners. The proportion of skip spawners varied among species. However, at least 30% of individuals determined to be adults were undergoing spawning omission during the upcoming reproductive season, and, in at least one species, the prevalence of skip spawners was related to size. Specimens for this study were primarily collected during the 2010 reproductive season in the central Gulf of Alaska; additional data are needed to determine the consistency of skip spawning across various temporal and spatial scales. The presence of skip spawning fish will influence the stock assessment results for these species. It is anticipated that the frequency of skip spawners will vary depending on environmental conditions, and that climate change may have significant impacts on the reproductive productivity of these species. Using a simulation model based on the life-history and assessment of the shortraker rockfish, we examined how variability in the presence of skip spawners impacts estimates of spawning biomass and recommended catch limits for this species.

November 10, 14:40 (S4-11322)

Impacts of recent environmental anomalies on seabirds of the Baja California Pacific Islands, Mexico

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As part of a long-term seabird restoration project on seven island groups in the Pacific Ocean, off the Baja California Peninsula, Mexico, we have been monitoring colonies of Brown Pelican (*Pelecanus occidentalis*; BRPE) and Brandt's Cormorant (*Phalacrocorax penicillatus*; BRAC). During the past couple of years, these two species have experienced an unusual nesting and reproductive behavior. We assessed the relationship between the number of BRPE and BRAC nests and environmental anomalies within the region. A general decrease was observed in the amount of nests for both BRPE and BRAC during 2014 and 2015 in comparison with historical numbers. In 2015, 38% of BRPE nests and 50% of BRAC nests were abandoned and a low reproductive performance was recorded for both species (<0.5 fledglings/breeding pair). Sea surface temperatures (SST) around all seven island groupswere warmer in 2014 and 2015 than the typical year (calculated for the period 2003-2016) while chlorophyll-a (Chl-a) concentration was lower than the 14-year average. The highest anomalies of both SST and Chl-a were recorded during 2015. Therefore, changes in seabird nesting patterns, reproductive performance and survival are most likely due to less food availability during warm El Niño type climatic anomalies. Extensive and long term research on seabirds is being conducted on the Baja California Pacific Islands, including: nest censuses, productivity analyses, feeding behavior studies and at-sea movement pattern monitoring. Additionally, the relationships between ocean and atmospheric conditions, breeding success and migration patterns will continue to be evaluated.

November 10, 15:00 (S4-10918)

Challenges associated with assessing maturity, skipped spawning, and abortive maturation rates for fisheries managers: A case study of *Sebastes pinniger*

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By incorporating accurate estimates of life history parameters into population models, we increase the reliability of biomass estimates used to manage fish stocks. In addition, understanding the reproductive biology and life history strategies of these fish provides support for sustainable management. However, data collections restricted by seasonal surveys create challenges for gaining a full understanding of their reproductive biology. Many groundfish species on the U.S. West Coast spawn between November – March, when opportunities to collect biological data on surveys or from fisheries landings are limited. We examined the reproductive biology of canary rockfish, *Sebastes pinniger*, using ovaries collected by the West Coast groundfish bottom trawl survey from 2009 – 2015 (n = 533) and Oregon Department of Fish and Wildlife port biologists from 2014 – 2016 (n = 308). These collections allowed for comparisons of length and age at maturity estimates based on the histological examination of ovaries collected within and outside the spawning season. We identified several key factors essential for understanding reproductive biology of west coast groundfishes: (1) spatial and temporal patterns, (2) the effects of oceanographic conditions on reproductive patterns related to skip spawning and abortive maturation, and (3) the estimation of biological (sexual) versus functional (potential spawner) maturity for fisheries management models. Ecosystem variables, such as habitat, food availability, upwelling, and oceanographic patterns may also have an outsized influence on the reproductive behavior of groundfish stocks. Understanding how these variables influence reproduction can provide useful information for predicting the influence of shifting oceanographic conditions on the spawning output of groundfish stocks.

November 10, 15:20 (S4-11014)

Inter-annual variation in the reproductive pattern of Manila clam *Ruditapes philippinarum* and impacts of *Perkinsus olseni* infection on the reproduction observed from the west coast of Korea

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We monitored inter-annual variation in gametogenesis, egg production and the level of *Perkinsus olseni* in Manila clams distributed on the west coast of Korea over a four year period. For the analysis, clams were collected monthly from January 2007 to December 2010 from high *P. olseni* infection area (Hwangdo). Gonad development and quantity of the eggs in individual clams were determined simultaneously using histology-ELISA combined assay. *P. olseni* infection intensity in each clam was determined using RFTM and 2M NaOH digestion assay. *P. olseni* level in clams varied year to year remarkably. The infection intensity increased markedly from June 2008 (1.5 million cells/g tissue) to January 2009 (4.6 million cells/g tissue). In 2009, the infection level stayed in high ranging 1.92 (September) to 4.6 million (January) cells/g tissue. Mass mortality of Manila clam was observed (ca 40%) during the post spawning season in 2009. In spring 2010, *P. olseni* infection level dropped markedly, ranging from 0.6 to 1.3 million cells/g tissue. Monthly mean *P. olseni* density in clams in 2010 was significantly lower than the previous year, possibly due to the mass mortality which might remove the heavily infected clams. During 2007 and 2009, female clams in the area showed comparatively longer spawning period, from June to October, with the pulses in August and September. GSI of the females during the spawning peaks from 2007 to 2009 varied from 4.8 (2009) to 11.4% (2007), which were comparatively smaller than GSI of clams at the low infection area. In 2010, as the *P. olseni* level dropped, the females spawned in June and July, 2-3 months earlier than the previous years. The GSI from the females in June was recorded as 16.8%. The earlier spawning, combined with higher GSI observed, demonstrated remarkable inter-annual variation, which was in part explained by the decreased abundance of *P. olseni* due to the mass mortality in the previous year.

November 10, 15:40 (S4-11312)

Interannual variability in larval production of rockfishes (*Sebastes* spp.) in the California Current

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Climate effects on ecosystem productivity are well established for the California Current, and climate variability is reflected in bottom-up effects on fish growth and productivity. Stock assessments have begun to include these important effects in estimating critical metrics such as growth, spawning biomass, spawning output and recruitment, however, such variability is often difficult to quantify and typically even more difficult to appropriately account for in assessment models. In this study, we explored the consequences of variable oceanographic conditions on female larval production by assessing interannual differences in fecundity and maternal condition. From 2009 through 2016, rockfish were collected during the winter reproductive season by hook-and-line methods off Central California. We combined our results with two published datasets to create a time series of female condition and egg production for *Sebastes goodei* (2005-2008, 2009-2016) and *S. flavidus* (1985-1991, 2005-2008, 2009-2016). *S. flavidus* exhibit the typical annual reproductive cycle commonly observed throughout the genus, whereas *S. goodei* are capable of producing multiple broods of young over a single reproductive season, the consequences of which are not fully understood, or accounted for in production models. The results of this study will be used to incorporate effects of variable oceanographic conditions on growth and reproduction into West Coast rockfish stock assessments.

November 10, 16:20 (S4-10975)

Evaluating environmental effects on maturity, spawning stock biomass, and biological reference points of Georges Bank Atlantic cod using state-space models

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The proportion mature, as a function of age, is an important input to age-structured stock assessment models for estimation of spawning stock biomass (SSB) and biological reference points (BRPs). Maturity at age is often assumed to be known and constant over time in stock assessment models. However, environment is known to influence maturation, and changes in maturation rates will produce unaccounted for annual variation in SSB and BRPs. Furthermore, uncertainty in maturity parameter estimates result in additional uncertainty in the annual estimates of SSB and BRPs. We fitted different maturity models as functions of age and bottom temperature to observations for the U.S. Georges Bank Atlantic Cod (*Gadus morhua*) stock, and compared model performance based on AIC. The models include a state-space component for annual variation in bottom temperature and associated observations. We then simultaneously estimated the best performing model with a state-space age-structured assessment model to evaluate effects of annual variation in maturation on SSB and BRPs. We also fitted an assessment model where the maturity at age was treated as fixed input, to evaluate effects of maturity parameter estimation on uncertainty in SSB and BRPs estimates. Bottom temperature in the first, second, and third year of life were important predictors of maturity for Georges Bank cod. Effects of uncertainty in maturity parameter estimates were variable over time, but did not typically add substantially to the uncertainty in annual SSB and BRP estimates.

November 10, 16:40 (S4-11102)

Fisheries-induced evolution effects on fish populations in the East China Sea and its management implications

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In recent years, increasing evidence demonstrated that the fish phenotypic traits have changed in many exploited fish populations. Typical examples of the fish phenotypic traits are smaller size-at-age and an earlier age-at-maturation. The East China Sea, one of the over-exploited ecosystems in the world, most of the fish populations, such as hairtail (*Trichiurus lepturus*) are under overfishing. Fishing selectivity has great potential to change the biological characters of exploited fish populations. Long-term fishing pressure induced changes in fish phenotypic traits, eventually fisheries-induced evolution. Here, both simulation and experimental methods are used to evaluate fisheries-induced evolution effects on commercially-important fish populations in the East China Sea and to explore the differences of the phenotypic plasticity and irreversibility when halt fishing pressure. Our results contribute to basic theoretical development in the study of fisheries-induced evolution, and also suggest important implications for the references of fishery management.

November 10, 17:00 (S4-11028)

Differences in biological characteristics and recruitment variability of walleye pollock (*Gadus chalcogrammus*) off the eastern Korean Peninsula during 1960s–2000s

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Commercial catches of walleye pollock (*Gadus chalcogrammus*) has been recorded in South Korean waters since the mid 20th century, and there have been several developing stages in this fishery over the last 5 decades. Concurrently, the National Institute Fisheries Science has collected information from biological specimen and habitats, and ecological characteristics on pollock were investigated during the beginning stage of fisheries (Period 1: 1958-1968), peak fishing period (Period 2: 1973-1985) and after peak fishing (Period 3: 1991-2002), respectively. Length at 50% maturity was 37 cm at age of 3, and a significant difference in length frequency distribution was found. In Period 1, large-sized old pollock (>40 cm) as well as young immatures were obviously abundant, while the high proportions of maturing adult (25-37 cm) were common in Period 2 and Period 3. Proportional Size Distribution (PSD) analysis indicates that PSD values lowered in Period 2 and Period 3, which means moderate proportion of individuals entered recruitment in later periods. Condition factor was positively correlated with euphausiid in August ($r=0.619$, $p<0.01$) and December ($r=0.678$, $p<0.01$) and with zooplankton biomass in summer through winter ($r=0.478\sim0.631$, $p<0.05$). The Cross-Correlation Function analysis showed that there was a significant positive correlation between juvenile walleye pollock catch and euphausiid in June with the time lag of 1 year ($r=0.566$, $p<0.05$). Also, the adult pollock catch and zooplankton biomass showed positive correlation in June with the time lag of 3 year ($r=0.483$, $p<0.05$). These results imply that biotic environmental factors during the early life stages of pollock have a significant influence on recruitment.

November 10, 17:20 (S4-11330)

Fecundity estimates for walleye pollock during varying climate conditions

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Atresia, or oocyte resorption, may occur to remove abnormal or damaged oocytes or as a way to adjust resource allocation towards reproduction as in downregulation. High levels of atresia may result from anomalous water temperatures that prevent normal oocyte development or indirectly limit nutrient intake by reducing available prey. Because female spawning biomass is used as a proxy for reproductive output in stock analysis of pollock, understanding the processes associated with atresia are important for stock assessments. For this work we look at the seasonal patterns of atresia and the level of occurrence in specimens analyzed for fecundity. Collections include specimens from the Gulf of Alaska, the Bering Sea, and the Aleutian Islands from the early 1990's to present. These data are used to compare the level of occurrence and the developmental stage of oocyte atresia to adult estimates of fecundity and body condition along with the impacts of environmental variations such as temperature and ocean productivity.

S9: FIS/TCODE Topic Session (DAY-2)
Resilience, Transitions and Adaptation in Marine Ecosystems under a Changing Climate

November 10, 11:50 (S9-11317)

Are Arctic and sub-arctic fish stocks more prepared for a changing climate?

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This paper examines current and projected ocean shelf ocean conditions in 5 high latitude Arctic ecosystems. Estimates of sea surface temperature, bottom temperature, and total net monthly production show marked within season stability and dramatic between season changes. This paper examines the implications of climate change in five distinct shelf domains: the northern Bering Sea, the Chukchi Sea, the Beaufort Sea, the Canadian Archipelago and north Greenland Shelf, and the Barents Sea. These domains include in-flow, outflow and interior shelf domains. Spring and summer ocean conditions in the present, near – future and longer-term future are derived from the CMIP5 earth system model of the Geophysical Fluid Dynamics Laboratory Earths System Model (GFDL-ESM2) under two representative concentration pathways (4.5 and 8.5). Near term and longer term projected changes from current ocean conditions are considered within the context of current variability using z-scores. Significant within season changes in sea surface temperature and bottom temperatures are projected. However, despite projected changes in temperature, the projected seasonally averaged monthly net total production appears to be limited by seasonal light. We examine the adaptations of fish and shellfish residing in the 5 high latitude regions to discern key mechanisms underlying survival of marine fish in the high arctic.

November 10, 12:10 (S9-11244)

Going with the flow: Ocean currents modify the coupling between climate change and biogeographical shifts

Jorge **García Molinos**[1], Michael T. Burrows[2] and Elvira S. Poloczanska[3]

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Biogeographical shifts are a ubiquitous global biodiversity response to climate change. Responses across taxa and geographical locations are however highly variable and only partially explained by climate. Here, using a global meta-data set of marine climate-driven distribution shifts, we demonstrate that a significant proportion of this unexplained variation can be accounted for by coupling climate expectations with other non-climatic drivers. In particular, we found ocean flow directionality to both facilitate and hinder shift responses to warming depending on its agreement with spatial gradients of temperature. These effects were dependent on the location of the shift within a species' range and its biological identity, evidencing links between range and ocean dynamics through climate. Our novel results strengthen confidence on the global imprint of climate change on distribution shifts and stress the importance of framing expectations by reference to other interacting non-climatic factors shaping the coupling between climate change and biogeographical shifts.

November 10, 14:00 (S9-11135)

Life history spatial constraints and species adaptability to climate change

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Climate change is affecting ecological processes and biogeochemical cycles of marine environments. Species respond and adapt to climate change by shifting their spatial distribution. However there are limits to these changes, imposed by the presence of essential habitats and critical conditions in the species life cycle, such as during spawning, overwintering, and settlement. These limits are linked to the species life history strategy, and cannot be solely overcome through phenotypic plasticity – genetic adaptation is also required. In this study we develop and apply analytical methodologies to identify and quantify the spatial constraints throughout a species' entire life cycle. Spatial constraints are identified and quantified by assessing the spatial distribution of 3-5 well-monitored commercially harvested fish populations throughout their respective life cycles. The methodology assumes that spatial configurations that are consistently repeated over time (e.g., during spawning, settlement or larval dispersal phases) are indicative of strong spatial constraints. To allow extension of the analysis to data poor species (i.e., species for which we have life history information but lack survey data), we conceptually relate constraints (intensity and timing) to life history traits of data-rich cases, including migration distance, longevity, time of maturation, pelagic larval duration, sensory abilities, social structure. Through this analysis, and its conceptual extension, we build capacity to study species adaptability and resilience to climate change utilizing analytical approaches that can account for potential bottlenecks affecting spatial distribution of a species throughout its life cycle.

November 10, 14:20 (S9-10884)

Assessment of management strategies for eastern Bering Sea walleye pollock fishery with climate change

Chang **Seung** and James Ianelli

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Recent studies indicate that rising sea surface temperature (SST) may have negative impacts on eastern Bering Sea walleye pollock stock productivity. A previous study (Ianelli et al. 2011) developed projections of the pollock stock and alternative harvest policies for the species, and examined how the alternative policies perform for the pollock stock with changing environment. The study, however, failed to evaluate quantitative economic impacts. The present study showcases how quantitative evaluations of the regional economic impacts can be applied with results evaluating harvest policy trade-offs; an important component of management strategy evaluations. In this case, we couple alternative harvest policy simulations (with and without climate change) with a regional dynamic computable general equilibrium (CGE) model for Alaska. In this example we found (i) that the status quo policy performed less well than the alternatives (from the perspective of economic benefit), (ii) more conservative policies had smaller regional output and economic welfare impacts (with and without considering climate change), and (iii) a policy allowing harvests to be less constrained performed worse in terms of impacts on total regional output, economic welfare, and real gross regional product (RGRP), and in terms of variability of the pollock industry output.

November 10, 14:40 (S9-11086)

Fisheries collapse and social changes in a fishing-dependent community: The case of Goseong

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There has long been much interest in how human society and ecosystems interact. Fishing-dependent communities and their surrounding marine ecosystems, which together form a marine social-ecological system, are one good example that reveals the interaction.

This study explores the changes of a fishing-dependent community brought on by the collapse of the walleye pollock (*Gadus chalcogrammus*) fishery. Goseong, a small fishing town situated in the central part of the Korean peninsula, enjoyed economic prosperity through its pollock industry until the fishery collapsed in the early 2000s. This paper illustrates the complex interaction between human society and ecosystems by addressing three major questions. First, we will provide the historical background of the pollock industry in Goseong in its social and ecological context. Second, we will explore how society changed along with the pollock industry, specifically by highlighting how the industry coped with the pollock crisis through large-scale social indicators and in-depth interviews. The collapse brought about changes including demographic change and economic distress in the community, to which relevant actors coped with the changes by adopting alternative livelihoods while clinging to their existing way of life and local identity. Third, we will detail the reasons why Goseong failed to successfully adapt to the pollock population collapse. This case study offers insight into how human societies react to changes in ecosystems.

S10: FUTURE Topic Session (Day 1)
The Response of Marine Ecosystems to Natural and Anthropogenic Forcing: Past, Present and Future

November 10, 10:40 (S10-11157)

An ecological compensation mechanism for marine protection area in China, based on the ecosystem services valuation

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Rapid economic growth has resulted in serious degradation in many ecosystems in China. Since the 1990s, policies were developed by the Chinese government to curb unsustainable interactions between economic development and environmental protection, including Ecological Compensation Mechanism (ECM). In China, the ECM was initially designed for forest and grassland protection, but has been gradually applied in the management of wetlands. However, ECM has scarcely been established for marine ecosystems. In this study, we suggest an Ecological Compensation Mechanism for Marine Protection Area (ECMMPA) based on the ecosystem service valuation. First, the typical ecosystems of Chinese MPA were selected, and their ecosystem services were indentified. Then, the omni-directional and situ ecosystem services of each typical ecosystem of MPA was discussed. On this basis, the ECMMPA was established, containing two alternative tactics which comply with different compensatory principles: (1) Consider the increment of the value of omni-directional ecosystem services in MPA after its protective measures are implemented as an ecological compensation; (2) Consider the change of the value of in situ ecosystem services used by the stakeholders of MPA after protective measures are implemented as an ecological compensation. This ECMMPA demonstrates a distinct theoretical framework for the ecological compensation of Chinese MPA, and it also provides flexible options to the policymakers.

November 10, 11:00 (S10-11288)

Extreme ocean temperature events in the North Pacific under greenhouse forcing

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Ocean temperature extremes and marine heatwaves in the Northeast Pacific have significant impacts on marine ecosystems, and have been linked to significant die offs of birds, mammals and the emergence of harmful algal blooms. Using available observations and the Community Earth System Model (CESM) Large Ensemble dataset we explore how the spatial and temporal probability distribution functions (PDFs) of winter temperature extremes change over the period 1920-2100 under the greenhouse forcing scenario RCP8.5. A large ensemble of climate model realization reveals that warm temperature extremes (>2°C) increase in amplitude (~ 0.5°C warmer) and tend to exhibit a preferred spatial pattern resembling the North Pacific Gyre Oscillation (NPGO) with a large body of warm water in the Gulf of Alaska. Cold temperature extremes (-2°C) also increase in amplitude (~0.5°C warmer/colder), however, their pattern is similar to the Pacific Decadal Oscillation (PDO). We show that changes in the oceanic warm/cold extremes reflect changes in the statistics of the large-scale atmospheric circulation, and the mean position of the storm tracks. Our results indicate that the PDF of ocean temperatures of the North Pacific will not only shift towards warmer temperature (changes in the mean), but also that the tails of the PDF (changes in the variance) will become larger under greenhouse forcing. These changes in the PDF dramatically increase the frequency at which ecologically-relevant ecosystem thresholds will be exceeded, like in the case of harmful algal blooms.

November 10, 11:20 (S10-11065)

The Icarus challenge - Predicting vulnerability to climate change using an algorithm-based species' trait approach

Henry **Lee II**[1], Christina Folger[1], Deborah A. Reusser[2], Patrick Clinton[1] and Rene Graham[3]

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Like Icarus, the world's ecological resources are "flying too close" to the sun, and changes in temperature, sea-level rise, and ocean acidification will affect many near-coastal species. Effects will vary both by species and geographically, though predicting the patterns of likely effects is hindered by the large number of coastal species. One approach to this challenge is assessing vulnerability from species' traits, including biogeographic distributions, depth preferences, and life history attributes. A major advantage is the ability to assess thousands of species using available information. Current applications of trait-based climate analyses have relied on expert opinion, but these have the potential limitations of biases, lack of transparency and repeatability, and difficulty in updating analyses. To address these limitations, we developed an "algorithm-based" approach, where vulnerability in an ecoregion is automatically calculated from synthesized traits using a set of a priori rules. We are applying the approach to the brachyuran and lithodid crabs (381 species) and rockfish (74 species) over 12 Marine Ecosystems of World ecoregions (Gulf of California through Beaufort Sea), with vulnerability analysis implemented in a web-based tool (CBRAT). Patterns emerging from preliminary analyses include: 1) impacts of increased sea-surface temperature are primarily limited to the southernmost occupied ecoregion of a species; 2) sea level rise will have minor impacts on crabs in Alaska compared to those in Puget Sound through Southern California; 3) while adult decapods appear more resilient to ocean acidification than many other taxa they are potentially at high risk in the Arctic.

S12: MONITOR/BIO/TCODE Topic Session
Causes and Consequences of 25 Years of Variability in Ocean Conditions on the Ecosystems of the North Pacific

November 10, 10:50 (S12-11391)

Changes in climate and changes in concepts: Physical-biological interplay in the Pacific Ocean over the PICES years

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The physical-biological environment of the Pacific Ocean has been studied for many decades. Numerous long-term observational time series, ocean model simulations and targeted research programs have been executed to better understand physical-biological variations, fluxes and interactions. Since the inception of PICES, many new ideas have emerged about what physical processes are the key controls on Pacific Ocean dynamics. These new perspectives will be reviewed to show how they resulted in our obtaining a better understanding of what climate patterns exert influences on Pacific physical variations and what physical controls are most important in driving Pacific ecological changes.

Physical oceanographic and climatological conditions in the Pacific varied widely since the inception of PICES, including unusual climate events and persistently anomalous states. The broad-scale climate variations that occurred over the North Pacific during this time period will also be discussed to provide the physical context for organizing the various regional ecosystem changes that took place. Relating these physical states to the numerous biological measurements in retrospective studies help us develop a vital long-term perspective of how changing climate conditions control the Pacific ocean ecosystem and possible information on how the ecosystem might be expected to evolve over the coming decades under global warming conditions.

November 10, 11:20 (S12-11357)

Increasing variance and synchrony in North Pacific climate and ecosystems

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There is growing evidence that the climate variance of the Pacific Ocean has increased over the last century. Using available marine and terrestrial observations of physical and biological variables we show that the increase in variance is significant and accompanied by an increased level of synchrony between climate and ecosystems. To understand the role of natural versus anthropogenic forcing, we diagnose the processes leading to the increased climate variance in a large ensemble of the Community Earth System Model (CESM) over the period 1920-2100 under the greenhouse forcing scenario RCP8.5. We show that the coupling between the North Pacific climate and the El Niño Southern Oscillation (ENSO) becomes stronger due to an intensification of the thermodynamic coupling between the ocean and atmosphere. This extra-tropical/tropical coupling is a key generating mechanism of Pacific decadal variability that leads to multi-year persistence of anomalies such as in the 2014/15 North Pacific heatwave. The dynamics of the persistence can be explained through a spatial and temporal progression of known climate patterns such as the North Pacific Gyre Oscillation, ENSO and Pacific Decadal Oscillation. Using these dynamics, we suggest a framework and index to track the Pacific decadal variability in physical and biological systems, and quantify the changes in variance for past and future climate states.

November 10, 11:50 (S12-11069)

Relationships between climate variability and fisheries catch in the central North Pacific

Phoebe A. **Woodworth-Jefcoats**[1,2], Jeffrey J. Polovina[1] and Jeffrey C. Drazen[2]

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The fishing ground of the Hawaii-based longline fleet spans over 13 million km^2 in the central North Pacific. The magnitude and composition of the fleet's catch varies on both intra- and interannual scales. We investigate over 20 years of commercial logbook and observer data to gain an understanding of the upper trophic level ecosystem supporting this fishery. Both satellite remotely-sensed and Argo float data detail how the region's biophysical oceanography has changed over the same time period. By combining these data sets, we provide an in-depth look at how both oceanography and fishery expansion have influenced catch over the last two decades. For example, the ratio of target catch to by-catch ranges from 2.0 to 0.6 over the course of the year as a result of the fleet's seasonal movement into cooler temperate waters north of Hawaii. We also examine the role changing ocean conditions and fishery expansion have played in the annual ratio of target catch to by-catch, which has fallen by half (2.0 to 1.0) over the time period examined. Finally, we offer insight into the role anomalously warm ocean conditions may have played in record target catch levels in 2015. Understanding how catch varies as a result of climate variability on multiple time scales can lead to a more efficient, resilient, and cost-effective fishery.

November 10, 12:10 (S12-11367)

Climate variability and changes in the marginal Far-Eastern Seas

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The presentation summarizes our recent studies on the features of climate variability and change in the Okhotsk, Bering and Japan/East Seas. We investigated the structure and evolution of regional climate variability and instabilities in the relationships between large-scale and regional-scale climate processes in the seas. Determination of the climatically significant parameters for the analysis is realized on following principles: duration, uniformity and regularity of the observations and utility of the climatic variables for the marine ecosystem researches and for fisheries forecasts. For example, the timing of the spring bloom, seasonal and interannual dynamics of zooplankton communities, seasonal fish migrations and other features of marine ecosystems are closely connected with variability of such important climatic parameter as sea ice coverage. We consider that the regime shifts and extreme events played more "dramatic" role for marine ecosystems in comparison with long-term trends and low-frequency quasi-periodical oscillations through high rates of change. Among the Far-Eastern Seas, the most significant warming occurred in the Okhotsk Sea during the last 25 years. Unprecedented reduction in the Okhotsk Sea ice extent occurred in winter 2014/2015 on the background of the statistically significant long-term negative trend. The total variance of the many "thermal variables" has increased over the last 25 years in the Far-Eastern Seas. Frequency of extreme situations occurrence has also increased, especially in the Okhotsk Sea.

November 10, 14:00 (S12-11072)

Warm and cool years in the California Current: Relation to ENSO

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The tropical El Niño – Southern Oscillation (ENSO) is a dominant mode of interannual climate variability throughout the Pacific. The extra-tropical California Current System (CCS) in the northeast Pacific warms, and cools, from year to year. Relationships between these two phenomena have been noted and explored since the late 1950s. We update the known record of warm events in the CCS that are and are not contemporaneous with a tropical El Niño, and tropical El Niños that are not accompanied by a CCS warming. Sea level pressure (SLP) and surface wind anomalies illustrate the different atmospheric forcing mechanisms associated with tropical ENSO and California Current warm events. CCS warm events are associated with negative SLP anomalies in the NE Pacific – a strong winter Aleutian Low /weak North Pacific High – and resulting weaker than normal winds driving coastal upwelling, whether or not there is a concurrent El Niño. El Niños are associated with basin-wide atmospheric forcing along the equator. There is some linkage between these mechanisms, but local forcing is predominant in most of the CCS, while remote tropical forcing is relatively important only to the south off Baja California. Cool events in the CCS tend to be more closely associated with tropical La Niñas, although separate forcing is evident. The forcing of co-occurring cool events is analogous to that of warm events. This paper focuses on warm/cool events of 1-2 year duration; we are not addressing longer scale (decadal) warm/cold regimes or global warming.

November 10, 14:20 (S12-11174)

California sea lions: Historical diet patterns in relation to environmental changes in the California Current

Mark S. **Lowry**, Stephanie E. Nehasil, Alan R. Jackson and Robert Holland

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Historical diet patterns of California sea lions (*Zalophus californianus*) in relation to environmental changes were examined from analysis of 16,449 scat samples collected seasonally during 1981-2015 at San Clemente Island and San Nicolas Island. Environmental variables, including the Multivariate El Niño Index and local sea level height, were examined in relation to sea lion diet and pup production. Of 133 prey species identified, seven common prey were found. Northern anchovy (*Engraulis mordax*) dominated the diet during the 1980s, and market squid (*Doryteuthis opalescens*) dominated the diet during the 1990s and 2000s. When consumption of these species declined, sea lions switched to other common prey and consumed more non-common prey. Consumption of non-common prey increased during El Niños when pup production decreased, and consumption decreased during La Niñas when pup production increased. Size of prey consumed averaged 12.6 cm, but varied by and within species and time. Recent anomalies in the diet during the 2013 and 2015 Unusual Mortality Events were derived from 1981-2007 diet data. In 2013 and 2015 hake (*Merluccius productus*), anchovy, and sardine (*Sardinops sagax*) consumption dropped, while consumption of shortbelly rockfish (*Sebastes jordani*) and non-common squid and fish prey species increased. High diet diversity indices for summer 2009, spring 2013, winter 2015, and spring 2015 were found when Unusual Mortality Events occurred at southern California Channel Island rookeries. This study shows how California sea lions reflect environmental change, and how they may be affected by climate change when ocean temperatures increase.

November 10, 14:40 (S12-11071)

Mid- and upper trophic level responses to variability in ocean conditions off central California

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Point Blue Conservation Science has been monitoring the abundance, phenology, productivity and diet of marine birds and mammals breeding on the Farallon Islands since 1968 in collaboration with the USFWS. Warm PDO regimes and El Niño events have typically resulted in decreased populations, delayed breeding, low productivity, and major changes in diet of studied species. Variability in productivity increased through time in planktivorous seabirds and the onset of breeding is earlier for some piscivorous species. Major breeding failures were observed during the anomalous ocean conditions of 2005-2006. However, the 2009/2010 El Niño led to record breeding success for planktivorous seabirds, and had negligible effect on piscivorous species. Most seabirds had slightly below average productivities in 2014 and 2015. For mammals, there were record numbers of aborted California sea lion fetuses during winters of 2014 and 2015, and record numbers of pups born at the Farallones during summers of 2014 and 2015. Putting our colony based work into the broader regional marine context, Point Blue has collaborated with the Greater Farallones and Cordell Bank National Marine Sanctuaries since 2004 to conduct at-sea surveys to assess oceanographic processes, and the abundance of mid- and high-trophic levels off central California. Warm ocean periods in 2005-06 and 2014-15 were associated with lower zooplankton abundance, lower abundance of lipid-rich copepods and krill, and increased abundance of gelatinous zooplankton. Large volumes of doliolid tunicates and small adult krill dominated samples from mid-2014 and most of 2015. Blue and humpback whale abundance declined following changes in krill availability in the region.

November 10, 15:00 (S12-11371)

The subsurface and inner-shelf structure of 25 years of variability in the Northern California Current

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Large-scale, interannual changes in ocean conditions impact water properties along productive eastern boundary currents from the continental slope to rocky intertidal shores. These changes come about by both an oceanic pathway bringing anomalous ocean conditions to Oregon's shore from across the North Pacific and by changes in local winds and freshwater input. Changes in temperature, salinity, nutrients, dissolved oxygen and carbon dioxide occur across the continental shelf, but differ in strength and impact by distance offshore and from surface to sea floor. Nearshore waters off Oregon have experienced low oxygen (hypoxia) summers to varying extents over the last 15 years and are increasingly feeling the negative effects of ocean acidification. We use in-water observations offshore of Oregon in the Northern California Current to understand the wildly variable coastal ocean over the last 25 years. Data come from long-term hydrographic sampling along the Newport, Oregon, line, from instrumented moorings and from underwater gliders. During the last 25 years, we describe the subsurface and inner-shelf structure of many large interannual events including the 1997-1998 and 2015-2016 El Niños, the 2002 subarctic invasion, the appearance of near-bottom anoxia during summer 2006, the far reach of anomalous Columbia River freshwater input during the 2010-2011 La Niña, and the "warm blob" of 2014-2016. We complement the in-water observations by using a large-scale, long-term ocean circulation and biogeochemical model simulation of the California Current to understand the observed variability. The model output is used to characterize changes in the equatorward and poleward boundary currents and water properties, sorted by the strength of the upwelling winds and the California Undercurrent in each year.

November 10, 15:20 (S12-11304)

Effects of the Blob on phytoplankton and copepod species composition, community structure and biodiversity off the central Oregon coast

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The Gulf of Alaska (GOA) became anomalously warm in autumn/winter 2013-14 due to a lack of cyclonic storms that usually mix (and subsequently cool) the water column. Warming continued through spring/summer 2014, spreading across the North Pacific (NP) Ocean, resulting in SST anomalies up to +4.5°C. This warm mass of water, named colloquially "The Blob", began to shift eastward towards North America in spring 2014, but the offshore Ekman transport associated with coastal upwelling held it offshore of California, Oregon, and Washington. Northerly winds weakened in mid-September and the Blob moved onshore, raising SST off Oregon by 6°C in five hours. Fortnightly sampling along the Newport Hydrographic Line has shown that this warm water mass occupied the upper 60-80 m of the shelf off Oregon, and brought ~ 20+ species of phytoplankton and copepod species that were either new records or known to occur only in waters far offshore and/or during past major El Niño events (1983 and 1998). Many of the unusual species have NP Gyre and/or NP Transition Zone affinities indicating that the source waters of the "Blob" were of offshore and subtropical/tropical origin. New copepod records include: *Subeucalanus crassus*, *Mecynocera clausi, Acrocalanus* spp., *Clausocalanus furcatus*, *Cl. farrani*, *Calocalanus pavo*, *Calocalanus pavoninus*, *Scolecithricella dentata, Pleuromamma borealis*, *P. xiphias*, *Labidocera euchaeta*, *Temora discaudata*, and *Acartia negligens.* Copepod biodiversity was the highest ever observed, with 6-12 species greater than climatology during most of 2015 and 2016, and continues to be high through at least June 2016.

November 10, 15:40 (S12-11286)

Euphausiid responses to recent warming events in the coastal upwelling zone off the Oregon Coast, USA

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The arrival of the warm Blob off of Newport, Oregon, in September 2014 began a period of unprecedented warm ocean conditions that has persisted for two years. How euphausiids respond to these changes has implications throughout the food web, as they are important prey items for fish (including salmon and hake), seabirds, and marine mammals. The ongoing Newport Line time series has sampled euphausiids since 2001, a period that encompasses several PDO sign changes but nothing approaching recent elevated temperature conditions. Abundance, biomass, length, reproductive activity, and cross-shelf distribution of the euphausiids *Euphausia pacifica* and *Thysanoessa spinifera* were compared across years. From 2001-2013 the biomass of *E. pacifica* was similar during warm and cool years, with a consistent cross-shelf pattern of lower biomass inshore and higher biomass offshore. Offshore biomass was higher during warm phases of the PDO, suggesting that *E. pacifica* adapts well to moderate warming. In 2015 there were no *E. pacifica* at inshore stations and their offshore biomass was dramatically lower. Lengths of *E. pacifica* adults were below average during 2015. Biomass of *T. spinifera* was historically higher at inshore stations during cool conditions and similar at offshore stations regardless of whether conditions were warm or cool. In 2015 *T. spinifera* biomass offshore was similar to previous years but comprised entirely of juveniles. No adult *T. spinifera* were found anywhere in the study area during 2015. Possible effects of warming on these species of euphausiids and potential impacts on the food web will be discussed.

November 10, 16:20 (S12-11075)

Historical context for the atmospheric forcing of record high SSTs in the NE Pacific Arc in 2014-16

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This study examines the origins of record 2014-2016 sea surface warmth around the North American margins of the northeast Pacific and the offshore subtropics extending to Hawaii. Sea surface temperatures (SSTs) in this northeast Pacific 'Arc' reached the highest levels observed back to 1900, traced here to historically unprecedented negative anomalies of subtropical sea-level pressure that signify a unique episode of weakness in the North Pacific high and associated surface winds. We show that recent SST responses to subtropical SLP and winds are consistent with long-term relationships, which include an unsteady century-long decline in subtropical SLP and closely associated rise in regional SST. The observed trends in SLP are not predicted to be a response to historical natural and anthropogenic forcing by state-of-the art climate models, suggesting that either the climate models are wrong or that the SLP and associated SST trends are due to some other causes.

November 10, 16:40 (S12-11351)

The impacts of climate variability on the distribution of groundfish along the Northeast Pacific coastal shelf

Lingbo **Li**[1], Anne Hollowed[1], Steve Barbeaux[1], Jennifer Boldt[2], Edward Cokelet[3], Toby Garfield[4], Stéphane Gauthier[5], Darin Jones[1], Aimee Keller[6], Jackie King[2], Michelle McClure[6], Olav Ormseth[1], Wayne Palsson[1], Patrick Ressler[1], Dale Sweetnam[7], Phyllis Stabeno[3], and Chris Wilson[1]

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Global warming has impacted marine organisms in many different ways, including changes in species distribution. Species have been observed to move to higher latitudes and deeper waters; however, to date, ontogenetic changes have rarely been taken into account. Due to differences in habitat requirements across life stages, changes in species composition likely plays an important role in the distributional shifts reported for species in many studies. Here we present distributional responses of groundfish across size ranges to climate variability in the Northeast Pacific with an emphasis on the unusual warm event "the Blob". We analyzed a large amount bottom trawl and acoustic survey data from the west coast of US, the west coast of Canada, and the Gulf of Alaska 2000 - 2015. A group of commercially exploited fish species, gadids, sablefish, rockfish, and flatfish, were selected as representatives for the three regions. Length bins were chosen through expert opinion to capture ontogenetic differences in distribution for each species. We computed the centroids of the fish distribution (abundance-weighted location, depth and temperature) for each species in each size bin and linked their distributions with potential predictors of environmental changes, including absolute temperatures, temperature anomalies, and climate velocities. Finally, we summarized the size-specific sensitivity and resilience of species to environmental changes.

November 10, 17:00 (S12-11374)

A decade of phytoplankton composition and environmental measurements along Line P in the NE subarctic Pacific

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Phytoplankton form the base of the food web and play key roles in climate regulation, carbon sequestration and biogeochemical cycles. A better understanding of the links between phytoplankton abundance, community composition and environmental conditions is required to predict potential future responses of phytoplankton to climate change. In this study, we examine a decade (2006 -2015) of phytoplankton assemblage composition (as determined by HPLC-derived phytoplankton pigment concentrations) along Line P in the northeast subarctic Pacific as well as environmental conditions that could potentially control its seasonal and interannual variability. Nutrient concentrations are usually high (>5 mmol m^{-3}) and chlorophyll concentrations low (<0.5 mg m^{-3}) year around in the Fe-poor prymnesiophyte dominated offshore waters, whereas high seasonal variability in phytoplankton biomass occurs in the nutrient-rich diatom dominated inshore waters of Line P. Unusually high chlorophyll concentrations (~1.3 mg-Chl m^{-3}) were observed at the offshore end of Line P in August 2008 following a natural volcanic Fe fertilization. Although an increase in diatoms was observed, the relative composition of phytoplankton was similar to that of Aug/Sep of previous years. In comparison, the anomalous warming of the surface waters in October 2013 that persisted into 2015 resulted in low surface nutrients, low phytoplankton biomass and dominance of cyanobacteria. Possible implications of these changes to lower trophic levels and biogeochemical cycles will be discussed.

November 10, 17:20 (S12-11203)

Variability in North Pacific Ocean conditions: Assessing habitat-specific vital rates and thresholds for fishes

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The critical importance of habitat to fish growth, reproduction, survival, and species interactions is well recognized. Indeed, most stressors or environmental drivers (e.g. hypoxia, climatic fluctuations, and upwelling events) act on fish populations through altering habitat conditions. Growth rate is a quantitative, integrative and nonlinear response of a fish to the prevailing biological and physical/chemical conditions of the ecosystem and has thus been considered a good indicator of habitat quality. Growth Rate Potential maps how well a fish would grow if placed in a particular pelagic environment. We suggest that spatial and temporal distributions of growth rate potentials for key top predators (e.g. Salmon, Tuna) could be used to assess the variability of habitat quality and quantity and that summary values (e.g. volume of habitat quantity capable of supporting growth) could provide an index of ecosystem production. As an example, we evaluated the growth rate potential of adult Chinook salmon in the North Pacific over a number of years. We analyzed water temperature, dissolved oxygen, wind speed and direction, and salinity across the Pacific Northwest to contrast salmon growth rate potentials. Results show that: 1) salmon growth rates differ both spatially and inter-annually; 2) a change in the salmon open-ocean habitat quality occurred post-1970; and 3) salmon growth rates may be limited by both dissolved oxygen and water temperature. Measures of annual growth rate potential correlated with annual catch rates of adult salmon.

November 11

Session 10, FUTURE Topic Session (Day 2)
The Response of Marine Ecosystems to Natural and Anthropogenic Forcing: Past, Present and Future

November 11, 09:00 (S10-11212)

An ensemble approach to understanding climate change in the Pacific

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Pacific climate variability on interannual to decadal timescales is known to be sensitive to changes in background climate conditions, as well as atmosphere/ocean feedbacks. However, the degree to which shifts in modes of variability can be attributed to external climate forcings remains unknown. Efforts to assess these changes in a multi-model framework are subject to uncertainties due to both differing model physics and unforced internal variability. New community ensembles created at the National Center for Atmospheric Research and the NOAA Geophysical Fluid Dynamics Laboratory are ideally suited to addressing this problem, providing many realizations of the climate of the 850-2100 period with a combination of both natural and anthropogenic climate forcing factors. Here we analyze the impacts of external forcing on Pacific climate variability, including the El Nino/Southern Oscillation (ENSO), Pacific Decadal Oscillation (PDO), and North Pacific Gyre Oscillation (NPGO). Results from four model ensembles are presented: the CESM Last Millennium Ensemble (CESM-LME), which covers the 850-2005 period and provides long-term context for forced responses; the Large Ensemble (CESM-LE), which includes 20th century and 21st century (RCP8.5) projections; the Medium Ensemble (CESM-ME), which is composed of 21st century RCP4.5 projections; and the GFDL Large Ensemble (GFDL-LE), which includes 20th century and RCP8.5 projections. Implications for assessing future tropical and North Pacific responses to external forcing are discussed, as is the detectability of effects from climate mitigation strategies.

November 11, 09:25 (S10-11104)

Marine habitats in a changing world: Looking beyond correlation

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Understanding the spatial distribution of natural resources is necessary if integrated resource management is to be legitimate to stakeholders, and relevant to managers. To also be credible, species distribution models need to integrate more ecological understanding, and rely less on statistical correlations than prevailing approaches. Current dominant approaches to habitat suitability modeling include machine learning and random forests, where observations of species occurrence are correlated with a suite of abiotic environmental attributes. Forecasts of future habitat are made by applying these correlative relationships to scenarios (e.g., via output from a climate model). The challenges to such forecasts lie in the many (often implicit) assumptions necessary to construct such coupled models. Some of the least credible assumptions include spatial and temporal stationarity of process, sufficiency of model context, and equating of potential with realized habitat. The confidence we have (or don't have) in these assumptions is typically absent from such model forecasts. Drawing on an example from Canada's Pacific coast, we first demonstrate the importance of place-based, integrated indicators of marine ecosystems. We then show how process-based models can help represent ecological knowledge of species distributions, and how independent data validation can help uncover biases in our analyses. We also show how explicit consideration of model scope and scaling can improve our understanding of the confidence we might place in our models. Such steps towards explicit communication of what we can and cannot expect from our models are necessary if we are to build credible forecasts of species distributions.

November 11, 09:45 (S10-11083)

The influence of ENSO diversity on North Pacific ecosystems

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El Niño Southern Oscillation (ENSO) is a well-known driver of ecosystem variations in both equatorial and extra-equatorial regions. While along the equator biological variations are directly affected by the stratification changes accompanying the evolution of ENSO events, in the extra-equatorial regions such as the California Current System (CCS) the ENSO influence can occur through both oceanic (coastal Kelvin waves) and atmospheric pathways, or "bridges". ENSO events differ in amplitude, temporal evolution as well as spatial patterns, aspects that can significantly impact both local and remote influences. Previous studies have shown that warm ENSO events with largest anomalies in the central Pacific (CP events) can trigger atmospheric changes responsible for forcing the North Pacific Gyre Oscillation, a mode of North Pacific variability which is strongly related to coastal upwelling and variations in important ecosystems indicators. Thus, the predictability of CP El Niño events may translate into the ability to anticipate NPGO-induced ecosystem changes. In this presentation I will first review the main characteristics of ENSO diversity and its influence on equatorial and off-equatorial Pacific ecosystems. I will then use the Linear Inverse Modeling (LIM) methodology to identify the 6-month precursors of CP events from sea surface temperature (SST) and thermocline depth data over the period 1958-2007. The LIM analysis outlines a promising approach to investigate the sensitivity and predictability of tropical states that have the greatest impact on North Pacific ecosystems.

November 11, 10:05 (S10-10942)

Wind stress, stratification, and source waters: How will eastern boundary current upwelling processes respond to climate change?

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The close relationships among various atmospheric, oceanic, and biological processes in the upwelling ecosystems to captivate the imagination of oceanographers from all disciplines, particularly in attempt to explain the considerable ecosystem fluctuations that have occurred over decadal and multi-decadal periods. This natural variability in physical and biogeochemical properties poses challenges for marine populations inhabiting eastern boundary upwelling ecosystems. As a consequence, there is growing concern for the sensitivity of these systems to climate changes that may be exacerbated by anthropogenic activities. A number of hypotheses have been offered to describe the impacts of climate change on three key components of the upwelling process: changes in winds (including intensification, poleward shifts, and altered seasonality), increased water-column stratification, and modified characteristics of source waters supplied to the upwelling systems. Rejection of hypotheses based on observational records is hampered by limited ability to distinguish the impacts of anthropogenic climate change from those of natural variability, but examination of numerical model projections offers some insight to changes in the upwelling process over the coming century. I will describe the current understanding of the upwelling response to basin-scale anthropogenic climate change, compare the California system to the other prominent eastern boundary upwelling systems, and propose some ideas about the impacts of such changes on the communities inhabiting the upwelling regions. Improving such understanding is critical for anticipating the future evolution of these systems and their ability to sustain productive ecological communities.

November 11, 10:50 (S10-11023)

Simulated influence of the 1976–77 regime shift on anchovy and sardine in the California Current System

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We investigate the influence of the well known 1976–77 regime shift on the Northern anchovy (*Engraulis mordax*) and the Pacific sardine (*Sardinops caeruleus*) in the California Current by using a fully-coupled end-to-end model. This model is a multi-species, spatially explicit (3D), time-evolving, and consists of four coupled submodels (hydrodynamics, Eulerian nutrient–phytoplankton–zooplankton-detritus (NPZD), an individual-based full life cycle anchovy and sardine model; agent-based fishery). Analysis of a 50-year historical simulation (1959–2008) showed that anchovy recruitment (survival to age-1) was lower just after 1977, while sardine recruitment was relatively unaffected by the regime shift.. The recruitment of both species was influenced by the growth and survival of individuals in the larval stage. The modeled zooplankton density shift from high to low in 1976–77 was most drastic in winter in the coastal area. Anchovy larvae feed extensively in the winter in the coastal area, while sardine larvae were mainly distributed in the offshore area in the spring. The differential seasonal and spatial responses of zooplankton in the simulation caused anchovy recruitment to be more sensitive than sardine to the 1976–77 regime shift. The zooplankton shift itself was a result of the nutrient concentration changes in the surface layer. Nutrient concentrations decreased from 1977 due to the weakening of both the coastal upwelling and mixed layer shoaling, which reduced the vertical nutrient flux from the bottom layer to the surface layer.

November 11, 11:10 (S10-11392)

Environmental DNA metabarcoding from fishes (and other vertebrates) using universal primers MiFish: A data-driven approach for fish community research

Masaki **Miya**

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Environmental DNA (eDNA) in aquatic environments refers to genetic material found in the water column. Recent studies demonstrated the utility of eDNA for detecting fishes from various aquatic environments, including ponds, rivers, streams, and seawater. Most of these studies focused on detection of a single or a few invasive and rare or threatened species, while some recent studies attempted simultaneous detection of multiple species in local fish communities and mesocosms. The latter approach is called "metabarcoding" and eDNA metabarcoding uses one or multiple sets of PCR primers to coamplify a gene region across taxonomically diverse samples. This is followed by library preparation with indexing and adapter addition, and the indexed libraries are analyzed by a high-throughput parallel sequencing platform. Recently Miya *et al.* (2015) developed universal PCR primers for metabarcoding eDNA from fishes (called "MiFish"). The MiFish primers target a hypervariable region of the mitochondrial 12S rRNA gene (163–185 bp), which contains sufficient information to identify fishes to taxonomic family, genus and species except for some closely related congeners. With the use of MiFish primers in eDNA metabarcoding (MiFish metabarcoding), Miya *et al.* (2015) detected more than 230 subtropical marine species from aquarium tanks with known species composition and coral reefs near the aquarium. Subsequently I have detected various marine fishes from various environments by these metabarcoding approaches. This high-throughput approach can yield approximately 15,000,000 reads from >1,000 libraries in a single MiSeq run. The MiFish metabarcoding approach is non-invasive, more efficient, more cost-effective and more sensitive than the traditional survey methods. It could serve as an alternative (or complementary) tool for biodiversity monitoring that will greatly aid natural resource management and ecological studies of fish communities on unprecedentedly larger spatial and temporal scales.

November 11, 11:35 (S10-11296)

Seasonal climate predictions to improve fisheries management decisions

Désirée **Tommasi**[1] and Charles Stock[2]

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Fish populations are strongly influenced by climate variability. The inability of fisheries managers to anticipate such environment-driven fluctuations in fish productivity can lead to overfishing and stock collapses. We show that recent advances in dynamical global climate prediction systems such as the state of the art NOAA Geophysical Fluid Dynamics Laboratory (GFDL) 2.5-FLOR model, allow for skillful sea surface temperature (SST) anomaly predictions at a seasonal scale over many shelf ecosystems. Such seasonal forecasts were coupled to a population dynamics model of Pacific sardine in a management strategy evaluation framework to evaluate harvest strategies more robust to climate variability. The harvest guideline that incorporated stock biomass forecasts informed by skillful SST predictions led to increases in stock biomass and yield, and reductions in the probability of yield and biomass falling below socioeconomic or ecologically acceptable levels. However, to mitigate the risk of collapse in the event of an erroneous forecast, it was important to combine such forecast-informed harvest controls with additional harvest restrictions at low biomass. This analysis highlights the utility of skillful seasonal climate predictions to enhance forecast capacity for marine ecosystems and build management systems more resilient to climate variability and change.

November 11, 11:55 (S10-11178)

The mechanics of range shifts in a warming world

Jennifer **Sunday**

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As the world has warmed, species distributions are moving polewards in latitude, upwards in elevation and deeper in depth. This global redistribution of biodiversity calls on ecologists to apply long-standing hypotheses about the factors that limit species distributions. Here I present macrophysiological analyses of the extent to which global ectotherms are physiologically limited within their distributional range. I use records of marine species' range shifts to further elucidate the relative roles of species traits and ecological interactions in mediating range shifts in a warming world. From this and other work, I review emerging generalities on the ecology and mechanics of climate range shifts and directions of climate adaptation strategies.

Abstracts

Poster Presentations

Session 1: Science Board Symposium
25 Years of PICES: Celebrating the Past, Imagining the Future

S1-P1

Highlights from 16 years of the North Pacific CPR program, a PICES MONITOR project

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At the 1998 PICES annual meeting the PICES MONITOR Task Team recommended that the Continuous Plankton Recorder be used to monitor the plankton populations of the North Pacific, to provide large scale coverage of the then poorly-sampled open ocean ecosystems of the PICES region. This recommendation was acted upon and the first routine plankton sampling began from two commercial ships in 2000, which towed the CPR on a monthly basis on their regular routes. Over 24,000 plankton samples have now been collected and archived, with taxonomically-resolved abundance data available from over 6,000 of them. This poster showcases some of the highlights from research conducted on these data over the last 16 years. We specifically chose examples that demonstrate the wide-ranging geographic coverage and applicability such as; East-West comparison of zooplankton size structure, links between plankton and larval herring, responses of the plankton to ocean climate changes, molecular analyses of *Pseudo-nitzschia* diversity. The program is now firmly established and represents a significant achievement of PICES.

S1-P2

Negotiating the international instrument on BBNJ: Long-term implications

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With United Nations General Assembly Resolution 69/292 in 2015, discussions regarding biodiversity in marine areas beyond national jurisdiction (BBNJ) entered a new phase. This phase will move forward the negotiations of a legally-binding agreement, which will impact the long-term conservation and sustainable use of BBNJ. At the international level, states are now engaging in Preparatory Committee meetings focused on the four "package" elements of (1) area-based management tools, including MPAs; (2) marine genetic resources including aspects of benefit sharing; (3) environmental impact assessments; and (4) capacity building and the transfer of marine technology. The negotiations, however, have been marked by imbalances in participation and the technical capacity of different states to participate, despite international mechanisms and commitments to reduce inequality (not least, Sustainable Development Goal 10). We will present initial research outcomes that quantify these imbalances and, through a comparison with experiences implementing the UN Fish Stocks Agreement, will emphasize how short-term investments towards fostering equal participation in the ongoing BBNJ process will be in the interest of all states.

S1-P3

25 years history of ecosystem modeling related to PICES and myself

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In 1991-2, I published two important papers, named "A biomass-based model for the sand lance (Ammodytes personatus) in Seto Inland Sea, Japan." *Ecological Modelling*, 54, 247-263 and "A numerical analysis of population dynamics of the sand lance (Ammodytes personatus) in the eastern Seto Inland Sea, Japan." *Fisheries Oceanography,* 1, 321-332. These papers compare two methods on the same ecosystem. Former is with biomass based model (like NEMURO) and latter is with population dynamics. And at that time I was mainly involved in coastal ecosystem modeling. (e.g., "Numerical simulation model for quantitative management of aquaculture." *Ecological Modelling*, 72, 21-40). After PICES was established and I moved to Hokkaido, I began to make open ocean model (e.g., 'Modeling of spring bloom in the western subarctic Pacific (off Japan) with observed vertical density structure. *Journal of Oceanogrrphy*. 51, 471-488.' Effect of ontogenetic vertical migration of zooplankton on the results of NEMURO embedded in a general circulation model. *Fisheries Oceanography*, 12, 284-290, "NEMURO―a lower trophic level model for the North Pacific marine ecosystem. Ecological Modeling, 202, 12-25."). I want to review these historical papers, which "I" think are important for PICES science history.

S1-P4

Visitor activities and awareness of Marine Protected Areas and species composition at rocky intertidal sites in San Diego

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Human actions are changing both terrestrial and aquatic ecosystems, and ultimately causing increased rates of species extinctions. Furthermore, a majority of species' population sizes and/or geographic ranges are declining worldwide due to anthropogenic stressors. Many of the stressors that impact rocky intertidal ecosystems result from increasing urbanization, recreational activities, and harvest of species at the shore. San Diego's temperate coastal climate, in particular, attracts large numbers of visitors who conduct recreational activities and harvest species at the ocean water's edge including the rocky intertidal zone. As a result, following years of planning, several marine areas around San Diego have been protected from harvest as part of a network of Marine Protected Areas (MPAs). This study investigates (1) visitor knowledge about Marine Protected Areas (MPAs) in San Diego County, (2) visitor activities and (3) species composition in three MPA intertidal locations and three nearby non-MPA intertidal locations. Visitor intensity varied between 8-70 visitors per 10-minute period. This thesis confirmed that the main problems facing rocky intertidal MPAs in San Diego County are (1) lack of effective enforcement, (2) inadequate signage, and (3) lack of visitor knowledge about MPA no-take regulations. Improvements in management strategies are recommended such as additional efforts to educate visitors before and during visitation, expanded docent programs, and increased enforcement of regulations. Better management techniques are needed to reduce human impacts on all rocky intertidal ecosystems.

S1-P5

Increase in toxic *Alexandrium tamarense* blooms with the climate regime shift to warming in the eastern Bering Sea shelf

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Recently, high numbers of resting cysts of the toxic dinoflagellate *Alexandrium tamarense* were found on the bottom sediment surface on the eastern Bering Sea shelf. In addition, warming has been recently reported along with several biological changes in the area. Thus, a climate regime shift potentially affected the occurrence of *A. tamarense* on the eastern Bering Sea shelf. We aimed to detect the occurrence of the *A. tamarense* vegetative cells in this area and evaluate the relationship between climate regime shifts and occurrence of *A. tamarense*. Inter-annual field surveys of *A. tamarense* were conducted along a transect line on the eastern Bering Sea shelf during summers from 2004 to 2013. Massive blooms of *Alexandrium tamarense* were observed during the warm period (2004 and 2005) on the shallow shelf (<100 m), while low abundances were observed during the cold period (2009, 2012, and 2013), with a positive correlation between abundance and water temperature. The maximum cell density of *A. tamarense* observed during the warm period (60,900 cells L^{-1}) was much higher than the PSP warning level (>100 – 1,000 cells L^{-1}) in other subarctic areas. This study demonstrated that warming triggered the massive occurrences of *A. tamarense* on the Bering Sea shelf, and suggests that future predicted warming not only in the Bering Sea shelf but also in other subarctic and arctic regions will bring increases in frequency and scale of toxic blooms and toxin contamination of plankton-feeders that are serious threats to human and marine ecosystems.

S2: BIO/TCODE/FIS Topic Session Early Life History Stages as Indicators and Predictors of Climate Variability and Ecosystem Change

S2-P1

Interactive effects of incubation temperature and salinity on the early life stages of Pacific cod *Gadus macrocephalus*

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The interactive effects of incubation temperature and salinity on the early life stages of Pacific cod *Gadus macrocephalus* were examined under controlled laboratory conditions. Data were collected from two synchronized experiments. Experiment 1 was designed to evaluate the interactive effects of incubation temperature and salinity on the hatchability of fertilized *G. macrocephalus* eggs. The egg thermal niche, contributions of temperature and salinity on embryonic development, larval size and yolk storage at hatch were also noted while collecting egg hatchability information. Experiment 2 was set up to evaluate the interactive effects of incubation temperature and salinity on the mean time from hatching to death of 50% of the unfed *G. macrocephalus* larvae (M_{50}). The results show that temperature could significantly influence the development and hatchability of the fertilized eggs, as well as the hatching characteristics of *G. macrocephalus*. Viable hatch was significantly influenced by salinity as the upper and lower thermal limits were approached, which shows the low-temperature–low-salinity synergism and high-temperature–low-salinity inhibitory effects. Data on developmental rates as influenced by temperature were presented at each tested salinity level. No such influences were found when considering the salinity at each tested temperature level. A dome-shaped relationship was observed between temperature and the incidence of larval size and yolk storage at hatch for most of the tested salinity levels. However, no such effect existed when the effect of salinity was considered at each tested temperature. The influence of temperature influence on larval duration (M_{50}) could be described in all cases by a power exponential function. Evidence on low-temperature–low-salinity synergism, as well as high-temperature–low-salinity inhibitory effects, was also observed. The results were discussed in reference to salinity modified temperature effects on the early life stages of *G. macrocephalus*. The temperature of 4°C to 6°C, maximum hatchability and larvae size at hatch, and moderate salinity tolerance and larval duration suggest the optimal temperature range for the survival and development of the early life stages of *G. macrocephalus* in the field.

S2-P2

Density dependent effects on growth and migratory rate during sockeye salmon early marine residency

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Spawner length-at-age data and growth reconstructions from scales have long been used to identify density dependent processes during ocean rearing in salmonids. However, these previous analyses have necessarily focused on data from returning adult spawners and as a result, density dependent effects during early marine residency are potentially underrepresented. Here we used otolith microstructure techniques to examine density dependent effects during the first 1-2 months of marine residency in twelve populations of juvenile sockeye salmon (*Oncorhynchus nerka*). Specifically, we tested whether smolt size, ocean entry phenology, marine growth and migratory rate differed between years of extremely low (2011) and extremely high juvenile abundance (2012)

in the Strait of Georgia. After accounting for stock-specific variation, juvenile salmon that migrated in 2012 were smaller at ocean entry, but ocean entry timing, marine growth rates and migratory rate did not differ between years. Since abiotic conditions and the abundance of potential prey taxa were also relatively stable between years, it is unlikely that density dependent effects were masked by differences in environmental conditions at sea. The similar patterns that we observed between years suggest that early marine growth and behaviour in juvenile sockeye salmon may not be strongly influenced by competitive interactions. Instead, early marine residency may provide an opportunity for compensatory growth after density dependent impacts during freshwater rearing.

S2-P3

Interactive effect of thermal gradient and prey mismatch on thermal selection of juvenile Pacific cod (*Gadus macrocephalus*)

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Climate change can cause spatial and temporal variance in thermal environments and prey abundances, which can influence the cohort strength and productivity of marine fish particularly during the first summer of juvenile life. In this study, we explored the relationship between prey mismatch and thermal selection of juvenile Pacific cod in experimental thermal gradients. Prey mismatch was simulated by depriving food 24 h prior to each trial. Thermal selections were exhibited by vertical positions of fed and unfed juveniles in different thermal gradients: I, 12 to 8 °C; II, 8 to 4°C; III, 8°C throughout the column. Neither prey condition (fed or unfed) nor thermal gradients separately affected the thermal selection of the juveniles, but the interaction of the two factors significantly did. In the present of thermal gradients, fed fish occurred at both warmer temperatures (10-12°C) and colder temperature (4-6°C), while unfed fish mainly occurred at acclimated temperature (8°C) in terms of average median depth. It appears that prey mismatch narrows the temperature range of juvenile cod exhibiting avoidance of warmer or colder waters when thermal gradient exists. Therefore, if the fish are mismatched with the distributions of their prey in thermal-gradient waters, juvenile cod might face limited scope for searching for prey, possibly followed by elevated starvation risk.

S2-P4

Climate-driven variability in forage fish biodiversity in the California Current

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Biodiversity has served as a benchmark for pristine and optimally functioning ecosystems. Marine biodiversity is under threat of climate change and increasing human-related stressors, such as pollution, overfishing and habitat destruction. Yet little is known about the natural variability of biodiversity in pelagic upwelling marine ecosystems, which are often subject to substantial inter-annual and decadal variability of ocean-climate conditions. Attributing changes in marine biodiversity to productivity cycles and anomalous climate events, and detecting long-term biodiversity trends, is paramount to understanding climate forcing on trophodynamics of upwelling ecosystems. Using data from the NMFS Rockfish Recruitment and Ecosystem Survey, we quantified diversity indices of forage fish collected over 26 years (1990-2015) during May/June to determine the natural variability and environmental determinants of biodiversity within the central California upwelling ecosystem. We found that diversity and evenness of the total assemblage declined within Monterey Bay. Biodiversity time series indicate there are two alternate forage fish assemblages that relate to differences in warm/cool and strong/weak upwelling years that vary in 3-5 year cycles. Cool years are associated with increased biodiversity of juvenile rockfish, whereas warm years coincide with increased biodiversity of coastal pelagic species and mesopelagic fishes. During 2015, a year of anomalous warm surface-ocean conditions, we observed unprecedented high levels of biodiversity and attribute it to productivity of rockfish and transport of sub-tropical species. Using a combination of remote-sensing and in situ hydrographic data, we compare 2015 to previous anomalous ocean-climate conditions and discuss how biodiversity of forage fish may impact trophodynamics of upwelling ecosystems and predator-prey interactions.

S2-P5

Autumn ichthyoplankton assemblage in the Yangtze Estuary shaped by environmental factors

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This study investigated the response of the ichthyoplankton community to environmental changes in the Yangtze Estuary using canonical correspondence analysis. Ichthyoplankton community and environmental data were recorded during autumns in 1998, 2000, 2002, 2003, 2004, 2007 and 2009. Among the ichthyoplankton, the dominant larval and juvenile families were the Engraulidae, Gobiidae and Salangidae, and the most common eggs were from Trichiurus lepturus. The ichthyoplankton was identified via canonical correspondence analysis to three assemblages: an estuary assemblage dominated by *Chaeturichthys stigmatias*, a coastal assemblage dominated by *Engraulis japonicus* and *Stolephorus commersonii*, and an offshore assemblage dominated by *Trichiurus lepturus*. Regarding environmental factors in the Yangtze Estuary, suspended matter and surface seawater salinity were the main factors influencing the distributions of the different assemblages, while sediment from the Yangtze River during the rainy season and chlorophyll a were the principle drivers of the annual variances in the distribution of ichthyoplankton assemblages. Our aims in the present study are to provide detailed characterizations of the ichthyoplankton assemblage in autumns, examine the long-term dynamics of autumn ichthyoplankton assemblages, and evaluate the influence of environmental factors on the spatial distribution and inter-annual variations of ichthyoplankton assemblages associated with the Yangtze Estuary. This study was supported by National Natural Science Foundation of China (No.41406136, No.31272663, No.41176138 and U1406403).

S2-P6

Source water variability in the California Current System and implications to rockfish production

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Understanding connections between ocean-climate conditions and early life stages of fish is critical for informing ecosystem-based management strategies. In particular, investigating changes in the abundance of late larval and juvenile life history stages (after the influence of density-independent processes) in response to regional ocean conditions, such as anomalous transport patterns and water mass properties, is important for understanding the physical drivers of recruitment to support marine fisheries. Using output from a regional ocean model and a 34 year time series of pelagic juvenile (young-of-the-year; YOY) rockfish (*Sebastes* spp.) off of Central California, we investigate the connection between regional source water variability and YOY abundance. Interannual variability of spiciness on deep potential density isopycnals explains a considerable fraction of the variation in rockfish abundance, due to changes in source water with in the California Current. Years of high rockfish abundances correspond to lower spice levels indicative of a greater portion of Pacific Subarctic Upper Water within the northern California Current region.

S3: MEQ Topic Session
Source, Transport and Fate of Hydrocarbons in the Marine Environment

S3-P1

Atmospheric concentration of petroleum derived polycyclic aromatic hydrocarbons after the *Hebei Spirit* oil spill

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The *Hebei Spirit* oil spill in December 7th, 2007 was the biggest oil spill in Korea. Approximately 10,900 tons of crude oil (mixtures of Kuwait Export Crude, Iranian Heavy Crude, and UAE Upper Zakum Crude) were spilled along the Taean coast (west coast of South Korea). Thirty percents of total mass of crude oil, mostly volatile hydrocarbons were evaporated at the initial stage of spill. Harner type passive air samplers (PAS) consisting of polyurethane foam were deployed at two spill sites (Gaemok-port and Mallipo) and one reference site (Mageum-ri) for one year after the spill on monthly basis. EPA priority PAHs and alkylated PAHs were measured. Concentrations of 15 PAHs at spill sites were similar to those reported at reference site. On the other hand, concentrations of alkylated PAHs measured at spill sites were significantly higher than that of a reference site right after the spill. In particular, the concentrations and profiles of alkylated phenanthrenes and dibenzothiophenes exhibited strong influence of petroleum derived PAHs inputs. One of oil fingerprinting index, PAHs double ratio using alkylated phenanthrenes and dibenzothiophenes identified petrogenic input source and further implicated environmental fate of volatile fractions of spilled oil.

S3-P2

Influence of ships bilge water on sea water pollution with petroleum hydrocarbons

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Bilge water are present in all types of vessels. When operating power plants of the engine room, a large number of tiny drops of fuel and oils, which are concentrated in the bilges, where pumped into special tanks. Bilge water is much less than the ballast, but the concentration of oil in these waters is much higher. Most intensively contaminated water in places where ships and during loading and unloading operations, that is, in the port waters and the outer roads. To assess the environmental performance of the fishing industry fleet, investigated several bilge water SRTM in parking mode. Investigated research ship: "TINRO" and "Professor Kaganovsky". They are medium-trawlers refrigerators displacement of about 1,000 tons. The average volume of bilge water on ships of this type is about 5 tonnes / day. The content of petroleum hydrocarbons in the test water was 1.5 mg / l. For this indicator, they are referred to the extremely-dirty. During the fishing season in one small area of fisheries are located hundreds of ships. Recorded content of petroleum hydrocarbons in the surface waters of the Bering Sea in areas with large concentrations of fishing vessels reached 0.4 mg / l, so that the role of the fishing industry vessels in the formation of oil pollution may be significant.

S4: FIS Topic Session
Climate Variability, Climate Change and the Reproductive Ecology of Marine Populations

S4-P1

Plasticity in reproductive strategies for rockfish in the Southern California Current and linkages to maternal characteristics and climatic variability

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Reproductive strategy is generally accepted to be a fixed life history characteristic in fish species (e.g. batch spawning species with indeterminate fecundity will demonstrate this type of reproduction each spawning season); however, it remains uncertain whether fecundity patterns are a genotypic response or the phenotypic response to prevailing environmental conditions. The majority of rockfish species (*Sebastes* spp.) in the California Current region exhibit total spawning, producing one brood of larvae annually. However, several species are known to produce more than one brood of larvae annually. These multiple brooding species appear to demonstrate indeterminate fecundity, being capable of doubling (or more) their annual reproductive contribution compared to single brooding individuals. Additionally, mass atresia events, whereby developing oocytes are resorbed and reproduction is suspended for the current reproductive season, have been documented in several rockfish species. Both phenomena vary annually and regionally and are believed to ultimately be driven by environmental conditions (temperature, food availability) that allow for some females to invest more heavily in reproduction or require that some females miss a reproductive opportunity altogether. Both multiple brooding and mass atresia are observed in Chilipepper rockfish (*S. goodei*) and appear to be related to maternal size. Fresh ovarian tissue as well as more detailed histological slides were examined to identify occurrences of these two phenomena. These phenomena; their relationship with maternal size and geography; and their potential influence on population dynamics and fisheries management will be discussed.

S4-P2

Ovarian development, energy storage, and skipped spawning in female sablefish in Alaska

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Female sablefish, *Anoplopoma fimbria*, were sampled close to the spawning season in December 2011 for the first time in the Gulf of Alaska. Skipped spawning females, fish that have spawned in the past but are not in the current season, were documented for the first time. Age at maturity was heavily influenced by whether skipped spawners were classified as mature or immature in logistic models of age at maturity. In December 2015 we sampled female sablefish in the same areas for a comparison of skipped spawning rates and age at maturity estimates by year. We also collected maturity data during the summer of 2015 for a comparison by season. Age at maturity varied greatly within the summer depending on the geographic area; these differences may partially be explained by variation in when females initiate maturation, which could be related to the environment and the age structure in each geographic area (older fish may initiate sooner). Livers, which are used as stores of energy, were collected in both seasons. Only in the winter, fish that would spawn had larger livers, relative to body weight, than those that would skip spawning and immature fish. For immature fish, relative liver weight increased with fish size in both seasons, but was constant for mature fish. This indicates that immature fish are focused on increasing energy storage and that this plateaus when they reach maturity.

S4-P3

Effects of the North Pacific Current on productivity of 163 Pacific salmon stocks

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Horizontal ocean transport can influence the dynamics of higher-trophic-level species in coastal ecosystems by altering physical oceanographic conditions, predation, or the advection of food resources into coastal areas. In this study, we estimated the effects of two modes of variability in the North Pacific Current (NPC) on productivity of North American salmon stocks to better understand how pathways of horizontal ocean transport could influence population dynamics of Pacific salmon. Specifically, we used Bayesian hierarchical models to estimate how strongly productivity of 163 pink, chum, and sockeye salmon stocks was influenced by (1) the north-south location of the NPC bifurcation (BI) as it hits the west coast of North America and (2) the NPC strength, which was indexed by the North Pacific Gyre Oscillation (NPGO). We found that for salmon stocks located in Washington (WA) and British Columbia (BC), both the BI and NPGO had significant effects on productivity: a northward-shifted bifurcation and a stronger NPC were associated with increased salmon productivity. For the WA and BC regions, the estimated NPGO effect was over two times larger than the BI effect for pink and chum salmon, whereas for sockeye salmon the BI effect was 2.4 times larger than the NPGO. In contrast, we found weak effects of both horizontal ocean transport processes on productivity of salmon stocks in Alaska. Taken together, our results provide some evidence that the relative importance of horizontal transport pathways may differ between northern and southern areas for the species examined here.

S4-P4

On identification of mesoscale eddies from satellite altimetry based on the area in the NW Pacific

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We considered three methods that are traditionally utilized to identify, by using of satellite data, synoptic eddies. A comparison is carried out on the example of a water area located in the NW Pacific. 1) Sea level anomalies, 2) relative vorticity, and 3) Okubo-Weiss parameter are mapped based on satellite altimetry data. It has been revealed that the distribution of these three differs significantly in number, size, and allocation of isolated irregularities that are usually identified as mesoscale eddies. Heterogeneities that are identified using the relative vorticity have smaller spatial scales compared with ones allocated in the sea level anomalies. Only distribution of sea level anomalies or relative vorticity can give a false picture of the vortices. Heterogeneities allocated in these fields are not synonymous of vortices since Okubo-Weiss parameter has positive values for them. We demonstrated that researchers often make erroneous interpretation of the altimetry data, finding eddies where they do not really exist. Formation of various heterogeneities in the sea level anomalies as well as in the relative vorticity could be influenced by other forces, especially by westward propagating planetary waves (low-frequency Rossby waves) and by their interaction with sea currents.

S4-P5

Influence of environmental factors and density dependence on variability in reproductive output and growth of Atka mackerel (*Pleurogrammus monopterygius*)

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We examined variability of length-weight relationships and condition factors for Atka mackerel at Seguam pass in the Aleutian Islands, Alaska from 1999 until 2015. Female Atka mackerel fecundity has been shown to be strongly correlated to weight. Therefore the variability of condition factor will be used as a proxy for potential variability in reproductive output. Condition factor and length-weight relationships for Atka mackerel are highly variable over time. We will examine the influence of environmental factors such as temperature and density-dependent factors such as year class strength on the variability of these parameters. In addition, we will examine the seasonal aspect of condition factor and discuss how seasonal and between year variability of length-weight relationships and condition factor can influence biomass estimates in the stock assessments and contribute to uncertainty when estimating spawning biomass.

S4-P6

Temperature effects on the reproductive traits of walleye pollock *Gadus chalcogrammus*

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In this study, the reproductive traits of walleye pollock *Gadus chalcogrammus* (formerly *Theragra chalcogramma*) in the same age class were examined in relation to temperature variation under rearing experiments. We conducted two experiments, in which 1) the temperature during and shortly before the spawning season was manipulated, and 2) the temperature long before the spawning season (non-spawning season) was manipulated. In the first experiment, the variation in temperature regime (2–8 °C) resulted in the variation in the peak of spawning period (the higher the temperature, the earlier the peak), but not in the size of eggs. In the second experiment, the fish reared at the lower temperatures in the non-spawning season grew more and spawned eggs of larger size than that of the other treatment. Meanwhile, total egg production was largely explained by female body weight for both experiments. Thus the temperature during the spawning season would mainly determine the speed of final maturation process, while that during the non-spawning season would determine the amount of resource storage which is invested on egg production. These findings would be fundamental to understand reproductive dynamics including maternal effects of this species.

S4-P7

Identifying robust model selection tools for including environmental links to recruitment in North Pacific groundfish stock assessments

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Effects of environmental and climate drivers on groundfish recruitment in the North Pacific have been identified, with calls to include these effects in stock assessment models used to provide management advice. However, the ability of model selection tools to distinguish among alternatives for the relationship between environment and recruitment within stock assessments has not been evaluated. The robustness of harvest policies that account for recruitment-environmental linkages is also unknown.

To determine appropriate models for conducting fisheries forecasts under climate change, we evaluate the ability of model selection tools (Akaike's Information Criterion (AIC), Deviance Information Criterion, Mohn's retrospective statistic, and cross validation) to choose among assessment models that differ in modeled linkages between recruitment and the environment. We use Stock Synthesis to simulation test the estimation performance of models chosen by these tools with that of models where recruitment-environment linkages are specified correctly. We determine the consequences for estimates of reference points used for fisheries management in the Gulf of Alaska. Comparing models with or without an environmental link to unfished recruitment for flathead sole, AIC failed to consistently choose the correct estimation model, on average selecting a model with no environmental link even when the true dynamics included this effect. Resulting estimates of management quantities were biased when the assumed recruitment-environmental link was incorrect.

Our study provides guidance on the use of model selection tools for stock assessment models incorporating recruitment-environment relationships, improving the ability to assess the sensitivity and robustness of fisheries forecasts under climate change to model uncertainty.

S5: BIO/MONITOR/MEQ Topic Session
Understanding our Changing Oceans through Species Distributions and Habitat Models based on Remotely Sensed Data

S5-P1

Impacts of climate change on suitable regions for Japanese scallop aquaculture in Shandong, China and southern Hokkaido, Japan, using RS/GIS

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The Japanese scallop (*Mizuhopecten yessoensis*) is an important commercial species in southern Hokkaido, and it was first introduced into China from Japan as an alternative species for aquaculture in 1982. Japanese scallops quickly became a popular species that was widely promoted and cultured in Shandong provinces. However, climate change, and human activities affect coastal environments and aquaculture, threatening food security and economic growth for the coastal communities of Shandong, China and southern Hokkaido, Japan. In this study, we combined satellite remote-sensing data, in situ observations, and a suitable aquaculture site selection model to explore the interactions between marine environments and climate variability over a recent 13-year period (2003–2015). Our analyses of climatic event (Winter East Asian monsoon (EAM), and El Niño/La Niña Southern Oscillation (ENSO)) and meteorological (precipitation, temperature, and wind) data allowed us to determine the impacts of climate change on regional coastal environments and more specifically, prospective sites for scallop aquaculture. These analyses showed that EAM strongly influenced the aquaculture areas on the Shandong through their effects on temperature during winter. We also determined that wind was the main driving force behind regional environmental changes during spring. Conversely, in southern Hokkaido, suitable areas for scallop aquaculture and variations in chlorophyll-a concentration and sea temperature were correlated with ENSO. Adaptation to oceanic and atmospheric changes should be considered when developing plans and management strategies for coastal scallop aquaculture in northeast Asia.

S5-P2

Integrating habitat, prey and predators over space and time to assess distributional responses to environmental variability and climate change

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Impacts of climate change on the distribution of marine predators are typically assessed in isolation from aspects of community ecology, such as predator and prey relationships. This omission limits our potential to understand, anticipate and respond to changes in ocean ecosystems. Our research uses species distribution models (SDMs) to integrate habitat, prey and predators to achieve more realistic spatial predictions. We generated SDMs of California sea lions and some of their prey items (anchovy, sardine, herring) off the Oregon and Washington coasts to describe and compare habitat use and to predict distribution patterns under various temporal and climate change scenarios. Prey SDMs are based on pelagic fish trawls (n=498) conducted 2-3 times annually since 1998 that frequently catch sea lion prey (anchovy, sardine, herring). Predator SDMs of California sea lions are based on satellite telemetry (n=26 tracks). Covariates in models of predator and prey include static features and remotely sensed oceanographic data. Prey models demonstrate distinct habitat and distributional patterns between fish

species. We also couple and compare prey and predator SDMs to describe spatial overlap and spatial shifts of predator and prey model predictions under forecasted climate change. These methods synoptically compare habitat preferences and distributional responses of California sea lions and their prey to environmental variability. Results describe how the permeating effects of climate change and environmental conditions will impact the redistribution of marine predators and their prey.

S5-P3

Distribution of Arctic and Pacific copepods and their habitat in the northern Bering and Chukchi Seas

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To quantify the factors affecting the abundance of copepod in the northern Bering and Chukchi Seas, we constructed habitat models explaining the spatial patterns of large and small Arctic and Pacific copepods, separately. The structures of water masses indexed by using principle component analysis scores, satellite-derived timing of sea ice retreat, bottom depth, and chlorophyll *a* concentration were integrated into generalized additive models as explanatory variables. The adequate models for all copepods exhibited clear continuous relationships between the abundance of copepods and the indexed water masses. Large Arctic copepods were abundant at stations where the bottom layer was saline; however they were scarce at stations where warm fresh water formed the upper layer. Small Arctic copepods were abundant at stations where the upper layer was warm and saline and the bottom layer was cold and highly saline. In contrast, Pacific copepods were abundant at stations where the Pacific-origin water mass was predominant (i.e. a warm, saline upper layer and saline and a highly saline bottom layer). All copepod groups showed a positive relationship with early sea ice retreat. Early sea ice retreat has been reported to cause spring blooms in open water, allowing copepods to utilize more food while maintaining their high activity in warm water without sea ice and cold water. This finding indicates that earlier sea ice retreat has positive effects on the abundance of all copepod groups in the northern Bering and Chukchi Seas, suggesting a change from a pelagic–benthic-type ecosystem to a pelagic–pelagic type.

S6: POC/MEQ/MONITOR/BIO Topic Session What Factors make or break Trophic Linkages?

S6-P1

Anomalous ocean conditions in 2015 and the impact on spring Chinook salmon and their prey field

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Anomalously warm winter ocean conditions in 2014-15, when prey resources of juvenile salmon develop, would typically predict low salmon prey biomass, based on our previous 18 year time-series. This was not the case in 2015, when abnormally high biomasses of northern anchovy and rockfish larvae were present. The trophic habits of juvenile Chinook salmon collected in coastal waters of the northern California Current in May 2015 reflected higher proportions of juvenile rockfish being eaten, but no evidence of northern anchovies being consumed. The May Chinook salmon diet composition most closely resembled those of other warm years of our study period, when subsequent adult salmon returns were poor. June diets also reflected a warm prey community being consumed, with higher amounts of juvenile rockfish, northern anchovies, and crab megalopae being eaten, similar to during the 1998 El Niño. Both May and June Chinook salmon had one of the highest percentages of empty stomachs, but overall stomach fullness was average in May and especially low in June. Most salmon in 2015 were below average weight for their length. In 2015, Chinook salmon weighed 17.6% less than the same size fish in a cold ocean year (2008). Poorer condition (thinness) of Chinook salmon related to decreased adult returns two years later. Prey type, high numbers of empty stomachs, low June stomach fullness, and thin small salmon in 2015 suggests that the prospects for the 2015 ocean-entry smolts are not favorable, and documents clear climate forcing on important marine trophic linkages.

S6-P2

Interannual variation in phytoplankton blooms and its biological impacts in the Sea of Japan

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The magnitude of phytoplankton bloom in the Sea of Japan is recognized to affect small pelagic fish productivity and are believed to have been influenced by human activity through an increase of anthropogenic nutrient supply and elevation of seawater temperatures. In this study, interannual variation in phytoplankton blooms was evaluated for the period September 1997 through May 2016, by using empirical orthogonal function (EOF) analysis and monthly multi-satellite-derived sea surface chlorophyll *a* (SSChl *a*) concentrations after validation with *in situ* chlorophyll *a* concentrations. The spatial structure of the first EOF of SSChl *a* was high in the south and relatively low in the north. The first EOF score indicated that phytoplankton blooms in the Sea of Japan occur in March–May and November. The interannual variation in the score in March was positively related to the abundance of copepod nauplii at the end of the next month, April, along the Japanese coast. This increase in the magnitude of spring phytoplankton blooms was considered to improve the feeding environments of small pelagic fishes in the Sea of Japan. The SSChl *a* trend in March was positively associated with the landings of Japanese sardine in the next year. In contrast, we found a negative relationship between the score of the first EOF of SSChl *a* in March and logarithms of recruitment per spawning biomass. It is suggested that production attributable to spring phytoplankton blooms in the Sea of Japan affects the feeding environment of both adults and larvae of the Japanese sardine.

S6-P3

Developing marine food web models to evaluate blue whale, Cassin's auklet and salmon responses to long- and short-term changes in oceanography in the California Current

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Upwelling of deep water delivers nutrients to the surface that results in recurring blooms of phytoplankton, abundant zooplankton, and a diversity of pelagic predators in the Gulf of the Farallones (GOF), in the California Current. Anomalous ocean conditions are linked to fluctuations in predator populations. Nutrients presumably play a key role in driving abundances of predators but has not been directly examined. Using the ten-year multivariate ACCESS dataset from the GOF, we investigate mid- and high-trophic level responses to Pacific-basin scale climate, regional and local ocean conditions. Using path analysis we examine how environmental drivers affect nutrients and determine spatial and temporal patterns in distribution and abundance of lipid-rich copepods and krill. Similarly we analyze how drivers affect temporal abundance of blue whale, Cassin's auklet, and salmon. We find that krill and copepod abundance associates with strong upwelling near the shelf break during May-June, with direct and indirect climate influence. Cassin's auklet densities associated with environmental factors that regulate krill availability near the surface where they feed. Blue whale abundance reflects overall krill biomass, driven by phytoplankton stock and ocean temperature. Salmon abundance is influenced by krill and climate during smolting conditions. We find that zooplankton and top predators do not respond uniformly to conditions and changing resources due to the complexity of the food web, how they utilize the ecosystem, and the traits of the various organisms involved. This complexity needs to be included in any attempts to model top predators' responses to changing ocean conditions.

S6-P4

Fine scale oceanography and the ecology of juvenile Chinook Salmon in the Salish Sea

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While many juvenile Pacific Salmon migrate rapidly onto the continental shelf, some stocks remain in coastal basins and inlets through their first marine summer. Epipelagic habitats in these regions may be highly structured: wind and tidal currents interact with complex topography, resulting in spatial variability in water column stratification and generating hydrological features including tidal jets. This structure may result in regions where conditions conducive to rapid growth lead to predictable concentrations of juvenile salmon; potentially modulating both intraspecific density dependence and interactions with higher and lower trophic levels. We are employing a flexible, low cost, small vessel based approach (microtrolling), coupled with sampling of zooplankton and water column properties, to investigate distribution, diet and growth of juvenile Chinook Salmon in Salish Sea. Our results suggest that diet and growth of juvenile salmon varies between spatially adjacent but oceanographically dissimilar sites. Furthermore, distribution and/or feeding activity is in some cases spatiotemporally structured by tidal forcing at scales of 100s of meters or less. Understanding utilization of foraging hotspots should inform attempts to determine factors controlling early marine survival in the Salish Sea and provide general insights into how behavior interacts with fine scale oceanography to influence the ecology of juvenile salmon.

S6-P5

Impact of physiological flexibility of phytoplankton on modeled primary production in the western North Pacific

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We compare modeled biomass and production from a recently developed flexible phytoplankton model (FlexPFT) to that obtained with an inflexible control model, which is a typical NPZD-type model based on Monod kinetics for growth with fixed C:N:chl ratios. We evaluate each model's ability to reproduce observed seasonal cycles of primary productivity, chlorophyll, and nutrients in the surface layer at two contrasting time-series sites, K2 (subarctic gyre) and S1 (subtropical gyre) in the western North Pacific. The two models are the: 1) inflexible control (NPZD) model, which uses the Monod/Michaelis-Menten equation, and 2) Flexible phytoplankton functional type (FlexPFT) model, which accounts for the adaptive physiological response to changing light and nutrient levels. These two models produce different vertical distributions and seasonal cycles of production at the two observation stations. Compared to the NPZD model, the FlexPFT has more intense peak production, which occurs closer to the surface at both stations, and a more even seasonality with a clearly defined sub-surface maximum at S1. Production is more evenly distributed vs. depth with the NPZD model, with low-levels of production occurring down to greater depth, compared to the FlexPFT model. We examine the reasons for these differences by comparing also the vertical distributions of chlorophyll and biomass (N) obtained with each model, respectively.

S6-P6

Climate events and recruitment dynamics of anchovy in the California Current: A mechanistic understanding using a climate-to-fish model

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A fully coupled climate-to-fish model is used to study the effect of varying ocean conditions of Californian waters on anchovy recruitment during the last century. Our focus is on better understanding the response of anchovy in terms of habitats, growth, survival, and consequently recruitment to regime shifts and major El Niño-La Niña events documented in the California Current. An individual-based model simulated the full life cycle of anchovy by following the processes of growth, mortality, movement and spawning during the stages of fish development: eggs, larvae, juveniles and adults. A coupled hydrodynamics-biogeochemical model provided the 3-dimensional physical (water velocities, temperature) and prey fields (zooplankton) as inputs for the IBM model during the 1965-2000 period. Model results demonstrated that the occurrence of 1977-1978 regime shift induced the northward shift of spawning grounds by 2.3^{o} and the notable decrease of survival for winter-hatched larvae compared to the 1965-1976 period. The post-1978 period was characterized by persistent changes on larval survival and latitudinal distribution of recruits distribution, implying a biological regime shift. Additionally, during the 1982-83 and 1991-92 El Niño warm events, simulated recruitment and weight of recruits decreased significantly, as a response to elevated temperatures and noticeable decrease of zooplankton biomass throughout the year. Our results provide an important step to mechanistically understand the fluctuations of anchovy population driven by the dynamic ocean environment of the California basin.

S6-P7

Deepening thermocline displaces salmon catch on the Oregon coast

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Establishing a linkage between fish stock distributions and physical oceanography at a fine scale provides insights into the dynamic nature of near-shore ocean habitats and potential insights for fishery management. The Project CROOS (Collaborative Research on Oregon Ocean Salmon) Chinook salmon catch data set represents an unprecedented high-resolution record of catch location and depth, with associated in-situ temperature measurements and genetic data. Here we connect these data with remote and in situ observations of temperature, as well as a data assimilative regional ocean model that incorporates satellite and HF radar data, to gain understanding of how circulation affects salmon catch distributions. Data from 2010 to 2014 near Newport, Oregon, USA, show that catch was primarily located within the upwelling front over seamounts and reef structures associated with Heceta and Stonewall Banks along the shelf break. In late September 2014 the anomalously warm "blob" began to arrive on the Oregon coast, coincident with a strong downwelling event. At this time, the thermocline deepened from 20 to 40 m, associated with a deepening and inshore shift of salmon catch location. A cold "bulb" of water over Heceta Bank may have provided a thermal refuge for salmon during the initial onshore movement of the anomalously warm water. These observations suggest that a warming ocean, and regional warming events in particular, will have large effects on fish distributions, in turn impacting the fisheries.

S6-P8

Biogeography of seabird assemblages in the Bering Sea: Spatial assessment of oceanographic drivers and multispecies aggregation hotspots

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Integrated ecosystem assessments involving syntheses of the distribution and abundance of lower and upper trophic levels reduce ambiguity about the location of key food web interactions. We assess how broad-scale changes in seabird assemblages relate to ocean physics and their functional relationship to the spatial organization of forage species such as larval fish and zooplankton. Our overarching hypothesis is that the along-shelf distribution and abundance of seabirds during summer will reflect underlying hydrography, with an abrupt change in middle shelf domain seabird species composition and abundance at about 60°N, where there is a reported change in bathymetry and hydrographic conditions. Using the North Pacific Pelagic Seabird Database, we developed spatial climatologies (1975-2014) of summertime species abundance and richness (50x50km grid), and quantified a spatially-explicit multivariate index of seabird assemblages. Furthermore, we linked seabird assemblages to results of an oceanographic model (e.g., temperature, current velocity) and to the distribution and abundance of fish and zooplankton to assess multispecies aggregation hotspots. Spatial coherence among ocean conditions and seabird assemblages indicate the following unique seabird biogeographic regions: (a) southeast Bering Sea Inner-Middle shelf domain, (b) outer shelf-slope domain, (c) central-northern Inner-Middle shelf domain, and (d) northern Anadyr Current. Furthermore, persistent multispecies hotspots of seabirds and forage species are related to spatial gradients of temperature and bathymetry across the inner and outer shelf domains. We discuss our results to highlight the location of key trophic hotspots in order to benefit spatial management of Bering Sea Ecosystem.

S6-P-11303 (Not a poster, Backup for oral presentation)

Life at the ice edge: Does the timing of ice retreat set the table in the eastern Bering Sea?

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Seasonal sea-ice cover is a signature aspect of the eastern Bering Sea shelf. The timing of sea ice retreat affects the availability of diatoms for herbivores, either by affecting the timing of the spring bloom, or by creating a gap between the availability of ice-associated algae and the start of the open-water spring bloom. In years with early sea-ice retreat, both the lipid-rich copepod, *Calanus marshallae* and the euphausiid *Thysanoessa raschii* have weak recruitments. When these zooplankton are scarce, age-0 walleye pollock have low lipid content, and fail to recruit to age-1. These recruitment failures can severely impact the pollock fishery. If there is a long-term shift to earlier sea ice retreat with climate warming, we may expect a very different ecosystem in the southeastern Bering Sea.

S6-P9

Winter phytoplankton blooms and trophic implications on copepod and krill biomass and egg production in the northern California Current

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In the northern California Current (NCC) ecosystem, phytoplankton are most productive during the summer upwelling season, biomass is highest, copepods and krill have high egg production rates, and linkages between lower and higher trophic levels is strongest. However, phytoplankton blooms also occur in late winter, before the upwelling season, and results in spawning by copepods and krill. Several published studies have shown that winter blooms serve to ‘precondition” the system for high zooplankton biomass in summer, by enhancing biomass due to winter spawning events and subsequent cohort development. To validate the hypothesis that winter phytoplankton blooms “precondition” the system for an enriched upper food chain during the upwelling season, this study uses a 15-year (2001-2015) time series of phytoplankton data with concurrent copepod and krill biomass and egg production rate time series to examine bloom (a) occurrences and relationships with broad scale drivers (e.g. PDO) versus local physical environments (b) association with reproduction and biomass of copepod and krill in winter and spring/summer (c) implication on upper trophic productivity. Preliminary analyses show that: diatoms are sensitive indicators of ocean condition changes; PDO has significant impacts on winter blooms (not local conditions); diatom abundance (not Chl *a* measurments) significantly correlated with both northern (negative) and southern (positive) copepod biomass in winter and the following spring and summer. The above causes and results will be discussed for a better understanding of the winter bloom benefits.

S6-P10

Jellyfish - fish trophic interactions in the Bering Sea: Ecosystem impacts of jellyfish population fluctuations

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Populations of scyphozoan jellyfish in the eastern Bering Sea (EBS) can grow rapidly within a single season and have fluctuated by orders of magnitude over recent decades. Understanding the trophic role of jellyfish in the EBS ecosystem is required for fishery and ecosystem management, however we lack direct measurements of the impact that changes in jellyfish abundance have had upon this ecosystem and its fish populations. We examined the role the dominant scyphozoan jellyfish in the region, *Chrysaora melanaster*, plays as a competitor, predator and ecosystem structuring agent in the EBS by simulating the direct and indirect impacts of jellyfish variability throughout the food web via large-scale ecosystem models. To estimate the impacts of changing jellyfish abundances on other planktivores (forage fishes and juvenile salmon), we developed a spatially-resolved trophic model for three coupled, cross-shelf regions representing different oceanographic domains. Models were configured separately for "warm" (2001-2006) and "cool" (2007-2010) periods using survey data. Over the EBS middle shelf, jellyfish require 20-fold more energy from the ecosystem than forage fish but pass along only 1/10th as much energy to the higher food web, thus playing a strong structuring role when in high abundance. Simulations with forced reductions in the scyphozoan jellyfish population (as during the "warm" 2001-2006 period) suggest increased productivity of mid and upper trophic level groups in benthic and pelagic food webs. Simulation trends agree qualitatively with empirically-observed differences among pelagic planktivorous and piscivorous fishes in the "warm" vs "cold" regimes in the EBS.

S6-P11

Sim-turtle: Biophysical interactions in the mesoscale

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We present preliminary results from a project designed to identify optimal migration pathways of turtles in the North Pacific and North Atlantic by applying control theory methodology to an individual based model of juvenile turtle migration. The global CESM-BEC earth system model, run at 0.1º, resolves the mesoscale ocean circulation consisting of jets and eddies, as well as the associated biological response. This includes a zooplankton pool, which we use as a proxy for juvenile turtle forage. Turtles are simulated using an off-line particle tracking code, modified to track turtle fitness and approximate turtle swimming behavior. In this first phase of the project, we are exploring the role of the mesoscale oceanographic velocity, food and temperature distributions in constraining turtle fitness and life history, looking for oceanographic bottlenecks defining critical habitat for juveniles. Simulated tracks are compared with observed turtle tracks.

S6-P12

Integrating stable isotope analyses of zooplankton and returning adult salmon tissues to inform high seas North Pacific food web dynamics

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Due to the logistical challenges and costs of collecting fish and measuring food web parameters on the North Pacific high seas, the feeding conditions experienced by maturing adult salmon remain relatively understudied and are not routinely monitored. Here we present an approach to inform high seas food web dynamics using salmon themselves as integrative samplers. The carbon ($\delta^{13}C$) and nitrogen ($\delta^{15}N$) stable isotope signatures of adult salmon reflect an integration of high seas nutrient availability, primary productivity levels, and food chain length (via trophic level estimates). Key parameters required to separate these three factors are the $\delta^{13}C$ and $\delta^{15}N$ values of the trophic baselines (plankton). From 2011 to 2015 tissue samples were routinely collected from sockeye salmon in Rivers Inlet (British Columbia), at the point of entry into their natal freshwater system. We establish the trophic baseline using two approaches: 1) bulk isotope analysis of zooplankton samples collected during the North Pacific Continuous Plankton Recorder (CPR) survey on transects between Vancouver and the Gulf of Alaska; and 2) amino acid specific $\delta^{15}N$ analysis of the sampled salmon tissue. We discuss these results in the context of high seas nutrient dynamics and productivity, and the implications for salmon productivity. Notably, we report on significantly elevated salmon $\delta^{15}N$ values in 2014 and 2015, pointing to a reorganization of the North Pacific food web in these years which were notable for their widespread impact by the warm blob.

S7: POC/TCODE/MEQ Topic Session
New Stage of Ocean Acidification Studies: Responses of Oceanic Ecosystem including Fisheries Resources

S7-P1

Ocean acidification observation system at Bohai Gulf based on ocean acidification characteristic parameters

Yumei **Zhao**, Wu He and Han Bing

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Ocean Acidification and Marine pollution are two of many stressors that our marine environments are contending with right now. The Gulf is a concentration space of human activity. It is in danger. What is at risk of being destroyed is not the gulf itself, but the conditions that have made it hospitable for human beings. We would build the real time in-situ multi-dimensional observation system based on voluntary observation ship, buoy, monitor, station and satellite remote sensing. From the system, we would get real-time data on ocean acidification and marine pollution in Bohai Gulf. So, we would build the relationship among pollution parameters, marine quality and ocean acidification in order to improve marine environment.

S7-P2

Is there decadal change in shell morphology of planktonic foraminifera due to ocean acidification?

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Presented by Sanae Chiba on behalf of Mimoru Kitamura

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Calcification process of marine organisms is thought to be vulnerable to ocean acidification. Foraminifera are unicellular organisms with calcitic shells. Several rearing experiments showed shell dissolutions in water undersaturated with calcite for not only benthic but also planktonic species. However, there have been no field research considering the influence of ocean acidification on shell morphology of foraminifera. So, we just started research to understand presence or absence of long-term change in shell density of planktonic foraminifera in the western North Pacific. Foraminiferal samples were collected in the North Pacific CPR program, a PICES MONITOR project, and shell density analysis was performed on X-ray microcomputed tomography (XMCT) system. The XMCT allows non-destructive observation of internal structures of the foraminiferal shell and provides CT-number which is an indication of shell density. In our poster presentation, we will show detailed methods and preliminary results. For planktonic foraminiferal shell, basic biological information such as its ontogenetic change or variability among specimens is still limited. However, these are needed to detect its long-term change. We should also understand presence or absence of shell dissolution during preservation. These potential problems will be also discussed.

S7-P3

Frequent column observations revealed low pCO_2 water under the sea ice melt in the Canada Basin of the Arctic Ocean

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In September 2013, we observed an expanse of surface water with low CO_2 partial pressure (pCO_2^{sea}) (< 200 µatm) in the Chukchi Sea of the western Arctic Ocean. The large undersaturation of CO_2 in this region was the result of massive primary production after the sea ice retreat in June and July. In the Canada Basin, however, salinity was low (< 27) and pCO_2^{sea} in surface water was closer to the air-sea CO_2 equilibrium (~360 µatm). From the relationships between salinity and total alkalinity, we found that the low salinity in the Canada Basin was ascribed to the larger fraction of melt water input (~0.16) rather than the riverine discharge (~0.1). These observations reinforced the previous finding about inhibited oceanic CO_2 uptake by melt water with low density in the Canada Basin. Meanwhile, relatively low pCO_2^{sea} (< 300 µatm) and oxygen supersaturation (AOU < -40 µmol kg^{-1}) suggested significant biological activity under the halocline there. According to the vertical profile of temperature and salinity, this biologically active layer consisted of the remnant of winter mixed layer in the Canada Basin and the Pacific Summer Water. If strong disturbances cause vertical mixing, this layer will appear on the surface and increase oceanic CO_2 uptake. However, likely retreat of sea ice in the future will thicken the surface melt water and make it more difficult for the subsurface layer to arrive on the surface.

S7-P4

The combined effect of high pCO_2 and warming on reproduction of Japanese whiting *Sillago japonica*

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Ocean acidification and warming, caused by increased anthropogenic carbon dioxide (CO_2), threaten marine organisms. However, little is known about the sensitivity of marine fish to the combination of acidification and warming. The objective of this study was to determine the combined effects of two temperature (control: 26 °C, +2 °C: 28 °C) and three levels of pCO_2 condition (control, 1,100 and 2,300 µatm) on Japanese whiting, *Sillago japonica*, throughout the reproductive life-history stages. Adult individuals and spawned eggs were continuously exposed to these experimental conditions and number of spawning, number of spawned eggs, rate of normal embryo development, rate of normal hatched larva, and notochord length and otocyst size of the hatched larva were examined. High temperature increased egg and larval development and no significant negative effects of high pCO_2 and/or high temperature were found except for the rate of normal embryo development. The rate of normal embryo development was significantly decreased 12.3 % at a pCO_2 of 2,300 µatm and T of 28 °C. Although the reproduction processes of Japanese whiting are not overly sensitive, acidification and warming may synergistically influence early egg development, and/or spawned gamete. Decrease of fish population in the future may occur.

S7-P5

Dynamic of aragonite saturation horizon depth in waters of Baja California (BC), Mexico

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The saturation horizon with respect to aragonite (HSΩA) has migrated to a depth such that today during period upwelling, it can occur at the surface. The aim of this study was to analyze the hydrographic data of a transect in front of the Ensenada coast, corresponding to line 100 of the IMECOCAL program during 1998-2014. Such data were used to apply an empirical model to estimate the aragonite saturation state (Ωa) in order to identify oceanographic conditions that could have influenced the variability of the depth of saturation horizon during the last 17 years. This variability may affect shellfish habitats and oyster production areas adjacent to the coast of Ensenada. It was found that temperature, salinity, oxygen, pH, dissolved inorganic carbon and Ωa showed a seasonal variation. Additionally, the depth of the HSΩA was not the same year after year, suggesting that the conditions of water chemistry is related to the oceanography of the region and changes in wind patterns. The latter two factors can modulate -ZHSΩArag variability by influencing mass transport of water to the region. These oceanographic characteristics cause seasonal variability, reflected in the depth of the horizon Ωa shallower (~ 66m + 21m) in spring and deeper into the winter (~ 122m + 35). It has been reported that the upwelling off the coast of BC transports water from a depth between 80 and 90m in spring and summer; therefore, undersaturated water (Ωa <1) may be transported through upwelling to the surface off the coast of BC.

S7-P6

Development of communication tools on ocean acidification

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As the IPCC 5th report points out the risks to marine ecosystems, ocean acidification(OA), along with global warming, is becoming a major subject that must be addressed. Though actions have begun in Europe and the US, along with discussions such as CBD and RIO+20, research in Japan is insufficient due to a lack of understanding by policy-makers and the general public. In response to this alarming situation, we have just launched a 5-year program of research last year to observe and analyze the changing situation. Our scope is as follows:

-Promote studies on social-economic influence of global warming and OA in the north-west Pacific area;

-Develop communication tools through project named “Marine Crisis Watch!,” in which both policy makers and the general public are able to share appropriate information;

-Make policy proposals (countermeasures etc.);

-Organize workshops and symposia.

S7-P7

Seasonal variations of pH and aragonite saturation at oyster culture beds in Tongyeong and Geoje Bays, southeast coast of Korea

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About 80~90% of the annual mass production of Pacific oyster *Crassostrea gigs* in Korea are cultured on the southeast coast, including Tongyeong and Geoje regions, where assigned areas for shellfish production, especially for export to other countries, have been conducting a sanitary survey program by the National Institute of Fisheries Science. Carbonate and environmental parameters as well as oyster body properties were observed at Tongyeong, Geoje and Jinhae Bays 4 times (in Feb., Aug. 2014, Apr. and Oct. 2015 and are considered representative of winter, summer, spring and fall respectively). Surface temperature in oyster culturing beds showed clear seasonal variation with about 6~12°C and 24~29°C in Feb. and Aug. 2014, respectively and 14~18°C and 22~26°C in Apr. and in Oct. 2015, respectively. Surface $p\mathrm{H}_{NBS}$ also ranged with about 8.20~8.53 and 7.28~8.95 in Feb. and Aug. 2014, and 8.04~8.40 and 7.91~8.32 in Apr. and in Oct. 2015. High *p*H with low salinity in summer resulted from input of land discharge in rainy seasons, however high *p*H at small bays in Apr. and Oct. 2015 resulted from massive primary production by phytoplankton bloom, supported by high chlorophyll *a* concentrations. Specifically in oyster growing season, aragonite saturation state (Ω_{arag}) in bottom water ranged about 0.2~2.9 (mean 2.1) and 2.2~5.0 (mean 3.2) in Feb. 2014 and Oct. 2015, respectively, suggesting low pH environments arose seasonally in coastal area due to some mechanisms. These results suggest that seasonal ocean acidification state might seriously affect oyster shell growth and mass production in southeast coast of Korea.

S7-P8

Physiological responses of coastal and oceanic diatoms to diurnal fluctuations in seawater carbonate chemistry under two CO_2 concentrations

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Diel or seasonal fluctuations in seawater carbonate chemistry are common in coastal waters, while in the open ocean carbonate chemistry is much less variable. In both of these environments, ongoing ocean acidification is being superimposed on the natural carbonate buffer system to influence the physiology of phytoplankton. Here, we show that a coastal *Thalassiosira weissflogii* isolate and an oceanic diatom, *Thalassiosira oceanica*, respond differentially to diurnal fluctuating carbonate chemistry in current and ocean acidification (OA) scenarios. A fluctuating carbonate chemistry regime showed positive or negligible effects on physiological performance of the coastal species. In contrast, the oceanic species was significantly negatively affected, with higher respiration than cells grown under the corresponding steady regime. The fluctuating regime reduced photosynthetic oxygen evolution rates of *T. oceanica* under ambient CO_2 concentration, while in the OA scenario, the fluctuating regime depressed its growth rate, chlorophyll *a* content, and elemental production rates. These contrasting physiological performances of coastal and oceanic diatoms indicate that they differ in the ability to cope with dynamic pCO_2. We propose that, in addition to the ability to cope with light, nutrient, and predation pressure, the ability to acclimate to dynamic carbonate chemistry may act as one determinant of the spatial distribution of diatom species. Habitat-relevant diurnal changes in seawater carbonate chemistry can interact with OA to differentially affect diatoms in coastal and pelagic waters.

S8: MoE/MEQ/TCODE Topic Session
The Effect of Marine Debris caused by the Great Tsunami of 2011

S8-P1

Marine algae carried across the North Pacific on Japanese Tsunami Marine Debris (JTMD) and their invasion threat to the coasts of Oregon and Washington, USA

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Carried across the North Pacific on currents from Japan, debris from the 2011 Great Tōhoku Earthquake and Tsunami has been arriving in Oregon and Washington since June 2012. The debris items are often laden with healthy Japanese marine algae that could recruit to invade NE Pacific shores. On 40 of the most heavily colonized items, we have identified 75 marine macroalgal species and species complexes. Of these species, 55% were found on only 1 or 2 debris items, and only 8% occurred on >15 debris items. 77% were fertile bearing mature reproductive structures, and many were ephemeral (48%) and/or opportunistic (77%) forms capable of reproducing multiple times during a single year and quickly invading new habitats. Two-thirds (66%) of the species on JTMD have been reported to already occur in the NE Pacific before the tsunami. These include widespread species, native species common to both the NW and NE Pacific, and also non-indigenous species by earlier introductions. Currently, we are using multiple genetic markers to analyze the JTMD specimens and determine their relatedness to native populations in the NE and NW Pacific. Our comparative studies are also revealing new cryptic species in populations on both coasts. Well-known global invaders on JTMD include: *Undaria pinnatifida*, *Codium fragile* subsp. *fragile*, *Grateloupia turuturu*, *Antithamnion nipponicum*, *Polysiphonia morrowii*, and *Saccharina japonica*. New populations of these species have not yet been found in Oregon or Washington. However, if they do recruit and become invasive in this area, they could dramatically impact the marine environment.

S8-P2

Marine algae carried across the North Pacific on Japanese Tsunami Debris: How have they survived the journey?

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More than 5 years after the Tohoku earthquake and tsunami, Japanese Tsunami Marine Debris continues to arrive on the shores of Oregon and Washington carrying healthy Japanese marine algae. How do these species survive at sea for such a long period of time? From June-2012 to April-2016 we identified 75 species of macrobenthic marine algae from tsunami debris. For these species, the basic requirements for survival were at least initially met, including: suitable substrate for attachment, appropriate seawater submergence, acceptable light and temperature, sufficient nutrients, minimal herbivory & also reproductive and recruitment success. However, not all of the species survived the full 5 years. This was due partly to stresses at sea but also to the variable longevity or life span of the species. Except for the crusts, none of the original colonizing thalli were present after the first year of collection – only their progeny. The longevity of most algal species is relatively short, and, to survive on debris, each species must recycle itself through sexual or asexual reproduction and recolonize the debris. In our study 50% of the species were found to be ephemerals with short life spans, 33% were annuals lasting up to a year, and 16% were longer-lived perennials and pseudo-perennials. Of the 75 species found on debris, 58 or 77% were observed to be actively reproductive. A comparison of the reproductive methods, longevity and survival time of the species on debris will be provided along with illustrations of the habit and reproductive features of example species.

S8-P3

Aerial surveillance for tsunami debris in British Columbia, Canada

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Aerial surveys are useful tools to search and document long stretches of inaccessible coastline in order to identify large debris items from the 2011 Japan tsunami, estimate the relative abundance of debris and prioritize areas for debris clean-up. In 2014-2015, aerial surveys were conducted off the exposed, outer coast of British Columbia using a fixed wing aircraft acquiring over 6,500 images and covering more than 1,500 kilometers of potentially affected coastline. Post-survey processing assigned unique identifiers (tags) for specific types of debris and quantified the amount of debris on a qualitative scale from 0-5. GIS analysis was conducted on the ranked photographs in order to create geospatial data for each coastline segment. Each segment contains the average debris rating from the photographs occurring on that segment and maps of the entire coastline highlight hot spots of debris accumulation. The analysis showed that debris accumulation increased with latitude, with more debris visible in the northern part of the study area and on the islands of Haida Gwaii. Peninsulas and other exposed, protruding coastline segments had higher debris accumulation. Nine vessels were detected in the aerial survey and two of these have been confirmed as Japanese tsunami debris. The debris ranking segments, maps and photographs are now available to the public through an online mapping portal created on B.C.'s Map Hub. This portal allows local bodies to prioritize clean-up activities across a region of interest and proactively estimate the time and resources required to clear specific stretches of coastline.

S8-P4

Synthesizing the state of debris in Hawaii from 2015 aerial imagery and spatial analysis data

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The 2011 Tohoku earthquake and resulting tsunami that devastated Japan dispersed an estimated 5 million tons of marine debris into the ocean. An estimated 70% of that debris sank (Ministry on the Environment of Japan, 2011), but the remaining 1.2 million tons were dispersed across the Pacific Ocean and began to appear in Hawai'i in 2012. This debris has the potential to physically damage the marine environment, poses a threat to coastal communities and beach-goers alike, and may harbor aquatic invasive species capable of devastating Hawaii's fragile and isolated ecosystems. In 2015, PICES funded *Mapping Patterns of Marine Debris in the Main Hawaiian Islands Using Aerial Imagery and Spatial Analysis*. Aerial surveys of the 8 Main Hawaiian Islands (MHI) were conducted and the resulting imagery was analyzed to identify and quantify marine debris on Hawaiian coastlines. The analysis concluded that about 12% of coastlines are areas of high marine debris accumulation. This project provided a baseline of marine debris densities at a moment in time, and collaborated with the State of Hawaii's Department of Land and Natural Resources to prioritize areas of highest marine debris accumulation, or "hotspots", in order to provide guidance to the regulatory agency and its local and federal partners.

S8-P5

Contamination of hexabromocyclododecanes (HBCDs) in styrofoam marine debris from Asia and Pacific region and the Great Tsunami

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Hexabromocyclododecane (HBCD) listed in the Stockholm Convention as a persistent, bioaccumulative and toxic chemical is an additive mainly applied to expanded polystyrenes as a flame retardant. In order to evaluate the HBCD content in styrofoam marine debris, the beached styrofoam samples including styrofoam buoys and their fragments (predominant marine debris in Republic of Korea) have been collected along the Korean coasts and analyzed. In addition, styrofoam marine debris from twelve countries in Asia and Pacific region (USA, Canada, Singapore, Hong Kong, India, Peru, Brunei, Sri Lanka, Vietnam, Thailand, Taiwan, and Bangladesh) and the Great Tsunami styrofoam debris stranded on Alaskan beach of USA were also investigated. A wide range of HBCD concentrations were detected in the samples. For the Korean samples, the HBCD concentrations were in the range of 282-2700 μg/g for styrofoam spherules, 3.6-878 μg/g for small-sized buoy (40-70 L), and 0-4680 μg/g for large-size buoy (> 200 L). In general, styrofoam debris from developed countries such as USA, Canada and Singapore showed higher concentration of HBCDs compared to developing countries. Three out of nine styrofoam debris samples from the Great Tsunami had HBCDs in the range of 3,160-14,500 μg/g, which was thought to be originated from construction materials. Owing to their buoyancy, styrofoam debris have great potential to travel long distances by ocean currents and winds. The transportation of styrofoam marine debris in the ocean is not only a problem of nuisance debris but can also result in the dispersion of hazardous substance.

S8-P6

An undescribed species of Japanese *Pyropia* appeared on the coast of British Columbia in 2015

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In 2015, on the central coast of British Columbia, we documented the occurrence of a Japanese species of seaweed that may have arrived with tsunami debris. The find occurred at a site that has been subjected to intensive characterization of the seaweed flora for the past five years so there is little doubt that the species was new to the area in 2015. Even before sequencing, we suspected that this species had affinities with Japanese rather than North American species because of the distinctive disposition of reproductive cells found on Japanese but not native North American species. In a molecular phylogeny, this species is basal in a clade of Japanese and other Far East species of *Pyropia*. That said, this species has yet to be reported from Japan. In addition to the central coast of British Columbia, the species has been recorded from the South Island, New Zealand, and from Monterey Bay, California, based on molecular sequences. This find highlights the difficulty of documenting possible invasives when the Japanese flora and fauna have not been adequately characterized to allow for comprehensive comparisons. The species was not observed in 2016, but overall *Pyropia* diversity and abundance were down in 2016.

S8-P7

Life history and environmental requirement analyses of Japanese tsunami marine debris (JTMD) biota

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The Great Tōhoku earthquake and tsunami released massive amounts of debris into the Pacific in 2011. This anthropogenic litter not only served as prime habitat for biofouling species, but also as a method of transport over large distances. We quantified the scale of variation of life histories, geographic ranges, and environmental requirements (including temperature, salinity, and other variables) of approximately 150 species in 13 phyla recorded on Japanese Tsunami Marine Debris (JTMD) landing in North America and the Hawaiian Islands. A combination of descriptive synthesis and multivariate analytical approaches were used to categorize these attributes and identify statistically independent axes of variation within the JTMD species pool. A primary focus of our

work was to compare traits of JTMD species known to have been introduced elsewhere with those JTMD species with no known prior invasion histories. This work contributes to the extensive efforts to record the biodiversity of JTMD biota over space and time by providing a critical ecological synthesis of JTMD species.

S8-P8

Trends in arrival and deposition of Marine Debris generated by the March 2011 Japan Tsunami on Eastern Pacific Shorelines

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The transport of marine debris generated by the Japan Tsunami was hindcasted from March 11, 2011 through March 2015. The debris was modeled as particles initialized at 8 sites along the Japan coast spanning a distance of ~700 km. Due to limited information about the distribution of debris that entered the ocean, the particles were distributed equally among the sites. Simulations were performed using the NOAA GNOME particle tracking model. GNOME inputs include modeled currents and winds which assimilated satellite data:

Currents: Global 1/12° operational HYCOM from Naval Research Lab http://www7320.nrlssc.navy.mil/GLBhycom1-12/skill.html

Winds: NOAA Blended Sea Winds 0.25° global http://www.ncdc.noaa.gov/oa/rsad/air-sea/seawinds.html

The particles were assigned varying values for windage, a parameter specifying the degree to which a floating object is acted upon by the winds. For these simulations we used a range of 0-5%, which translates to movement in the downwind direction of up to 5% of the wind speed.

Time series of particle movement illustrates how the different types of debris might have moved. Most of the particles are transported eastward in the North Pacific Current -- the higher windage particles released along the coast of Japan in March 2011 began approaching the West Coast of North America in fall/winter 2011/212. In contrast, relatively few low windage objects come ashore within the entire 4 year simulation. High and medium windage particles began approaching HI in spring/summer 2012. Sensitivity studies examine the impact of different windage specifications and initial particle locations on patterns in deposition.

S9: FIS/TCODE Topic Session Resilience, Transitions and Adaptation in Marine Ecosystems under a Changing Climate

S9-P1

Impacts of environmental changes on fluctuations in Bering Sea pollock recruitment, abundance and distribution

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The eastern Bering Sea pollock abundance and biomass has been increasing since 2010 and stabilized in 2014-2015 at an above-average level (10-11 mln. t) due to the recruitment of large year classes in 2008 and 2012 and average year classes in 2009-2011 and 2013-2014. Annual variations in pollock abundance and biomass in the Bering Sea occur primarily as a result of natural factors. The time series data demonstrates that numerous pollock year classes often had appeared in the periods of climate shifts with significant temperature gradients and temperature anomalies in the Bering Sea. The changing of annual thermal conditions in the Bering Sea has big influence on plankton community, trophic level and pollock food supply. The higher abundance of zooplankton in periods of climate shift quite possibly associated with rapid changing in species staff of zooplankton community, increasing range of diversity of plankton size groups, and potentially better food supply of pollock young-of-the-year in winter time. This data confirm hypothesis that winter period could be critical for survival of the Bering Sea pollock young-of-the-year and most important for level of annual recruitment. Resilience strategy of pollock behavior in periods with low trophic level due low abundance of large zooplankton in the Bering Sea are early active northwestern feeding migrations from winter habits and spawning grounds as well as early active back southeastern migrations.

S9-P2

Species composition and biomass dynamics of nekton in the upper epipelagial of the deep-sea part of the Okhotsk Sea during the autumn periods in 1998-2015

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Regular ecosystem surveys, using standardized methods and conducted on similar dates during autumn of 1998-2015, have been used to monitor species abundances and quantify environmental conditions. While pelagic trawl surveys were aimed at estimating young-of-the-year Pacific salmon, these surveys provided the opportunity to study the composition and dynamics of the nekton community over the period 1998-2015. The data are aggregated here over the total survey area, which encompassed 485,340 km^2. In the catches, we observed 56 species of nekton, including 40 species of fish and 16 species of cephalopods. In different years, the number of species varied from 19 in 2000 to 32 in 2011, and total nekton biomass varied from 134,170 t in 2014 to 1.86 million t in 2008, with a mean value of 655,320 t. In recent years, the abundance of nekton decreased compared to the late 2000s, with recent abundances ranging between 134,170 and 666,330 t (mean: 335,660 t. Species composition was divided into 9 groups, the most abundant of which were mesopelagic species (N =13), which undergo vertical migrations into the surface layers at night, and epipelagic anadromous species (N =8), consisting mainly of Pacific salmon. The dynamics of total nekton biomass was driven primarily by 1-2 species from these groups, including the mesopelagic northern smoothtongue (*Leuroglossus schmidti*), and the epipelagic pink (*Oncorhynchus gorbuscha*) and chum salmon (*Oncorhynchus keta*), despite the high species diversity in both groups. Fish species dominate the biomass of nekton in the upper epipelagial in the deep-sea part of Okhotsk Sea. The proportion of biomass consisting of fish varied from 71 to 96%, with a mean value 88%. Therefore, the dynamics of fish stocks are strongly reflected in the total biomass of nekton. Most sudden changes in biomass were determined not only by peaks in individual populations, but also by the combined biomass of several coinciding population peaks. For example, the high level of nekton total biomass in 1998 was the result of a high abundance of pink salmon (243,400 t) and northern smoothtongue (320,500 t) overlapping with a peak in the abundance of japanese anchovy *Engraulis japonicus* (797,040 t). In 2008, maximum levels of total biomass resulted from peaks in northern smoothtongue (882,200 t), pink salmon (558,700 t) and chum salmon (218,500 t). In 2006 and 2012, high levels of total nekton biomass were also connected with population peaks of these species, which form the "core" of the nekton community during the autumn period. The combined proportion of northern smoothtongue, pink salmon and chum salmon relative to all fish species was constantly at a high level and varied from 67% (2014) to 97% (2004), with a mean of 87% during the period 1998-2015.

S9-P3

Seasonal shifts of composition and structure of the nekton community in the Northwestern Pacific Ocean

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The nekton community of the upper pelagic layer (0-50 m) in the Northwestern Pacific Ocean (NWPO) is characterized by high dynamics and diverse composition at different seasons. We examined data from trawl surveys conducted in the NWPO from 2004 to 2015 in early spring (February-April) and summer (June-August).

From 2009 to 2011 in early spring 73 nekton species in total were caught. The most abundant families of the nekton community were fam. *Myctophidae*, which included 12 species and 29 % share of the nekton biomass, and fam. *Salmonidae* (6 species and 21 %, respectively). Dynamics of the nekton abundance were determined by the dominant species of myctophids (29 %) and salmon (21 %). Total share of squids was 32 % and the dominant species were Boreopacific squid (23 %) and Firefly squid (9 %).

With the warming of the water, subtropical species were becoming more abundant in that area. Consequently, the biomass of the nekton community increased from 0.6 to 7.5 million t, and the number of species increased to 98 nekton species in summer. Fam. *Scombridae* (3 species and 64 %) and *Ommastrephidae* (3 species and 16 %) were the most abundant groups. Subtropical Japanese mackerel (58 %) and Pacific sardine (9 %) were the dominant species. However, the share of myctophids decreased to 2 % and the share of salmon to less than 1 %. Thus, subtropical species were gradually replacing subarctic and boreal species in the nekton community in early spring and summer.

S9-P4

Inter-oceanic differences in macrozooplankton biomass and community structure in four regions around Hokkaido Island, Japan: Consequences for marine ecosystem structure

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Inter-oceanic differences in macrozooplankton (euphausiids, amphipods, cnidarians and chaetognaths) biomass and community structure were studied in four regions (northern Japan Sea, southern Okhotsk Sea, Donan and Doto areas of North Pacific) around Hokkaido Island. Whole zooplankton biomass ranged between 25 and 315 g wet weight m^{-2} and was significantly higher in the southern Okhotsk Sea. Macrozooplankton composed 5-15% of the whole zooplankton biomass. Across all macrozooplankton taxa, the number of species varied with region: the fewest species (2-4 species) were in the southern Okhotsk Sea, followed by the northern Japan Sea (3-5 species), and the most species (4-9 species) were in the Donan and Doto areas of the North Pacific. Depth topography and thermal conditions are considered possible causes of the differences in species richness across regions. Through inter-oceanic comparison, marine ecosystem characteristics of each region were evaluated. The zooplankton community in the northern Japan Sea was characterized by a predominance of carnivorous macrozooplankton taxa (amphipods, cnidarians and chaetognaths) and fewer herbivorous taxa (euphausiids and mesozooplankton), and it was determined to be as a top-down controlled ecosystem. In contrast, in the southern Okhotsk Sea, the zooplankton community was dominated by herbivorous mesozooplankton and euphausiids, and the marine ecosystem was determined to be a bottom-up control region. In the North Pacific, zooplankton community in the Doto area was dominated by chaetognaths. The zooplankton community in the Donan area showed mixed characteristics of the Doto area and the northern Japan Sea because of the seasonal water mass exchange from these two regions.

S9-P5

Literature review of fisheries management approaches that improve resilience for species, ecosystems, and/or fishing businesses

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Fisheries management actions can impact the resilience of a marine system either negatively or positively. Here we present a literature review of management approaches that could improve the resilience of the system at 3 levels: fish stocks, ecosystems and fishing businesses. The literature review does not introduce any new topics, rather it highlights existing options and future research priorities. On the whole, management actions that seek to increase management flexibility and provide incentives to the fishing industry to try new approaches, while preserving genetic diversity of the fished populations, should prove to be beneficial. New approaches will continue to emerge as managers across the globe grapple with this complex issue.

S9-P6

Advancing the practice of marine cco-compensation in China: Knowledge synthesis from implementation

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The historic development of the concept of payment for ecosystem services, environmental offsets, eco-compensation and marine eco-compensation provides a useful example of ecosystem-based thinking being adapted into practice in China. This comparative synthesis of the differences between these concepts and their implementation in the national context analyzes the theories and practices of current marine eco-compensation in China. This provides a synthesis of knowledge from implementing marine eco-compensation in three different dimensions (state level, provincial level, and city level) in China recently. The paper concludes that the establishment of marine eco-compensation based on marine ecosystem services valuation is very important in China because: it helps to avoid risks; provides a clear definition of methods and locally practical compensation standards; provides stable funding sources; and feasible payment or allocation methods to provide for ecosystem and environmental sustenance or improvement.

Keywords: marine eco-compensation; ecosystem services; marine protected areas

S9-P7

Food sources and trophic structure of fishes and benthic macroinvertebrates in a tropical seagrass meadow revealed by stable isotope analysis

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Stable carbon and nitrogen isotope analysis was used to examine the food sources and trophic structure of 17 fishes and 6 groups of benthic macroinvertebrates in a seagrass meadow in North Sulawesi, Indonesia. For the seagrass, their associated epiphytes, sediment organic matter (SOM), and particulate organic matter (POM) were identified to be the food sources, with $\delta^{13}C$ values ranging from -19.49 (POM) to -9.66‰ (seagrass). The $\delta^{13}C$ of the 23 fauna taxa were between -18.57 (*Arothron manilensis*) and -11.62‰ (*Protoreaster* sp.). For 5 of the 6 groups of benthic macroinvertebrates, seagrass and their epiphytes contributed more than 69.4%. For 14 of the 17 fish species, seagrass and their epiphytes are the main contributors. For 15 of the 17 fishes, the trophic levels inferred from SIA are lower than those from the previously reported diet composition analysis. These findings show that seagrass and their epiphytes are consumed by most of the fish and benthic macroinvertebrates, and are important for a large portion of the food web in seagrass meadows in the Coral Triangle area.

S10: FUTURE Topic Session
The Response of Marine Ecosystems to Natural and Anthropogenic Forcing: Past, Present and Future

S10-P1

The exploration for system stability in the coastal marine ecosystem of northern Yellow Sea of China

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The capacity to withstand perturbation and system sustainability were examined in the Lidao coastal sea of northern Yellow Sea, China using the quantitative modelling framework of Ecopath with Ecosim (EwE). The study region is one with multiple, intensive uses such as intensive suspended aquaculture, particularly kelp culture, and benthic fisheries enhancements, through the deployment of artificial reefs and stock enhancement programs. Changes in the marine ecosystem were explored using EwE for two scenarios: 1) major release programs for sea cucumber *Apostichopus japonicas* and abalone *Haliotis discus hannai*; 2) eliminating the surrounding kelp cultivation activities. Stock enhancement activity was simulated by linearly increasing the target stock scale in Ecopath from standing stock to its estimated ecological carrying capacity. The predicted system indicators of Relative Ascendency and Redundancy considered as an index of the system's ability to withstand disturbance indicated the practices of large-scale releases of *A. japonicas* would strengthen the system resistance to external perturbation to a certain extent. In contrast, releases of *H. discus hannai* would rapidly weaken the sustainability of current system, suggesting that large-scale releases of this herbivorous species are likely to impact the dominant macroalgae because of their grazing activities and thus change the energy flow through this coastal sublittoral ecosystem. The simulation results of removing kelp farms, and the detrital subsidy from kelp into the region, over 10 years and projecting forward for 10 years implied the nutrient interaction between surface kelp farm system and surrounding costal benthic community might facilitate the sustainability of coastal ecosystem.

S10-P2

Effects of climatic stressors on behavioral and physiological response of marine animals

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Carbon dioxide emission increased by human activity not only induces atmospheric warming but also accelerates ocean warming, hypoxia, and acidification. To understand the effects of climatic stressors on marine animals, their behavior and ecological responses were studied. First, the effect of changing temperature and hypoxia on foraging and hiding behavior of the Pacific abalone (*Haliotis discus hannai*) was explored. Hiding in response to light at higher temperature was much faster than hiding at lower temperature. Abalones climbed up more quickly to feed at higher temperature than those at low temperature, and the total number of feeding abalones was higher at high temperature than that at lower temperature. When both temperature and dissolved oxygen (DO) were regulated, temperature showed the similar beneficial effect on foraging and hiding, but low oxygen had a negative effect on the behavior. Second, whether coastal upwelling characterized by low pH and low DO influences the growth and mortality of red abalone (*Haliotis rufescens*) was explored. The population was intermittently exposed to low pH and low DO conditions. While low DO increased the mortality of abalone, low pH decreased the growth rate suggesting that DO and pH separately influence the physiology of red abalone. Third, response of manila clams (*Venerupis philippinarum*) to warming and hypoxia was studied. Low oxygen and high temperature had combined and complex deleterious effects on manila clams. Given the results, we need to study more on the effect of multiple stressors on marine biological resources for sustainable future.

S10-P3

Species-specific responses of demersal fishes to near-bottom environmental conditions within the California Current large marine ecosystem

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In response to hypoxia observed on the continental shelf of the Pacific Northwest, we added an environmental sampling program to the West Coast Groundfish Bottom Trawl Survey in 2007. Using chartered commercial trawlers, we annually sampled catch and an array of environmental parameters including near-bottom oxygen (DO) across a range of depths and conditions from upper to lower limits of the oxygen minimum zone and shoreward across the shelf from U.S. – Canada to U.S. – Mexico. DO ranged from 0.02 to 5.5 mL L^{-1} (n=3288) with 63.2% of stations experiencing hypoxic conditions (<1.43 mL L^{-1}). Catch and species richness exhibited significant and positive relationships with DO. The relation between catch per unit effort (CPUE) and DO was estimated for 34 demersal fish species in five subgroups (roundfishes, flatfishes, shelf rockfishes, slope rockfishes and thornyheads) using Generalized Additive Models. The models included terms for position, Julian day, near-bottom salinity, temperature, oxygen and depth. Positive relationships between CPUE and DO occurred for 19 of 34 groundfish species within hypoxic bottom waters. An additional seven species displayed negative trends. Based on AIC-values, near-bottom oxygen generally played a major role in the distribution of flatfishes, roundfishes and thornyheads. Although DO was not retained in the selected models for eight of 17 shelf and slope rockfishes, it was retained in models with slightly inferior AIC ($\Delta_i < 2$) for seven of these species, with six exhibiting positive relationships between CPUE and DO (over the range of DO values experienced or at hypoxic levels) and one negative.

S10-P4

Detection of anthropogenic impacts on ocean biogeochemical cycles

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Detecting anthropogenic impacts or attributing specific impacts is limited by the fact that most ocean data records are either short (e.g., limited to the "satellite era", post 1979), local (palaeoproxy data), or both (most in situ ocean observations), as well as the fundamental problem of having only one realization of historical climate variability. Climate models provide a proxy that allows Earth to be replicated, so that there can be multiple individual realizations of climate variability with identical statistical characteristics. This talk will explore the variety of approaches that have been used to characterize the statistics of model internal variability so as to get robust estimates of the time at which anthropogenic signals unambiguously emerge from the envelope of natural variability. The recent availability of large (>30 members) ensembles of simulations with full Earth System models including ocean biogeochemistry offers new opportunities to address this question in a quantitative way and inform the design of ocean observing systems, particularly those employing emerging technologies for measuring biogeochemical fields. Large ensembles have been used to understand natural variability in physical climate, and will be increasingly used in studies of emergence, detection, and attribution in ocean biogeochemistry.

S10-P-11232 (Not a poster, Backup for oral presentation)

Climate change and ocean uses – Adaptation from what?

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The adaptation of marine ecosystems and human uses of those ecosystems is an area of active research. However, adaptation is necessarily a planned or unplanned change in trajectory of an ecosystem component or a human use of those components relative to some trajectory that would be followed without the adaptation. For fisheries, the norms guiding the non-adaptive trajectory are not fixed, as considerations like the precautionary approach and ecosystem approach continue to be incorporated into management. However adaptation planning for fisheries is usually undertaken relative to norms and standards that assume accommodating a changing climate is the major incremental consideration, over and above the trajectories of the evolving standard management approaches.

This is short-sighted thinking and will not be sufficient preparation for sustainable future fisheries (or other ocean uses). At least two other drivers of change are likely to be given priority in marine policy, and will have to be accommodated *before* adaptation strategies for fisheries can be implemented. The first is the role of the ocean in climate change mitigation, the second in meeting human food security needs. So far ocean experts have been nearly absent from the climate change mitigation policy dialogue, and the food security SDGs are being planned with no engagement by the climate adaptation community. The alk will outline the developments in these other policy areas and highlight their relevance to adaptation planning. The case will be made for how to address these challengess in the right order.

S10-P5

Potential responses of phytoplankton community structure to future global warming

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In recent studies, empirical relationships between total chl-a concentration and a phytoplankton size/PFT (Plankton Functional Type) fraction on a global scale have been shown. For example, a fraction of diatoms increases with total chl-a concentration. The same tendencies can be seen in the most of the hindcast experiments by current PFT models although the reproduced absolute values of a phytoplankton fraction still have uncertainties. Then, two different mechanisms can be expected as potential responses of phytoplankton community to global warming. One is a possibility that the phytoplankton community structure (i.e., relationships between a phytoplankton fraction and total chl-a concentration) can be significantly changed by changes in ecosystem dynamics under global warming condition (e.g., changes in grazing pass/strength, decomposition/mortality/respiration rate and phytoplankton stoichiometry). Another possibility is that the plankton community shifts to the other stable states associated with changes in total chl-a concentration (e.g., by decrease/increase in nutrient supply to the surface ocean by changes in stratification) while maintaining the current relationship between a phytoplankton fraction and total chl-a concentration. To clarify impacts of both effects, we analyzed results of future simulation by nine different ecosystem models of Coupled Model Intercomparison Project Phase5 (CMIP5). PFT model more than half showed that current empirical relationships obtained by HPLC would be maintained even in a future environment. Based on this result, we projected a potential future community structure of phytoplankton using a multi-model ensemble mean of future changes in total chl-a concentration with the empirical relationship of HPLC.

S10-P6

Statistical downscaling of global projections to the Bering Sea, based on an ensemble of regional model output

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We compute the covariance between 1) the large-scale forcing patterns from IPCC global model projections and 2) regional biophysical indices generated by a 10-km resolution model of the Bering Sea (Bering10K-NPZD), driven by nine separate realizations of that large-scale forcing. This analysis – a model-based form of statistical downscaling – proceeds using both simple regression and multivariate EOF analysis of the output from global and regional models. Such EOF-based methods– sometimes referred to as "regression on the pattern level" – have in fact been widely used in both global and regional climate prediction. Ideally this would enable the direct use of forecast realizations of the IPCC climate models to effectively predict the Bering Sea indices, without the need to rerun simulations with Bering10K-NPZD for each global realization. At a minimum, this method provides an economical way to estimate forecast uncertainty and other statistics of the regional indices, given the large number of global realizations which have emerged (and will continue to do so) under IPCC Assessments Reports.

S10-P7

Upwelling-induced changes in the structure of plankton assemblages and role of heterotrophic bacterioplankton in biogeochemical carbon cycles in the Ulleung Basin, East Sea

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The Ulleung Basin (UB) in the southwest of the East Sea is characterized by the high plankton biomass and primary production. Wind-driven coastal upwelling and upward shift of nitracline below the pycnocline especially in summer have been known to be responsible for the enhanced biological production. However, the fate of high primary production associated with the bacterial activities remains to be solved. We investigated the abundance of phytoplankton, heterotrophic bacteria and microzooplankton, and phytoplankton primary production (PP) and bacterial secondary production (BP) to determine temporal and spatial variations of plankton assemblages and the quantitative role of heterotrophic bacteria in biogeochemical carbon cycles associated with the coastal upwelling in the UB. Phytoplankton assemblages changed from small-sized flagellates in non-upwelled stratified condition to larger diatoms in upwelled condition. Abundance and production of each microbial group increased significantly ($p < 0.005$) in upwelled condition compared to that measured in stratified pre-upwelling condition. BP accounted for average 53% of PP in highly stratified condition, but decreased to 6% in upwelling condition. Similarly, bacterial carbon demand exceeded PP by a factor of 5 in stratified condition, but it balanced with PP in upwelled condition. The results implied that larger bacterial contribution during to organic carbon mineralization during stratified condition will diminish export flux. Consequently, changes in the intensity and frequency of upwelling associated with climatic changes that are in progress in the UB would significantly affect the carbon cycles associated with the fate of primary production and the role of the microbial loop.

S10-P8

Estuarine ecology and environment: In response to long-term variations of Changjiang (Yangtze River) runoff input and sediment load

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Runoff and sediment input plays an important role in the Yangtze River Estuary. In this study, the integrative surveys were conducted in the estuary and its adjacent area from 1998 to 2012. Based on the survey data as well as the Yangtze River flux (runoff, sediment) data at Datong station since 1950, the relationship between estuarine environmental factors and the river flux were examined. The annual runoff of the Yangtze River into the estuary has maintained equilibrium, and there is no significant variation trend. However, the sediment discharge significantly reduced, mainly causing by dam construction in the upper reaches of the Yangtze River region. The runoff would directly affect the distribution of salinity and suspended particle materials. In the investigation area, sea surface salinity negatively related with runoff, and the reduction of runoff was the main reason for the increase in salinity. The Yangtze River flux has a direct impact on the surface suspended particulate matter content in the estuary. The construction of the Three Gorges Project has intercepted most of the sediment from the upper reaches of the Yangtze River. The content of suspended particulate matter after the Three Gorges dam construction performed substantial reduction. The physical and sedimentary environment of the Yangtze River Estuary had responses to the variations of river material flux. This study was supported by National Natural Science Foundation of China (No.41406136, No.31272663, No.41176138 and U1406403).

S11: POC Topic Session
Advances in Understanding and Modeling of Physical Processes in the North Pacific in the Past 25 Years of PICES and Future Directions

S11-P1

Rapid freshening of the Kamchatka and Oyashio currents

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The south-flowing waters of the Kamchatka and Oyashio currents and west-flowing waters by the Alaskan Stream are key components of the western subarctic Pacific gyre. We use CTD and Argo buoys data to investigate the recent freshening in the region. Initially CTD data collected during the implementation of the International North Pacific Ocean Climate Study (INPOC). We found that the salinity in the upper layer of the Kamchatka Current decreased by 0.19 psu/26 years ±0.06 from 1990 to 2015. The temperature increased by 1.05°C/26 years ±0.22 at potential density $26.75\sigma_\theta$ .This freshening and warming is likely link to change in circulation in the western subarctic Pacific.

Historical data show that salinity in the intermediate layer of the Oyashio Current decreased by 0.13 psu/26 years ±0.05 from 1990 to 2015. This variability modulated by the 18.6-year period oscillation of the lunar orbital inclination. Large variations in the tidal mixing occur in subregions such as banks that are strongly dominated by the diurnal constituents. Enhanced modulation of tidal mixing exists near Kuril Islands and particularly in the Oyashio at Kruzenshtern Bank. Tidal harmonics computed from Argos drifters in the Oyashio and Sea of Okhotsk. The accuracy is evaluated through comparisons with independent bottom pressure gauges. The effect of the 18.6-year nodal modulation is estimated and found to cause the significant salinity variations. These variations correlate with tidal mixing and may have important consequences for biological productivity similar to those previously found for the Pacific halibut.

S11-P2

Spreading of Antarctic Intermediate Water in the Philippine Sea

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The Antarctic Intermediate Water (AAIW) is carried by the New Guinea coastal undercurrent (NGCUC) to Philippine Sea (PS), and is carried by Mindanao Undercurrent (MUC) northward as a salinity minimum of intermediate water. In this study, its spreading and temporal variations are explored using Argo floats. Spreading of AAIW is closely associated with the transports of MUC, and is separately carried northward to about 10°N and 15°N by the two branches of MUC. Both diapycnal and isopycnal mixing effects are shown to be elevated in the MUC owing to enhanced salinity gradient near the subthermocline anticyclonic gyre in the southern PS. We also examined the interannual variations of AAIW spreading, and found which may be related to ENSO.

S11-P3

Recent change of sea level variations in the East China Sea from merged altimetry data

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The change trends of sea level height is in the East China Sea (ECS) were examined using merged altimetry data, and possible mechanisms were studied using Ishii data and ORA-S3 assimilation data. The result shows that the mean sea level over the ECS has a rise rate of 7.2 mm/yr during 1993–2001, a fall rate of 8.3 mm/yr during 2001–2005 and a rise rate of 10.1 mm/yr during 2005–2009. The geographical distribution of the sea level variations over the ECS is asymmetric with a pronounced variation existing in the deep water. The trends of thermosteric sea level variations were also examined using Ishii data. The results indicate that thermal change of upper layer has a significant contribution to the sea level variations in the ECS. Heat budget analysis suggests that heat advection may be a key factor influencing the thermal change. Apart from thermal contribution, the contribution of precipitation and evaporation to sea level change were also studied.

S11-P4

A long-term reference for detecting oceanic variations in the western North Pacific: JMA 50-year long 137°E repeat hydrographic section

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Japan Meteorological Agency has been conducting ship-based repeat hydrographic and biogeochemical observations along the 137°E meridian since 1967 for winter and since 1972 for summer, and we celebrate its 50th anniversary this year. The 137°E section extends from 34°N south of Japan to 3°N off New Guinea, crossing major currents such as Kuroshio, North Equatorial Current (NEC), and North Equatorial Countercurrent (NECC) and major water masses such as Subtropical Mode Water (STMW), North Pacific Tropical Water (NPTW) and North Pacific Intermediate Water (NPIW) in the subtropical and tropical gyres. The 137°E section has provided a comprehensive set of physical and biogeochemical measurements, including temperature, salinity, dissolved oxygen, nutrients and carbonate system parameters. The repeat survey along 137°E has been playing an important role as a long-term reference for detecting variations in ocean circulation, oceanic structure and air-sea interactions in the North Pacific, including those related to climate change. The three major water masses mentioned above had significant decadal-scale (about 10 years) variations. The137°E section revealed long-term changes of salinity and temperature in the surface and intermediate layers. Rapid freshening on both isobars and isopycnals began in mid-1990s and persisted for the past 20 years in the subtropical gyre. The freshening trend was strongest in STMW in the upper main thermocline, and also existed in a deeper layer corresponding to the Central Mode Water, extending over the whole ventilated thermocline/halocline. Trends of CO_2 increase and acidification have also been clearly observed in both surface and interior of this section.

S11-P5

Comparison of chlorophyll-a responses to climate change in the tropical western Pacific marginal seas

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The present study examines and compares the responses of chlorophyll-a concentrations in the South China Sea (SCS) and Coral Sea (CS) to the marine climate change in the tropical western Pacific. The analyzed results reveal that, over the past decades, the SCS experienced a nearly linear change toward warmer and fresher water at faster rates than those of the CS, e.g., a faster rise in sea surface temperature (SST) at a rate (0.14 to 0.31) °C decade^{-1} versus (0.07 to 0.14) °C decade^{-1}, and a decrease in sea surface salinity (SSS) at a rate (-0.5 to -0.6) versus (-0.04) g kg^{-1} decade^{-1} in the SCS and CS, respectively. The climatological pattern of evaporation and rainfall in the tropical western Pacific indicates that the SCS is located in a rainfall-dominated region, while the CS is located in an evaporation-dominated area. As a proxy for marine productivity, concentrations of chlorophyll-a apparently varied with the SSS changes in the SCS and SST changes in the CS, respectively, although chlorophyll-a concentration in both the SCS and CS showed a slight decrease trend. Our preliminary findings suggest that pattern of rainfall and evaporation over the tropical western Pacific might play an important role in the changes of marine chlorophyll-a concentrations in the SCS and CS.

S11-P6

Time interpolation of surface winds and its impact on the modelling of inertial currents in the North Pacific

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The North Pacific is the storm track area, and the high temporal resolution of winds is required to predict high-frequency variability such as inertial currents. We developed a simple and robust time interpolation method from atmospheric reanalysis data for both stationary and propagating surface disturbances. Propagation vectors of the disturbances are evaluated on all of the grid points from two sea level pressure data maps. The data are interpolated on the grid points from the propagation vectors. This method is more effective compared with the linear interpolation as disturbances moving faster. The kinetic energy of the predicted inertial currents using the interpolation method is significantly changed from that using the linear time interpolation. The spatial distribution of kinetic energy is also different from that by the linear interpolation.

S11-P7

Vertical mixing observed on the continental slope of the southwestern East/Japan Sea

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Over the southwestern East/Japan Sea, 25 hours long hourly CTD, and a free falling microstructure profiler (TurboMAP) data were obtained during a spring tidal period and neap. Vertical diffusivities estimated density inversion from CTD profiles using the Thorpe scale, and shear from the microstructure profiler are compared. When converting the Thorpe scale into the diffusivity two different mixing efficiency parameterizations proposed by were utilized. One is a widely used method proposed by Osborn (1980) in which the functional form is independent of turbulent intensity. The other is relatively recent one by Shih et al. (2005) in which the functional form is dependent on turbulent intensity. The vertical structure Both methods produce similar vertical structure, but the one based on Shih et al. (2005) is smaller than that based on Osborn (1980), and compares better with estimation based on shear. The diffusivity was much greater during the spring tidal period than the neap suggesting internal tide induced mixing.

S11-P8

Mapping of the air–sea CO_2 flux in the Arctic Ocean and its adjacent seas: Basin-wide distribution and seasonal to interannual variability

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We produced 204 monthly maps of the air–sea CO_2 flux in the Arctic north of 60°N, including the Arctic Ocean and its adjacent seas, from January 1997 to December 2013 by using a self-organizing map technique. The partial pressure of CO_2 in surface water data were obtained by shipboard underway measurements or calculated from alkalinity and total inorganic carbon of surface water samples. Subsequently, we investigated the basin-wide distribution and seasonal to interannual variability of the CO_2 fluxes. The 17-year annual mean CO_2 flux shows that all areas of the Arctic Ocean and its adjacent seas were net CO_2 sinks. The estimated annual CO_2 uptake by the Arctic Ocean was 180 TgC yr^{-1}. The CO_2 influx was strongest in winter in the Greenland/Norwegian Seas (>15 mmol m^{-2} day^{-1}) and the Barents Sea (>12 mmol m^{-2} day^{-1}) because of strong winds, and strongest in summer in the Chukchi Sea (~10 mmol m^{-2} day^{-1}) because of the sea-ice retreat. In recent years, the CO_2 uptake has increased in the Greenland/Norwegian Sea and decreased in the southern Barents Sea, owing to increased and decreased air–sea pCO_2 differences, respectively.

S11-P9

About microwave radiometry and spectroellipsometric technologies for monitoring marine ecosystems

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Results of the investigations are stated in connection with the assessment of capabilities to use the sensors of optical and microwave ranges for the diagnostics of hydrophysical and hydrochemical systems having various spatial scales. Structure of multi-functional information-modeling system (MFIMS) MFIMS consists the sensors of optical and microwave ranges and it realizes functions for the diagnostics and adaptive identification of the liquids. The system is based on the base formation of spectral standards for the liquid solutions delivered by means of multi-channel spectrophotometer or spectroellipsometer and used for adaptive recognition of spectral images.

Education process and following recognition are realized in accordance with the certain series of the methods, algorithms and procedures for accumulation, analysis, sorting and processing observation data. Assembly of all tools forms the information-modeling system oriented on the operative diagnostics of the state of the water objects when multi-channel information is delivered by the on-site and remote sensors and high-performance information technologies are used for the solution of the tasks related to the classification and identification of the water objects.

A solution of operative multi-pronged task of the water quality control and state of hydrochemical systems when their spatial heterogeneity is taken into consideration and series of physical, chemical and biological factors exist to be as influencing on them is realized by means of the collection of computer algorithms and models that are the hydrochemical monitoring system. This collection gives a possibility to parameterize typical water balance on restricted territory that reflects an interaction between hydrological cycle components. Under this, the system has adaptation function to the real hydrophysical object or process. The MFIMS can used under the water media or other liquids quality control under the expedition conditions when chemical laboratory no exist.

S11-P10

Evaluation of surface winds over the Korean Peninsula and its surrounding seas

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Surface winds over ocean can influence not only on turbulent heat fluxes but on coastal erosion mainly through changes in ocean wave. To project a future change in surface wind, a global climate model has been widely used but for detailed regional information, dynamical downscaling with a regional model has been used. The purpose of this study is to evaluate the surface winds over the Korean Peninsula and its surrounding seas simulated by CORDEX-EA (Coordinated Regional Climate Downscaling Experiment for East Asia) multi-model ensemble. While in many studies the evaluation of climate models has been conducted based on reanalysis data, we first verified the ERA-interim and NCEP/DOE reanalyses based on an in-situ observational data and then evaluated the regional models in comparison with CMIP5 global models for 1989-2005. Although surface wind at the boundary of CORDEX domain was similar between these two reanalyses, the wind over the Korean Peninsula was different between them and was overestimated by more than two times compared to the in-situ data. The regional models simulated a relatively stronger wind over the east coast of South Korea during summer and over the east and west boundaries of the Japan Basin during winter, whereas the CMIP5 global models were incapable of simulating such a wind pattern varying with season over the coastal regions of the East Sea. Thus we suggest that a regional modelling is necessary for the studies on coastal regions and that a careful examination should be conducted before a use of reanalysis data.

S11-P11

Approach of dynamic physical thresholds on spatial-temporal phytoplankton variability in NE Pacific

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We estimated using generalized additive models the thresholds and the contribution of some dynamic physical variables to phytoplankton production and biomass spatial-temporal variability. The ocean circulation contribution to phytoplankton variability was 18% (for phytoplankton biomass), and 46% (for phytoplankton production). The pycnocline and mixed layer depths thresholds related to high productivity, were shallower for primary production than those for phytoplankton biomass (pycnocline < 68 m and mixed layer < 30 m vs. pycnocline < 45 m and mixed layer < 80 m), while for absolute dynamic topography (ADT) and Ekman pumping were similar (ADT < 59 cm and Ekman pumping > 0 cm d^{-1} vs. ADT < 60 and Ekman pumping > 4 cm d^{-1}). The thresholds explained the high productivity (integrated Chl*a* from 50 to 576 mg m^{-2}) in mesoscale (cyclones eddies), seasonal (spring), and interannual (La Niña 2008) scales, linked to the generally lower ADT conditions (45-60 cm), pycnocline sloping (9-68 m), and shallow mixed layer (8-40 m). Ekman pumping were mainly related to seasonal variability associated to alongshore wind during winter-spring. By contrast, the biomass depletion in anticyclone eddies, autumn-winter, and during El Niño and Warm-Blob conditions, was the result of the pycnocline and mixed layer deepening evidenced in high ADT. Two ADT ranges with data of the California Current area were estimated, both of which lead to a drop in primary production. The present study shows that estimated thresholds reliably explain the phytoplankton spatial-temporal variability of the subtropical-tropical northeast Pacific.

S12: MONITOR/BIO/TCODE Topic Session Causes and Consequences of 25 Years of Variability in Ocean Conditions on the Ecosystems of the North Pacific

S12-P1

Reponses of marine primary productivity (PP) to the future climate change scenario: the role of the subsurface chlorophyll maximum (SCM) in the mid-latitudinal marginal seas

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The seasonal cycle and magnitude of marine primary production (PP) is projected to change in response to future climate variability. It is likely that the changes in PP will also influence the structure and dynamic of the marine ecosystem and food web interaction. Studies have shown that the global PP appears to have decreased over the past several decades. Especially, recent global prediction models have indicated that the PP is expected to decrease in the mid-latitudinal marginal seas. However, the challenges in understanding and predicting PP in response to climate variability is quite complex, particularly the change of PP in the SCM is not well addressed.

In this study, we examined characteristics (thickness, depth, and peak) of SCM in the mid-latitudinal marginal seas of Northwestern Pacific. We also analyzed how the physical factors (temperature, salinity, sigma-t, etc.) affect the SCM variability using the in-situ data collected from CTD profiler at more than 100 stations. Our results showed that the depth of SCM layers highly correlates with MLD, as SCM being formed at or above the base of the thermocline. As global warming continues, stratification will be strengthened which will alter the depth and density gradient of the thermocline. This, in turn, will change the formation and depth of SCM and subsequently primary productivity of the upper mixed layer ocean. In this context, we will also discuss the further implication of such potential changes in SCM dynamics in the mid-latitudinal marginal seas.

S12-P2

Interannual variation of ocean environment in the Kuroshio Extension, Oyashio, and their transition area correlated with the recruitment of chub mackerel (*Scomber japonicas*)

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Interannual variations of temperature the Kuroshio Extension (KE), Oyashio, and their transition area were investigated in order to examine their influences on recruitment per spawning stock biomass (RPS) of chub mackerel (*Scomber japonicas*) during 2001–2012. Temperature data was provided by reanalysis data from an operational ocean forecast system (FRA-ROMS) coupled with a lower-trophic ecosystem model (eNEMURO). Particle tracking experiments revealed that sea surface temperature (SST) around the spawning ground was significantly correlated with the RPS. In addition, area expansion of "the sub-cold water region" defined as the area of 5–10°C at 100 m (in the area southern 43°N, 141–148°E) also showed a correlation with the RPS. Intensity of the meridional front along KE (35–38°N, 141–148°E) was related with the expansion of the sub-cold water region. We examined multiple liner regression models to the RPS, employing two indexes in addition to SST in the spawning ground: the first primary component of the empirical orthogonal functions (PC1) concerning the sea level anomaly in KE region (30–40°N, 142°E–180°) that is suggested as the latitude of KE axis, and North Pacific Index (NPI) that is suggested as the latitude of the Oyashio intrusion. The model including SST and lagged-NPI indicated a higher determination coefficient than that of the only-SST-regression-model. The results suggest that fluctuations generated in the central and eastern Pacific would affect the RPS variations during 2001–2012.

S12-P3

Mass mortality of small seabirds in NE Pacific 2014/2015: Consequences of NE Pacific anomaly

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Sea-surface temperature in the NE Pacific was severely perturbed from late 2013 through 2015. The anomaly centered in the Gulf of Alaska at its peak covered an area of ~ 9×10^6 km^2 and exceeded 2.5 °C above normal. In the boreal winter of 2014-15, carcasses of Cassin's auklet (*Ptychoramphus aleuticus*), a small zooplanktivorous seabird, were observed during standardized beach surveys at levels exceeding 100 times the long-term average. From September to March more than 9,000 carcasses were observed from central California through to Washington state by three citizen science programs. We found that annualized (2001-2014) carcass encounter rates (birds/km surveyed) were highly correlated with planktonic food composition and measures of cold-water availability. Furthermore, we demonstrate that the NE pacific anomaly likely compressed birds into a narrow band of cold water, and also caused a deleterious shift in planktonic community composition following its onshore movement in September 2014. Using an ocean circulation model and estimates of total carcass deposition, we determined the relative proportion of carcasses that reached shore, giving an estimate of total mortality to be 250-750 thousand birds. This event, caused by anomalous oceanic conditions and its effect on planktonic communities, may act as a forewarning of future mass mortality events of seabirds and other marine organisms that may occur as the NE Pacific continues to warm.

S13: MONITOR/TCODE Topic Session
Understanding the Changing Coastal Ocean: Advances and Challenges in Multi-parameter Observations

S13-P1

Multifactor effects of near-bottom processes in the coastal ocean

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Bottom boundary layers (BBL) always have been given special attention in regions with small bottom depth. Valuable results were obtained mainly for homogeneous flows with constant or surface wave caused stress above beds with different properties. The main goal of our experiments in the shelf zone of the Sea of Japan is to study processes in homogeneous and stratified BBL, which in non-storm conditions are not affected by surface waves and wind mixing. The main results of the theoretically supported analysis of the data concern the role of different kind internal waves in mass, momentum and heat vertical and horizontal fluxes in the near-bottom layers. It was shown that internal wave surf and uprush at inertial and tidal frequencies lead not only to intensive local mixing and sediment resuspension, but to ventilation of the near-shore waters as well. Detailed spectral analysis of temperature and velocity fluctuations at different levels combined with analysis of velocity profiles supports theoretical prediction of secondary high-frequency IW generation by vertical shear instability in stratified flows and in homogeneous flows with nonlinear vertical gradients of velocity. We can conclude that IW, generated in wide range of frequencies over the continental slope by tides and mesoscale eddies, as well as IW generated in near-bottom layers in near-shore regions, are universal processes providing considerable mixing and corresponding biological, ecological and morphological effects in the coastal ocean.

S13-P2

Submarine groundwater discharge (SGD) and SGD-driven nutrient fluxes in Geoje Bay, Korea

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Activities of ^{222}Rn and the concentrations of nutrients were measured in stream water, seawater, and coastal groundwater around Geoje Bay, one of the largest cultivation areas of oyster in the southern sea of Korea in April, 2013. Using the ^{222}Rn and Si mass balance model, the residence time of bay seawater was about 5 days and the submarine groundwater discharge (SGD) into the bay was estimated to be approximately 1.8×10^6 m^3 d^{-1}. The nutrient fluxes through SGD contributed approximately 56% for dissolved inorganic nitrogen (DIN), 5% for dissolved inorganic phosphorus (DIP), and 52% for dissolved inorganic silicate (DSi) of total nutrient input entering into the bay. Especially, the input of coastal groundwater with DIN/DIP imbalance (~ 70) and trigger elements around this study region could have a significant impact on oyster farming production as well as phytoplankton biomass in the bay.

S13-P3

Biochemical composition of surface sedimentary organic matter and material fluxes at the sediment-water interface of Jaran Bay, Korea

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To induce sustainable production of oyster farming in Jaran Bay, this study investigated the spatial and temporal changes in the biochemical composition of sedimentary organic matter and the material flux across the sediment-water interface. Sediment samples were collected in May 2015 and from August 2015 to February 2016 on a monthly basis. Material fluxes using a benthic chamber were estimated in October and December 2015. The biochemical classes of organic matter were dominated by proteins, followed by carbohydrates and lipids. The proteins might be the dominant class among labile compounds because about 60% of the body of the oyster is made up of proteins. The PLG:OM ratio, which represents the percentage of labile organic matter, ranged from 9.82 to 25.18%. The P:G ratio, which represents the presence of newly produced matter, ranged from 0.94 to 5.80. This result may indicate that labile organic matter in Jaran Bay might be fresh material that was recently formed. SOD ranged from 15 to 132 mmol/m^2/day, SPM ranged from 7.5 to 91.1 g/m^2/day, POC ranged from 0.43 to 2.36 g/m^2/day, and PON ranged from 0.02 to 0.32 g/m^2/day. Also, DIN and DIP effluxes were 5.14±5.5 mmol/m^2/day and 0.38±0.33 mmol/m^2/day, respectively. The burial flux was also lower than in other aquacultural areas along the southern coast of Korea. Therefore, Jaran Bay might have potential for sustainable production than other shellfish farming.

S13-P4

Analysis on coastline change under ecological environment of coastal zone - A case of Sanya

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The coastline is an important part of the coastal zone, which is of great significance for the development, utilization and management of the coastal zone. This paper adapted automatic and semi-automatic expert interpretation method to extract Sanya shoreline information using 2014 Rapideye, 2010 Quick Bird satellite data, assisted by field survey data, established coastline interpretation signs, application of fractal theory and constructed shoreline database to analysis coastline change against coastal zone environment. The results showed that Sanya shoreline change to artificial shoreline; sandy shoreline reduce obviously. Coastline changes in Sanya for a total of 27,845.72m. The artificial shoreline change for 15,691.18m, accounting for 56.35%; sandy shoreline is reduced by 2,132.12m, accounting for 7.66%. Sanya shoreline change are dominated by human activities, mainly from the base of the rocky shore line to artificial port changes, the expansion of the original artificial shoreline, reclamation, part of the sandy shoreline to artificial port changes. At the same time, changes of shoreline changes were developed for Port Development Zone. More coastal engineering construction, especially the construction of artificial levees, causes a certain impact on the marine environment and human activities on coastal zone affecting the shoreline strongly. The comprehensive management of shoreline development, utilization, protection and management should achieve the purpose of sustainable development of resources and environment.

S13-P5

Typhoon storm surges observed by Chinese HY-2A satellite radar altimetry

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HY-2A is the first Chinese ocean dynamic environment monitoring satellite, which was launched in August 2011. The satellite repeats its ground track every 14 days. It plays an important role in global monitoring of sea surface winds (especially extreme winds like typhoons and hurricanes), ocean waves, currents, eddies, and extreme events like storm surges by using its four major payloads, i.e. radar altimetry, microwave scatterometer, scanning microwave radiometer and calibration microwave radiometer. The HY-2A data are obtained from China's National Satellite Ocean Application Service (NSOAS). We use 1 s along-track data with a nominal spatial resolution of about 7 km. Typhoon storm surges in the Northwest Pacific Ocean were observed by HY-2A satellite altimetry. The storm surge magnitude and the cross-shelf e-folding decay scale are given. The present study shows that the HY-2A satellite altimetry is a useful tool for monitoring typhoon storm surges in the Northwest Pacific Ocean and their impacts on coastal areas.

S13-P6

The present and future of Ocean Research Stations (ORSs) of the Korea Hydrographic and Oceanographic Agency (KHOA)

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Constructed respectively in 2003, 2009 and 2014, the Ieodo, Gageocho and Socheongcho Ocean Research Stations are located in the jurisdictional sea area of Korea and are used to conduct oceanographic, meteorological and environmental observation. These stations were initially established by the Korea Institute of Ocean Science and Technology (KIOST) as part of the R&D project of the Ministry of Oceans and Fisheries. The Korea Hydrographic and Oceanographic Agency (KHOA) then took over control of the Ieodo Ocean Research Station in 2007, followed by the Gageocho and Socheongcho Stations in 2016. Located 149 km southwest of Jeju Island, the Ieodo Ocean Research Station makes an ideal spot for oceanographic and meteorological research due to its presence at the pathway of typhoons heading for the Korean Peninsula. It has 29 pieces of equipment installed for collecting oceanographic, meteorological and environmental data. KHOA has been conducting research stay at the Ieodo Ocean Research Station since 2014 to further enhance it to be an international observation station. Seven academic research projects are being carried out in 2016. The Gageocho and Socheongcho Stations respectively have 13 and 23 pieces of observation equipment installed. Efforts are also being made to conduct research stay to foster them as international stations along with the Ieodo Ocean Research Station. KHOA ultimately aims to establish these three stations as global scientific stations through a variety of academic research.

S13-P7

Multivariate Ocean Climate Indicator (MOCI): Describing the California Current

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We present an operational regional indicator for California's continental shelf environment and investigate its skill in predicting a variety of biological responses across trophic levels. This updated MOCI (Multivariate Ocean Climate Indicator, version 2) includes data that are readily available from the Internet so the indicator can be automatically updated and shared regularly via the Web. Data included are buoy data, sea level, the Bakun upwelling index, and climate indices. MOCIv.2 is a simplified version of MOCIv.1 (Sydeman et al. 2014) but captures ocean-climate variability similarly. MOCIv.2 illustrates all major ENSO events that occurred over the past 25 years as well as the phasing and magnitude of the most recent North Pacific marine heat wave, 'The Blob'. It also shows differences in the magnitude and timing of ocean-climate variability in different regions off California. MOCIv.2 relates to variability in other environmental parameters like fog and river flow, and to coastal water conditions such as salinity. Similar to MOCIv.1, MOCIv.2 has skill in now-casting marine ecosystem dynamics, from zooplankton to top predators, and therefore may be useful in establishing bio-physical relationships important to ecosystem-based fisheries and wildlife management in California.

S13-P8

Non-market value of marine ecosystem service in Saemangeum open sea in Korea

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Saemangeum is an estuarine tidal flat on the coast of the Korean Peninsula. Saemangeum seawall, which was constructed for developing reclaimed land of 40,100 ha and freshwater lake for agriculture, is 33 km long and the world's longest man-made dyke. However, the construction of the Saemangeum seawall has made serious environmental impacts and thus marine environmental management policy for Saemangeum open sea is required to be prepared. This paper attempts to measure the non-market value of marine ecosystem in Saemangeum open sea. To this end, the contingent valuation (CV) method was applied. Two national surveys of 1,000 households were administered in Korea during the period 2014-2015. More specifically, we adopted a strategy to use two split samples. The first sample consists of 400 households residing in Saemangeum area (on-site) and the second sample comprises 600 households residing in the nation except for Saemangeum area (off-site). Moreover, we employed the spike model to deal with zero willingness to pay (WTP) responses obtained from the one-and-one-half-bounded dichotomous choice CV survey. The mean WTP values for the on-site and off-site areas are estimated for the years 2014 and 2015 and statistically significant at the 1% level. The national value to be expanded amounts to about yearly KRW 75.98 billion (USD 69.80 million) and 71.68 billion (USD 60.50 million) in 2014 and 2015 for the next ten years, respectively. This quantitative value could be a useful baseline information for any decision-making process particularly in the establishment of management policies for the Saemangeum open sea.

Keywords: Saemangeum, open sea, contingent valuation, willingness to pay, spike model

S13-P9

Spatial-temporal pattern analysis of sea surface temperature evolution in North Pacific Ocean

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Global warming and its ecological consequences are concerned among scientist community and the public. The knowledge of spatial –temporal pattern of sea surface temperature (SST) evolution is the fundament of the ecological impact studies of climate warming. Here we use gridded sea surface temperature data from January 1850 to 2015 to analyze the spatial-temporal pattern of SST evolution pattern for North Pacific Ocean by wavelet based multi-resolution analysis method. The results are expected to provide crucial context information for the ecological impacts of climate warming studies.

S13-P10

New light for time series: international collaboration in ship-based ecosystem monitoring

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The history of long-term ocean time-series started more than 100 years ago. But most of marine time-series sites were established across different oceans (and managed by different countries) following the recommendations from international programmes such as JGOFS and GLOBEC. Many of existing time-series gained international prestige (HOTS, BATS, CPR, L4, HELGOLAND ROADS, RADIALES) in particular for providing the reference baselines for different variables at local-regional scales and in different ocean biogeographical provinces.

In a time of increasing pressures on the marine environment, time-series are central to understanding past, current and future alterations in ocean biology and to monitoring future responses to climate change. There are an extraordinary number of unexploited data sets obtained by long-term ocean time-series. Analyzing the data sets obtained at multiple ocean sampling sites has a high scientific value, but sharing data has also important economic and social benefits. The demand from different stakeholders and decision makers for answers to the challenges posed by changes in the marine environment is growing rapidly and sharing and accessing time-series data would reduce the uncertainties in the management of marine resources and ecosystem services. Given that individual time-series are distributed across different oceans and managed by different countries, open collaboration with countries' institutions conducting the time-series is essential.

This poster aims to deliver new insights into existing biogeochemical and ecological ship-based times-series and also features an overview of the gaps and needs for a better sampling coverage in the different ocean basins and seas.

S13-P11

Integration and duplication removal of the oceanographic and marine meteorological data at CMOC/China

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WMO-IOC Centre for Marine Meteorological and Oceanographic Climate Data, Tianjin, China (CMOC/China), operationally maintained and upgraded by National Marine Data and Information Service (NMDIS), State Oceanic Administration (SOA) since 2012, aims at guarantee the oceanographic and marine meteorology data, metadata, and product service to end users on free basis.

Researches on methods of quality control and duplicates elimination are actively conducted at CMOC/China. Following the instruction of the *Oceanographic and Marine Meteorological Data Quality Control Manual* compiled by NMIDS, delayed mode surface temperature and salinity data, wind-wave data, monthly mean sea level data, marine meteorological data from Chinese oceanographic stations, integrated temperature and salinity datasets of GTSPP, Argo and WOD, DBCP drifter data and metadata have been processed, quality controlled and released. Key information item for identify the duplication were identified based on the characteristics of the observation variables. The integrated datasets are expected to facilitate the regional needs for oceanographic and marine meteorological data with uniform standard and known quality.

Efforts had also been made on seeking cooperation with the existing systems such as ICOADS and WOD to avoid overlapping and improve regional input to the Marine Climate Data System (MCDS).

Section on Harmful Algae Bloom Meeting

S-HAB-P1

The detection of lipophilic toxins and hydrophilic toxins in shellfish collected from Chinese East Sea

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A study was conducted to compare the difference of lipophilic toxins and hydrophilic toxins in four seasons of 2006-2008 years from Chinese East Sea using HPLC-MS/MS and HPLC–FLD. It showed the levels of hydrophilic toxins in spring and summer was significantly higher than in winter and autumn. In spring 2008, maximum total PSP concentration reached 106.01 mg STX eq/100g tissue, was the highest concentration in this study. The results revealed the toxin profiles had seasonal characteristics. The lipophilic toxins content was significantly lower than hydrophilic toxins, do not present a health risk. This is the first report on the qualitative and quantitative lipophilic toxins and hydrophilic toxins content and toxin profiles of 5 different main shellfish in 4 seasons from Chinese East Sea.

S-HAB-P2

Prorocentrum foraminosum Faust (Dinophyceae) as a potential source of DSTs in the Peter the Great Bay, Sea of Japan (East Sea)

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The species identification of *Prorocentrum foraminosum*, which was earlier identified as *P. lima* based on light microscopy, was confirmed based on the data of molecular analysis of SSU and D1/D2 regions of LSU rDNA. The additional morphological studies of *P. foraminosum* by SEM revealed some new morphological features of this species. The clonal culture of *P. foraminosum* was acquired from the sample collected in one of the regions of Peter the Great Bay Sea of Japan (East Sea) (43.021403 N, 131.930293 E). The toxin analysis of culture samples was done in form of 4-bromomethily-7-methoxycoumarine derivatives using high-performance liquid chromatography with fluorescence detection (HPLC-FLD). The presence on dinophysistoxin-1 (DTX-1) in relatively high concentration was found both in cells and in culture media. The concentration of DTX-1 in cells was 8.4 ± 2.5 pg/cell and, in cell-free media - 27.9 ± 14.7 μg/L. The study of the multi-year seasonal dynamics of epiphytic assemblages of Peter the Great Bay has shown that *P. foraminosum* occurred regularly from April to November. The highest cell abundance was recorded in June (1.5 x 10^3 cells/ g dry weight of macrophyta). This species occurred very rarely and at low cells density in near-shore sands of Peter the Great Bay. The potential of *P. foraminosum* to be the source of DTX-1 in the tissues of bivalves in the area is discussed.

This work was supported by Russian Foundation for basic research Grants № 15-04-05331 for collection of biological material and microalgae culturing, № 16-34-00413 for analysis of toxins and Russian Science Foundation (RSF grant No 14-50-00034) for molecular-genetic analysis.

S-HAB-P3

Treatment of saline aquaculture wastewater with a constructed wetland

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Constructed wetland, a new technique of wastewater treatment, has been widely used in fresh aquaculture wastewater treatment but not in mariculture wastewater treatment. In present study, we established a laboratory scale integrated vertical-flow constructed wetland (IVCW) to purify the mariculture wastewater. We examined the removal efficiencies of the main pollutants and explored the composition and structure of the bacteria community in IVCW using denaturating gradient gel electrophoresis (DGGE). The results suggest that the IVCW efficiently removed ammonia nitrogen, phosphate and COD (92.82±3.27)%, (72.53±2.31)% and (66.04±8.23)%, respectively. The results showed a variety of bacterial divisions in the IVCW. The quantities of the dominant species were different in each layer of the IVCW. The Shannon-Wiener (H) of the down-flow tank was higher than that of the up-flow tank and it showed a decreasing trend along the water flow. The Dice coefficient (Cs) of microbial community in each layer showed an inverse relationship between the distance along the water flow and Dice coefficient. Six known bacteria groups including *Proteobacteria*, *Bacteroidetes*, *Actinobacteria*, *Verrucomicrobia*, *Nitrospirae* and *Firmicutes* were observed in the system, and *Proteobacteria* and *Bacteroidetes* were the dominant species. This study provide a theoretical reference for elucidating the removal mechanism of contructed wetlands for mariculture wastewater treatment.

POC Workshop (W8): Mesoscale and submesoscale processes in the North Pacific: history and new challenges

W8-P1

Global distribution of mergers and splits of oceanic mesoscale eddies

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The global distribution of mesoscale eddy mergers and splits was investigated by analyzing a 21-year time series of satellite altimeter data. A neighbor-enclosed area-tracking algorithm that detects mesoscale eddy mergers and splits was used to track each eddy identified using a sea level anomaly-based method. The frequency of eddy merger and split varied among areas. Both merger and split occurred frequently in areas of western boundary currents and their extensions, areas of subtropical counter currents, the Indian Ocean, the North Pacific southeastern subtropical region, and Antarctic Circumpolar Current regions. In these regions, the ratios of the minimum distance between like-signed (or opposite-signed) eddies to the radius of eddies were mostly under 3.5, which is the critical merger distance indicated by previous theoretical studies. This result suggests that the distance between eddies is a factor that determines the distribution of mergers. Similar results were also obtained for Okubo-Weiss eddies.

W8-P2

Impact of mesoscale eddies on spring bloom initiation in the Japan Sea

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Spring bloom initiation timing influenced by mesoscale eddies was investigated in the region around Yamato Basin (133-139º E and 35-39.5º N), Japan Sea, in a period spanning 2002-2011. Results indicated early bloom initiation timing in cyclonic eddies compared to anticyclonic eddies. The initiation, within anticyclonic eddies, was observed despite deeper mixed layer depth (~ 100 m) whereas mixed layer in cyclonic eddies was mostly < 100 m. From the examination of net heat flux within eddies we found that the onset of spring bloom in cyclonic eddies occurred in spite of large and negative heat flux while in anticyclonic eddies it was observed close to the commencement of positive heat flux. These results revealed that processes controlling the depth of turbulent mixing in anticyclonic eddies play an important role in the initiation timing whereas in cyclonic eddies the temporal variation of mixed layer is of minor importance to the bloom onset.

W8-P3

Mesoscale eddies in the East/Japan Sea: Detecting methods and characteristics of eddy properties

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A new hybrid eddy detection method are applied to the 1/4° gridded satellite altimeter data (SSH) to investigate statistical characteristics of the mesoscale eddy field in the East/Japan Sea. The methods used include the vector geometry-based method to detect eddy centers, and the SSH-based method to identify eddy boundaries. About 15 eddies are detected per SSH snapshot. Eddies mostly distribute in the interior of each of three deep basins. Anticyclonic eddies are mainly detected south of the subpolar front, and they are more intense than cyclonic eddies prevalent north of the subpolar front. In spring (March ~ May), the number of eddies becomes maximum, but their intensity is the weakest. Mesoscale eddies in the East/Japan Sea do not show any westward propagation tendency. Instead, they seem to be advected by major currents.

POC Workshop (W9): The role of the northern Bering Sea in modulating Arctic environments: towards international interdisciplinary efforts

W9-P1

Seasonal dynamics of dissolved inorganic nutrients in the Bering Sea

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Dissolved inorganic nutrients are annually restored to the euphotic layer during winter mixing and serve as the base for marine productivity. Despite the Bering Sea being one of the most productive and commercially valuable marine ecosystems, receiving great scientific attention during the past few decades, research efforts on nutrient dynamics in this area are regional and sparse in time. The objective of the present study is to investigate multi-year mean seasonal nutrient dynamics in the Bering Sea. The project is based on freely distributed oceanographic station data from NODC (USA), BEST-BSIERP (USA), JAMSTEC (Japan), as well as data from TINRO-Center (Russia). This dataset has allowed us to delineate ecological regions using cluster and expert analyses of multi-year mean summer (July-September) distributions of temperature, dissolved oxygen, silicate, and phosphate at 10 and 50 m. The winter to summer transition of the ecosystem is assumed to be reflected in summer values of these environmental parameters. Nutrient data were monthly averaged within regions. Results have revealed regional differences in amplitude and time of seasonal nutrient draw-down, $\Delta Si/\Delta N/\Delta P$-ratios, and multi-year mean net community production. The upper 30-meter layer of the eastern Bering Sea shelf lacks nitrate and silica by June suggesting macronutrient limitation of primary production. However, macronutrients are present in the upper layer of the deep basins even in summer, indicating possible limitation of phytoplankton by micronutrients. The study is supported by RFBR, research project No. 16-35-00388 мол_а.

MEQ Workshop (W10): Distribution and risk analysis of radionuclides in the North Pacific

W10-P1

Effect of migratory life history on North Pacific albacore (*Thunnus alalunga*) uptake of radiocesium

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The Fukushima Dai-ichi power station released radionuclides into the Pacific Ocean off eastern Japan in 2011. Previous radionuclide releases to the ocean were either of much lower magnitude, released over a much larger area or released in a continuous format. This pulsed-release provided an opportunity to examine how differences in migration routes and population structure of North Pacific albacore affected their uptake of radiocesium. Albacore samples collected (2011-2015) from two regions (North and South of 40° N) in the eastern Pacific were tested for 134Cs and 137Cs. Pre-disaster control samples (2008) were also tested. Measurements made through now have shown almost no 134Cs in Southern region albacore and a mix of presence/absence of 134Cs (and associated elevated 137Cs) in Northern region albacore. North albacore showed a positive correlation of 134Cs and elevated 137Cs with length, which indicated that the smaller individuals generally had not recently migrated from waters with 134Cs such as eastern Japan or the North Pacific Transition Zone. The spatial concentration patterns for 134Cs suggest latitudinal migratory differences and limited mixing of N/S albacore in the eastern Pacific. Albacore tissue contained radionuclide levels orders of magnitude less than both US FDA food standards and natural 40K concentrations.

W10-P-11430

Application of environmental risk assessment for strategic decision making in coastal areas: case studies in China

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Environmental risk assessment (ERA) is a powerful technical tool for analyzing potential and extreme adverse environmental impacts, and has found wide application in supporting decision-making processes over the last two decades. However, to date there has been no interrelated application of ERA to support the processes of strategic decision-making (SDM), especially in coastal areas.

In this paper, we attempt to verify the feasibility of the proposed integrated ERA_SDM approach and its methodology by applying it to two case studies (in Xiamen Bay and Luoyuan Bay) of the principal coastal functional zoning (PCFZ, a kind of SDM and similar to the coastal and marine spatial planning in western). The results show that the integrated ERA_SDM approach could integrate ERA into the entire SDM process, directly support the PCFZ, and avoid or mitigate dire environmental risk that can be introduced by SDM processes.

BIO Contributed Poster Session 1
Recent Progress in Deep-Sea Research and Conservation: Lessons from Various Parts of the Globe

BIO-P1-1

Range-wide analysis of spatial distribution of Pacific flatnose *Antimora microlepis* in the North Pacific

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Pacific flatnose *Antimora microlepis* is distributed exclusively in the North Pacific from the Bering Sea in the north to Taiwan, Hawaii and California in the south. This species has no commercial importance but constitutes regular bycatch of deep-sea trawl, longline and trap fisheries and may occur in some areas in large amounts. Biology of this species is poorly understood, data on spatial distribution are limited by the Pacific waters off the northern Kurils and southeastern Kamchatka. Here we present new data on spatial distribution of Pacific flatnose within entire species' range based on the data from Russian (TINRO-Center) and US (AFSC and NWFSC) surveys. The analysis of our and literary data shows that reliable records of the species south of 20°N almost lack. Maximum occurrence was characteristic for continental slope along the coasts of southeastern Kamchatka, Kuril Islands, Japan (down to central Honshu), British Columbia, Oregon and northern California. High occurrence was also observed in the Bering Sea from central Koryak coast to the Aleutians. Pacific flatnose occurred on seamounts as well but less frequently. Catches of mid-water trawl reached 450 kg per h (mean 6.3) with maximum values off Kurils and Japan. The species considered was captured as bycatch in Russian longline fishery in the western Bering and Okhotsk seas and on Emperor Seamounts. Longline catches varied 0.1 to 164.2 ind. per line (mean 5.3). During Russian bottom trawl surveys, Pacific flatnose was recorded in maximum amounts in the Sea of Okhotsk, off the northern Kuril Islands and on Emperor Seamounts. Catches of standard 1 hour trawling reached 74.5 kg with mean value 0.98. According to data of US bottom trawl surveys, maximum catches of species considered were observed in the central Bering Sea. On the whole, catches in Alaskan waters and along US west coast were 0.002 to 2.445 (mean 0.263) kg per ha. According to data of US observers on board of fishing vessels, maximum bycatches of Pacific flatnose were observed in central Bering Sea and central Gulf of Alaska. Generally, bycatches reached 5.7% of total catch (mean 0.0260 or 9333 kg per year per 400 sq. miles (mean 34.4).

BIO-P1-2

Spatial distribution, size composition, and dynamics of abundance of Okhotsk skate *Bathyraja violacea* in the North Pacific

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Results of long-term research of spatial and vertical distributions, dynamics of abundance and size composition of the Okhotsk skate *Bathyraja violacea* in the North Pacific are presented. This species is most abundant at depths 200 to 400 m. During cold season they migrate to deeper depths (exception is the eastern Bering Sea), during warm period they feed at shallower depths. The catches consisted of individuals with total length 12 to 132 cm with prevalence of skates with length 50-80 cm. Male and female Okhotsk skates did not differ notably by length and body weight. Condition factor of skates from January to August decreased with subsequent increasing since September. Among individuals with total length < 30 cm males dominated, in size group 30-60 cm females prevailed, in size group 60-70 cm sex ratio was equal, among larger skates females predominated again. The dynamics of abundance of Okhotsk skate in various areas differed. In the western Bering Sea and Sea of Okhotsk, during the period of research catches successively increased. In the Pacific waters off Kuril Islands and Kamchatka, increasing of catch rates was observed until mid-1980s – early 1990s with subsequent decreasing of relative abundance. In the eastern Bering Sea, peak of abundance was recorded in mid-1970s with further decline. Off the Aleutians, rise of catch rates was observed until early 1980s.

BIO-P1-3

Joint German-Russian deep-sea expeditions in the NW Pacific

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Presented by Alexei Orlov

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Study of deep-sea biota is important for understanding the global biodiversity and evaluation of biological resources. The aim of the current German-Russian deep-sea investigations in the NW Pacific is to study the biodiversity and biogeography of benthos in different abyssal areas. Three joint expeditions have investigated different abyssal environments: young semi-enclosed deep-sea basin of the Sea of Japan (SoJaBio-2010); open ancient Pacific abyssal area off the Kuril-Kamchatka Trench (KKT) (KuramBio-2012) and having intermediate characteristics comparing to the first areas, the Kurile Basin of the Okhotsk Sea (SokhoBio-2015). Since the RV Vityaz expeditions in the 20th century it was the first extensive biological investigations in the region with using sampling gears and methodology standardised in the frame of the CeDAMar programme. For each sampled area much higher abundance and diversity of marine biota was retrieved than it was reported before. For the >500m depths of the Sea of Japan with expected low biodiversity, number of the collected species (621) was 6 times higher than former known. In the KKT area >1780 benthic species were collected at 5000–6000 m depths what is at least 6 times exceeded the previously known number for these area and depths. In the Kurile Basin of the Okhotsk Sea > 1000 species of benthic organisms were collected in contrast to about 50 species known there. The abyssal macrofauna of the Sea of Okhotsk is richer than in the Sea of Japan and shows similarities to the abyssal Pacific fauna. About 50% of all sampled species are new to science.

Highest abundance and species richness observed on the KKT slope made future exploration of the KKT hadal depths very promising. It will be performed during the German-Russian expedition KuramBio II onboard the RV "Sonne" in August-September 2016.

BIO-P1-4

A novel approach to estimating active carbon flux using the biomass size spectra

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Micronekton (size range 20-200 mm) play a critical role in global carbon cycling, through active transport of carbon between surface and deep waters during their diel vertical migrations. Carbon transport is mediated via respiration, feeding, excretion and mortality of migrating organisms. Because marine ecological processes are strongly size dependent, it was proposed that patterns of active carbon transport via vertical migrations are correlated to body size and hence can be measured from a normalized biomass spectra. Sampling was carried out onboard the *RV Oscar Elton Sette* during October 2004 along the southwest coast of Oahu Island using three micronekton gears (Cobb trawl, Isaacs-Kidd Midwater trawl, Hokkaido University Frame Trawl) and an acoustic echosounder (hull-mounted, dual-frequency, split-beam Simrad EK60), during both day and night in the epipelagic (0 – 120 m) and mesopelagic (550 – 650 m) layers. A size-dependent inter-calibration of the micronekton gears was successfully conducted for organisms ranging from 20 – 100 mm in length, and biomass spectra were produced. Approximately 63% of the total micronekton catch were undergoing diel vertical migrations. Depending on the trawl, the main contributors in terms of biomass to active carbon transport were myctophids (11-32%), decapods (3-35%), cephalopods (0-45%), and stomatopods (2-31%). Active carbon transport by vertically migrating micronekton was estimated at 3.9 $gCm^{-2}day^{-1}$, confirming that these organisms play a significant role in active carbon flux contributing substantially to downward carbon export. The biomass spectrum inferred that this contribution is largely size dependent, and will provide a promising new tool for assessing active carbon transport.

BIO-P1-5

Progress of Chinese deep sea research activities in recent 2 years

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From November 2013 to April 2015, Chinese scientists used 3 Research Vessels with the name R/V "*Dayangyihao*", R/V *"Xiangyanghong 9" and* R/V "*Zhukezhen*" to prospecting the Mineral resources which located in the West Pacific, Southwest Indian, Northwest Indian, and south Mid-Atlantic respectively. During the cruises, many new equipments were used such as the manned submersible "*Jiaolong",* deep-tow system, MAPR and ROV, Shallow Drilling system etc. Crusts, cobalt nodule, Sulfide chimney, hydrothermal fluids, Vent-associated fauna samples, as well as Giant zoobenthos samples were collected to help the scientists understand the distributions, geological characteristics of the mineral resources with their biochemical environment.

BIO-P1-6

Georeferenced sensor, survey and sample data for the Endeavour Hydrothermal Vents Marine Protected Area

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In 2003, the Canadian government proclaimed the Endeavour Hydrothermal Vents Marine Protected Area (EHVMPA), on the Juan de Fuca Ridge, approximately 250 km offshore of Vancouver Island. Ocean Networks Canada (ONC) operates a cabled observatory at several sites within the EHVMPA, and provides online access to real-time and archived observatory sensor data to researchers worldwide. In 2014, DFO partnered with ONC to build a geodatabase that combines observatory sensor data, multibeam bathymetry, and observations made during ROV surveys and maintenance expeditions. The resulting geodatabase, assembled in ArcGIS, integrates time-series and baseline data from all of these sources, together with relevant publications. Layers include annual observatory infrastructure deployments, remotely operated vehicle (ROV) dive tracks, sampling activity, anthropogenic debris, high-resolution bathymetry, observations of species of interest, and locations of hydrothermal vents. Enhancements in 2015 and 2016 include support for links to annotated video logs from ROV dives, seafloor characterization, integration of 3rd party data, improved structure, and fly-throughs. The end result is a tool that can integrate many types of data to enable monitoring of environmental and human stressors that impact the MPA, and support evidence-based management of a remote, dynamic and fragile environment.

BIO-P1-7

Biogeographical analysis of abyssal bottom habitats: Using an abiotic province scheme and metazoan occurrence databases

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Poster will present results of analysis of a Deep-Sea abyssal plain province scheme, using biological occurrence data. The biological database CeDAMar, was compiled by the Census of Marine Life initiative. It is a comprehensive database of metazoan records spanning from 1872-2005. Two versions of this database exist and are utilized. The original unpublished version (CeDAMar) which includes a number of factors in addition to species records (including: sampling gear used, date of sampling, and recorded depth at site), and the version available online, GBIF, which includes updated records after 2005, but primary data is limited to species occurrences.

The abiotic province scheme was created using a combined topographic, hydrographic, and physiognomic approach. Where topographic features delineate provinces within basins, and abyssal habitats fall within the depth range of 3500- 6500 meters.

BIO-P1-8

Data-driven bioregions for local ecosystem context in species distribution models

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Species Distribution Modeling (SDM) involves statistically relating species observations with co-occurring environmental variables, and then using the observed relationships to map species distributions from spatially extensive environmental data layers. Biological interactions, while known to also influence species distributions, are not explicitly taken into consideration in SDM. Biological interactions vary depending on local environment and community composition, and environmental proxies must thus describe this local environmental context. Alternatively, if a distribution model is calibrated with data constrained by local species assemblages, the model can be considered to account for local species interactions. This project aims to define data-driven bioregions based on the turnover of species assemblages. Values of species turnover were generated by applying the Gradient Forest algorithm to trawl catch data from the Scotian Shelf, Canada. The turnover values were then plotted across principal components of environmental variables, and a cluster analysis was used to define distinct assemblages. The assemblages were then overlain onto the study area using associated primary component values. Depth and temperature were shown to be the most influential predictor variables in the gradient forest model. Three primary clusters were found, dividing the shelf into eastern and western regions, with the deep water as a separate region. Further validation of data-driven bioregion effects on SDM on the Scotian Shelf will require greater sampling in deeper waters.

BIO-P1-9

A time-series of epibenthic community turnover along a dissolved oxygen gradient

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As dissolved oxygen in the northeast Pacific declines, we need to assess the effects of oxygen loss on marine ecosystems. Saanich Inlet, a seasonally hypoxic fjord, provides insight into the response of benthic communities to marked spatial and temporal oxygen gradients. We examine a ten-year (2006-2016) time-series (n=13) remotely operated vehicle (ROV) transects from 200 to 40 m depth encompassing anoxia through normoxia with counts of epibenthic macrofauna. We extend results in Chu & Tunnicliffe [*Global Change Biology,* 21, (2015)] to include the severely hypoxic year of 2016, in which animal distributions were greatly compressed causing overlap of mobile species that sort to different depth ranges in less extreme oxygen gradients. We assess the utility of a statistic to detect spatial regime shifts in these assemblages. Data from all ROV transects are examined for critical transitions in dissolved oxygen levels at which different epibenthic community regimes occur. Fisher Information, an information theory metric, was adapted to characterize the dynamic order of the system along a dissolved oxygen gradient ranging from ~0.00 to ~5.00 mL/L. Three different regimes were seen in the benthic community: a highly ordered normoxic regime, a loss of order in a transitional zone, and a re-establishment of high order in the hypoxic regime. The development of Fisher Information to determine critical transitions in community structure may aid in creating community and/or regional level hypoxia thresholds in other systems.

BIO-P1-10

Endeavour Hydrothermal Vents Marine Protected Area conservation and management supported through institutional collaborations and interdisciplinary research

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The Endeavour Hydrothermal Vents Marine Protected Area (EHV-MPA) was established in 2003 and is managed by Canada’s Department of Fisheries and Oceans (DFO). EHV-MPA is a conservation landmark, representing the first MPA established within Canada, the first deep-sea MPA in the North Pacific, and the first MPA established globally to protect hydrothermal vents. More than a decade after its establishment, DFO is actively obtaining information essential to the management of the EHV-MPA. The most recent survey in August 2016 combined the expertise of scientists and environmental managers from DFO, the University of Victoria, and Memorial University to improve the current knowledge of ecosystem function, community structure, habitat distribution, and geological settings of vent fields across the MPA. Using the ROPOS ROV, we conducted visual surveys, collected samples, and deployed experiments as part of longer term studies. Collections of dominant community types enabled us to document variation in taxonomic and functional ecology within and among sites representing a gradient of environmental conditions. This work will allow ecosystem management guidelines to be tailored to the ecology and vulnerability of particular vent fields and enable DFO to prioritise implementation of management strategies across the extensive EHV-MPA (~90 km^2). Geological and biological samples will be used to describe the temporal succession of fauna and habitats on sulphide structures within the EHV-MPA. Similar features in other oceans will likely be mined before 2020. Knowledge of communities colonising extinct vent chimneys will help to inform environmental management strategies as deep-sea mining projects take shape globally.

BIO Contributed Poster Session 2

BIO-P2-1

Green tide (*Entermorpha Prolifera*) monitoring in the Yellow Sea and East China Sea using multi-sensor

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Entermorpha Prolifera, named green tide, over the Yellow Sea and East China Sea were first reported in summer 2008. Greed tides destroy the marine ecosystem, threat coastal tourisms and block the ship navigation when they gather over the coastal area. Based on the spectral characteristics of green tides, NDVI (Normalized Difference Vegetation Index) and Floating Algae Index (FAI), the green tide over Yellow Sea and the East Sea was monitored with data MODIS (Moderate Resolution Imaging Spectro-radiometer) operationally and the detection reports, including the distribution range and coverage range, are given to the relevant authority and coastal city every day. When the green tides move to the coastal area and influence the ship navigation and it need to be cleaned, the images of HJ-1A/1B satellite's CCD and GF-1's WFV are used to supply the more detailed information with their high spatial resolution. Based on the monitoring results with multi-source satellite remote sensing image of the past few years, we can get the drift trend and distribution area of green tide by dynamic monitoring of drift path and impacting marine area.

BIO-P2-2

Effects of temperature on embryonic development and paralarval behavior of the neon flying squid *Ommastrephes bartramii*

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Studies on the relationships between the early life stages of the neon flying squid Ommastrephes bartramii and oceanographic conditions are essential for understanding the spatial and temporal distribution patterns of this ecologically and economically important species. In this study, O. bartramii eggs were artificially fertilized and incubated at temperatures found in its known distribution range (16-26°C). Complete organogenesis with normal successive cleavage and the distinct continuity of morphological features was limited to between 18 and 25°C. Exper- imental rearing, cruise-collected specimens, and oceanographic data confirmed that the optimal temperature range for paralarval survival around Hawaii is 18 to 25°C. Embryos reared at 16°C showed abnormal organogenesis; however, normal development resumed when the embryos were transferred to 22 or 24°C after blastoderm formation. Hatchlings showed a variety of swimming behaviors, which may allow squid to regulate their thermal distribution in the wild. Furthermore, ball formation and associated chromatophore expansion might represent an apo - sematic adaptation to imitate unpalatable prey. This study highlights the flexible strategy of O. bartramii embryo development and illustrates how information on paralarval behavior and oceanographic data (sea surface temperature) may be combined to improve our understanding of the factors that influence the survival of this species.

BIO-P2-3

Atlas of neon flying squid embryonic and paralarval development

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Neon flying squid *Ommastrephes bartramii* is among the most commercially important squids in the North Pacific, but little is known about its early life stages. In this study we investigated its embryonic and paralarval development. Embryos were obtained through artificial fertilization conducted on board the research vessel *Kaiyo Maru* during a cruise around the Hawaiian Islands in December 2013. We established an atlas for the normal development of *O. bartramii* from fertilized egg to advanced stages of paralarvae. Based on morphological features, different developmental stages could be clearly distinguished under a stereomicroscope. Though morphology-based identification of paralarvae to the species level is difficult, the present illustrations can complement other tools for species identification such as photographs and genetic analysis.

BIO-P2-4

Spatial and temporal heterogeneity in distribution of euphausiid *Thysanoessa longipes* from the northern Gulf of Alaska

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The euphausiids *Thysanoessa longipes* are distributed over the subarctic Pacific Ocean and its marginal seas, often prevailing over co-occuring euphausiid species. In the northern Gulf of Alaska (GOA) they are an important prey for many of the commercially harvested fishes and seabirds. However, despite apparent importance of *T. longipes* for the local pelagic ecosystems, no analyses of spatial and interannual variability in *T. longipes* abundance and reproduction in relation oceanographic settings in the northern GOA have ever been done. The Pacific Decadal Oscillation (PDO) and associated phenomena appear to be major drivers of oceanographic and biological variability in the northern GOA. Over the last two decades the PDO repeatedly reversed between warm to cold phases, providing a unique natural experiment on the response of the ecosystem to rapidly changing environment. Other predominant euphausiid species demonstrated remarkably differential feedbacks to the alternating PDO phases, largely dependent on the species biological traits. Based on long-term population surveys started in 1998, we test the hypothesis that the combination of local topography and dynamic oceanographic settings of the northern GOA facilitate two distinct *T. longipes* sub-populations: one in Prince William Sound fjords and the other offshore over the continental slope. The alternating PDO phases markedly influenced reproduction in the offshore population, while the fjord population appeared more resilient, which may dramatically increase their role in the coastal food web.

BIO-P2-5

Study on material cycling in the coastal waters and the role of the Kiritappu Wetland, in Hamanaka Town, Hokkaido: An analysis using surf clam (*Pseudocardium sachalinense*) as an environmental indicator

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Suspension-feeding benthos surf clam *Pseudocardium sachalinense*, living on phytoplankton, benthic microalgae and detritus, is one of the most important marine products in Hamanaka Town, Hokkaido Prefecture, Japan. We measured stable carbon and nitrogen isotope ratios ($\delta^{13}C$ and $\delta^{15}N$) and carbon-nitrogen (C/N) ratios of surf clam (adductor muscle and stomach contents), oceanic particulate organic matters (POM), oceanic sediments, riverine POM and soil as well as physical and chemical parameters such as temperature and salinity, chlorophyll-a and nutrients in April through September, 2015 in coastal areas in Hamanaka Town. We also examined the food sources that support surf clam, the possible connection between wetland and coastal waters, and also spatial and seasonal variation. Our results show that the isotope and C/N values of surf clam and oceanic organic matters were significantly different from those of riverine organic matters, and that there was no significant difference among the fishing areas. This means that land-derived organic matter is not direct food source of surf clam and land-derived organic matter does not affect the coastal environment. Also, benthic microalgae and epiphytes are considered to be the major food sources of surf clam in all sampling seasons since they have close isotope and C/N values to surf clam. The overall results imply that excess inflow of land-derived organic matter may harm surf clam and the coastal environment, suggesting the importance of the importance of the role of the wetland and the conservation.

BIO-P2-6

An overview of culturing and breeding of *Fenneropenaeus chinensis* in China

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Fenneropenaeus chinensis, distributed along the North-western coast of Pacific Ocean, has been one of the most important fishery resources in the field of marine economy in China. Its farming history in China has been about 60 years according to the earliest written records from related research in 1952. In 1959, research on artificial rearing and inshore cultivation was initiated. Techniques for large-scale industrial seed-stock production were broken through in 1981, resulting in its farming peak period from 1987 to 1992 with total farming yield around 200,000mt and its primary position in the mariculture field. Considerable attention was also focused on development of more efficient culture modes such as industrialized culture and multi-trophic integrated culture since 1959. China made new shrimp varieties selected for faster growth and greater disease resistance a priority especially after the outbreak of white spot syndrome in 1993. The first new variety Huanghai No.1 was obtained in 2003 after seven generations of selective breeding incorporating with biotechnology approach. Multi-trait selective breeding based on BLUP estimation was applied to another new variety Huanghai No.2 in 2008, and more varieties have been bred and well received by farmers. Development of modern molecular techniques will greatly promote further shrimp breeding, as we have developed abundant SNPs to construct high-density genetic map for further QTL analysis and genome selection, and can precisely detect the viral load using a TaqMan real-time PCR method. These innovative approaches will unquestionably provide necessary technical and theoretical support for industry development of *F. chinensis*.

BIO-P2-7

Temperature effects on the egg development time and productivity of *Acartia omorii* and *Acartia steueri*

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Copepods are important food resources for larval fish. Changes of sea water temperature driven by season and climate change may effect on survival of copepods. Temperature effects on the rate of egg production and embryonic development of copepods, further population variations. Population variations of Acartiidae was investigated based on weekly collected samples from the Dadaepo beach, Busan, Korea from August in 2015 to April in 2016. Live copepods were also reared in the laboratory at five temperature regimes (10, 14, 18, 22 and 26ºC) to test temperature effects on the egg production rate *of Acartia steueri* and the embryonic development rates of *A. omorii* and *A. steueri*. Egg production rates, egg development time and hatching success rate were significantly correlated with temperature. Average egg production of *A. steueri* ranged from 8.8 to 35.0 eggs female-1 d-1. The embryonic development time of *A. steueri* and *A. omorii* were longest at 10ºC and shortest at 22ºC. Optimal temperature for hatching success rates of *A. omorii* was between 14 and 18ºC while *A. steueri* was between 18ºC and 22ºC. Total five Acartiid species occurred in the study area. *A. steueri* and *A. omorii* dominated in colder season from January to April in 2016. In contrast, *A. pacifica*, *A. erythraea* and *A. sinjiensis* dominated during warmer months from August in 2015 and then decreased to December in 2016. This study indicated that embryonic development rate can estimate temperature-dependent generation time and their population variations, which may affect the larval survival of fishery target species.

BIO-P2-8

Application of end-pairing sequencing technique for phytoplankton community analysis in East Sea

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We designed primers for phytoplankton community analysis using the Illumina MiSeq. The universal primer set was designed to amplify the plastid 23S rDNA of both prokaryotic and eukaryotic plankton species, while suppressing proteobacterial sequences. The obtained amplicon sizes (404 - 411 bp) by end-pairing of two reads were enough to distinguish algal taxa. A total of 345 operational taxonomic units (OTUs) including Dinophyta, Rhodophyta, Ochrophyta, Chlorophyta, Cryptophyta, Haptophyta, and Cyanophyta were found in six samples collected from East Sea. In coastal surface samples, the lowest number of OTUs were identified whereas the open sea surface samples showed the highest number of OTUs. Especially, OTUs belonging to the Ochrophyta occupied > 80 % of the coastal samples. A major difference between the surface and deep waters of the open sea was the increased populations of cyanobacteria, which occupied more than 20% of the total phytoplankton community in the surface water of the open sea. By contrast, only 1 % of was occupied by cyanobacteria in coastal waters. Further study should be made to know the relationship between community structure and physical or chemical factors. Based on our results, we suggest that metabarcording using illumina system will be a promising strategy to analyze phytoplankton community structure with relatively low cost and labor.

BIO-P2-9

Boreopacific gonate squid (*Boreoteuthis borealis*) abundance and its relation to climate indices in the Northwest Pacific

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Boreopacific gonate squid (*Boreoteuthis borealis*) is widely spread in the North Pacific Ocean and its marginal seas. The species is highly abundant in the northwestern and southwestern Bering Sea, deep waters of the Okhotsk Sea and around the Kuril Islands, and is not found in the Japan Sea. We selected several hotspots of squid abundance in the Northwest Pacific from the database "Marine Biology" to trace annual changes in the standardized species quantity (CPUEi) and relate these changes to atmospheric indices.

We used generalized additive model for standardization of numbers. Coordinates with soap spline were constrained by coastline as the barrier where needed, years and types of trawls as independent factors, months and logarithms of depth, length of trawling and minimum size of squids in the catches were smoothed by splines or linearized according to the best information criterions. We used negative binomial family with logarithmic link function.

We restored CPUEi of squid in every cell of grid for each year and then gathered statistics from the full grid. We obtained comparable year to year CPUEi estimates eliminating misbalance in original data by quantity and positions of stations by years, months and types of trawls. Since the squid CPUEi had several orders of magnitude in the response, we used CPUEi on the link scale to compare them with climatic indices. Only PDOs and Arctic oscillation were significantly related with CPUEi of *B. borealis* in the Bering Sea.

BIO-P2-10

Pilot application of a framework to assess vulnerability of biological components to oil spilled in the marine environment to the Canadian Pacific Region

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A framework to assess the vulnerability of species groups to spilled oil in the marine environment has been developed to support the development of oil spill response planning within the Department of Fisheries and Oceans, Canada (DFO). The framework provides a structured and adaptable process to identify which marine biological species sub-groups are most vulnerable to spilled oil, and to focus data collection for spill response planning. The product of the framework is a list of species sub-groups identified as being most vulnerable to spilled oil , produced through the scoring of criteria in three categories (Exposure, Sensitivity and Recovery), and a screening process. The framework is being piloted in 4 locations (3 on the East Coast of Canada and 1 on the Pacific coast of Canada). Here we describe the findings and challenges of the pilot application of the framework to the Pacific Region of Canada (British Columbia). If successful, we anticipate this approach will be useful for identification of biological components most affected by spilled oil in any marine environment.

BIO-P2-11

Geographical variation in the concentration and form of biogenic elements in the North Pacific Ocean.

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Nutrient supply is one of the most important factors controlling marine ecosystem structure and productivity. In most subtropical region, nutrient concentration is below the detection limit of conventional measurement method, and the chlorophyll concentration is low. In addition to their small seasonal variability, subtropical regions have been recognized as homogeneous and stable environment. However, after the development of high-sensitive methods for nutrient measurement, it was found that the variations in nitrate and phosphate concentration were more than 3-order of magnitude within the western subtropical Pacific Ocean. We also applied the high-sensitivity absorption photometry with LWCC (Liquid Waveguide Capillary Cell) for nutrients into particulate forms of P and Si and also for DOP. The detection limits are 1-2 order higher than conventional methods. We used this methods during Hakuho-Maru western North Pacific cruise and described geographical variation in the concentration and form of biogenic elements. It is suggested that particulate forms of P and N, including phytoplankton and zooplankton, play an important role as a source of biogenic elements in the subtropical region of the North Pacific. We will discuss contrastive dynamics of biogenic elemental between subtropical and subarctic ecosystems.

BIO-P2-12

The dietary response of the California sea lion population during the 2013 Unusual Mortality Event

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Variations in the diet of California sea lions have been shown to correlate with oceanographic conditions and broad regional patterns of prey availability. Recently, the 2013 Unusual Mortality Event (UME) of California sea lion (*Zalophus californianus*) pups in Southern California highlighted the need to better understand how changes in prey availability within the California current ecosystem affected the sea lion population. The long-term (1981-2007) means of seven common prey species and non-common prey groups found in scat samples collected seasonally at San Clemente Island and San Nicolas Island were used to evaluate prey consumption by sea lions before, during, and after the 2013 UME. The summer 2012 to fall 2013 data show below-average consumption of anchovy (*Engraulis mordax*) and sardine (*Sardinops sagax*) and above-average consumption of market squid (*Doryteuthis opalescens*) and shortbelly rockfish (*Sebastes jordani*). Samples collected during spring of 2013 also show above-average consumption of non-common prey, suggesting that sea lions diversified their diet to compensate for less available common prey near the rookeries. Consumption of jack mackerel (*Trachurus symmetricus*) and Pacific mackerel (*Scomber japonicus*) differed between the two islands, indicating spatial differences in the diet. These recent diet anomalies show that pup production and survival is poor when forage species are underrepresented in the diet, and that the sea lion population is susceptible to changes in abundance and availability of common prey.

BIO-P2-13

Density and distribution of seabirds on the Baja California Pacific islands, Mexico

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The Mexican Pacific islands off the Baja California Peninsula are particularly important because they provide nesting sites for many seabirds. In order to better understand the population dynamics of a group of selected seabird species and to evaluate restoration interventions, since 2013 we started a systematic monitoring. We have gathered information for several seabird species including the Black-vented Shearwater (*Puffinus opisthomelas*), the Cassin's Auklet (*Ptychoramphus aleuticus*), the Western Gull (*Larus occidentalis*), the Laysan Albatross (*Phoebastria immutabilis*), the Guadalupe Murrelet (*Synthliboramphus hypoleucus*) and the Leach's Storm-petrel (*Oceanodroma leucorhoa cheimomnestes* and *O. l. socorroensis*). We have also conducted detailed studies to assess the spatio-temporal nesting distribution and density of these seabird species on the Baja California Pacific Islands. Nests distribution and density maps on the islands surface provide valuable information about the population dynamics, habitat and resilience of seabirds, becoming an important tool for conservation management and monitoring efforts. We have found that seabirds have a differentiated distribution on Baja California Pacific islands in relation to habitat availability. On Todos Santos, the Western Gull is densely distributed on the two islands; on San Martín Island it prefers the west site of the island; while on Natividad Island it has a preference for the northernmost and southernmost portions of the island. We have also determined seabird burrow density, obtaining 0.05 burrows/m² for Black-vented Shearwater on Natividad Island and 0.24 burrows/m² for Cassin's Auklet on San Jerónimo Island.

BIO-P2-14

Synthesis of benthic macroinvertebrate diversity in coastlines of the Puget Sound before and after shoreline restoration

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Armoring shorelines with bulkheads and ripraps can increase beach erosion rates and change hydrological & ecological processes, thereby altering natural habitats for shallow marine species. The shorelines of the Puget Sound in Washington, USA provide valuable habitats for nearshore fish species (i.e. endangered Chinook Salmon) and diverse benthic macroinvertebrates that provide the staple diet for many fish populations. While over 25% of the Puget Sound shorelines are armored, many shorelines' armoring has been continually removed through restoration. It is essential to understand how the changes of regional armoring alters benthic macroinvertebrate community diversity-- a reliable indicator of shoreline ecosystem health. We collected benthic macroinvertebrates from 2004 to 2015 with sediment cores at different tidal elevations in Seahurst Park in Burien, Washington, USA (restored in 2005). Using multivariate analyses in PRIMER-E software, we found few differences between the macroinvertebrate communities before and after restoration years; in the single year after restoration, however, the macroinvertebrate communities changed greatly from pre-restoration as they were mainly dominated by nematodes instead of oligochaetes like other sampled years. Our synthesis showed that shoreline restoration caused the greatest changes in macroinvertebrate communities at higher shoreline elevation through changing densities of a few taxonomic groups in 2006. The macroinvertebrate community structures in the subsequent years aligned closely with the communities prior to the restoration, suggesting that a more comprehensive synthesis across different sites in the Puget Sound is needed to understand if restoring armored sites changes benthic macroinvertebrate diversity, benefiting the greater coastal ecosystem as a whole.

BIO-P2-15

Macromolecular compositions of phytoplankton in the Japan/East Sea

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The macromolecular compositions (carbohydrates, proteins, and lipids) of particulate organic matter (POM) as a basic food source through phytoplankton photosynthesis are useful information for their physiological status and environmental growth conditions. Using colorimetric techniques, concentrations of these compositions were conducted at three light depths (100, 30, and 1%) at 15 different stations on board in the Japan/East Sea, 2014. The macromolecular compositions of the phytoplankton were not significantly different among different light depths in this study. The overall average compositions of carbohydrates, proteins, and lipids from all the stations were 40.1% (S.D.=±9.6%), 31.9% (S.D.=±8.5%), and 28.0% (S.D.=±14.1%), respectively. Along with other evidence, the high protein and low lipid compositions of POM in this study suggest that phytoplankton might have had no severe nitrogen-limited condition during the cruise period, 2014. Based on the macromolecular compositions, the average food material concentration was 221.9 μg L−1 (S.D.=±108.0 μg L−1) and correlated positively with the primary productivity in the Japan/East Sea.

FIS Contributed Poster Session

FIS-P1

Application of an age-length structured population dynamics model to data for eastern Bering Sea tanner crab (*Chionoecetes bairdi*), Pribilof Island blue king crab (*Paralithodes platypus*), and Pacific cod (*Gadus macrocephalus*)

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Fishery stock assessments are frequently based on either age-structured population dynamics or length-structured dynamics. We have developed and implemented a model to account for both age and length dynamics for an individual fishery. An age-length assessment model is unique in its ability to capture the dynamics of fishing mortality and natural mortality on fish populations, which are functions of both length and age. By accounting for both factors, the age-length model should reduce estimation bias present in models that only account for age (or length) dynamics, and assist managers in achieving statutory goals for fishery management.

Simulation studies have showed that the age-length models can provide essentially unbiased estimates of biomass trajectories and have low sensitivity to the precision of the data. Here we evaluate these models using the actual data for the Eastern Bering Sea Tanner crab (*Chionoecetes bairdi*), Pribilof Island blue king crab (*Paralithodes platypus*), and Pacific cod (*Gadus macrocephalus*) fisheries. These data include catches, fishing effort, and survey index, as well as length-composition and conditional age-at-length. Survey and fishery data (including several fleets) are available for each stock. We compare the results of our age-length model against current stock assessment model results for each species. Uncertainty is characterized using Bayesian methods. Posterior distributions for parameters are sampled using a Markov Chain Monte Carlo approach. Fit to the data is evaluated with a range of diagnostics, including posterior predictive intervals for the observed data.

FIS-P2

Comparison of fish-killing activities of *Chattonella antiqua* and *Chattonella marina* against three fish species and possible mitigation effect of alginate oligomer on *Chattonella* sp.

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Harmful algal bloom (HAB) is a serious environmental issue. *Chattonella antiqua* and *C. marina* are major HAB species, and they cause mass mortality of fish leading to economic damage on aquaculture industry. In this study, we conducted comparative study between *C. antiqua* isolated in Nagasaki in 2010 and *C. marina* isolated in Kagoshima in 1985 by laboratory exposure experiments. We found that *C. antiqua* showed potent fish-killing activity on red sea bream, Japanese horse mackerel, and blue damselfish, while *C. marina* showed no significant toxic effects on these fish species. *C. antiqua* produced higher level of reactive oxygen species (ROS) such as superoxide and hydroxyl radical than those of *C. marina*. Furthermore, analysis of the amounts of *Chattonella* cells bound on the gill surface of blue damselfish exposed to *Chattonella* suggested that *C. antiqua* had higher affinity on the gill surface than *C. marina*. These results suggest that ROS-producing activity and affinity of *Chattonella* cells to gill surface may be important factors influencing the fish-killing activity of *Chattonella* species. Under these circumstances, we examined the effect of alginate oligomer on the fish-killing activity of *Chattonella,* and found that alginate oligomer showed partial protective effect on red sea bream exposed to *C. antiqua*. Since alginate oligomer showed no significant toxicity on *C. antiqua*, it is considered that protective effect of alginate oligomer may be due to the inhibition of the binding *C. antiqua* cells on the gill surface in addition to ROS scavenging.

FIS-P3

Reproduction and growth of the spiny lebbeid shrimp, *Lebbeus groenlandicus* (Fabricius, 1775) (Caridea, hippolytidae) in the East sea of Korea

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Reproduction and growth of the spiny lebbeid shrimp, *Lebbeus groenlandicus* (Fabricius, 1775), were investigated based on samples in the East Sea of Korea, from January 2012 to April 2013.We collected 2,964 shrimp samples during the study period, which included significantly more females than males (male : female ratio, 1.0 : 1.17). The females were generally larger than the males, and significant differences in the linear-regression slopes of carapace length (CL) versus body weight between the sexes indicate sex-specific differences in allometric growth. The gonadosomatic index (GSI) varied monthly, reaching a maximum in November 2012 (10.28) and a minimum in March 2013 (2.15). The proportion of ovigerous females varied from month to month. The highest values of the GSI coincided with the breeding period, and there was a significant difference between the mean GSI of females with non-eyed and those with eyed eggs, indicating that *L. groenlandicus* is a consecutive breeder. There was a significant correlation between CL and the number of eggs in the early egg stages. Based on the dry weights in the early egg stages, reproductive output was determined to be 0.18 ± 0.006. The Von Bertalanffy growth function parameters were CL_∞ = 38.80 mm, K = 0.48 year−1, C = 0.5, and WP = 0.4 for males, and CL_∞ = 43.64 mm, K = 0.41 year−1, C = 0.6, and WP = 0.6 for females. The growth performance index (ϕ') was 2.86 for males and 2.89 for females.

FIS-P4

Linking Pacific Ocean perch productivity to deep-sea corals and sponges in Alaska

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Pacific Ocean perch populations in Alaska support large commercial fisheries. This species has exhibited highly variable recruitment, with some evidence for density dependent affects. Late stage juveniles are often found in distinctive nursery habitats (rocky areas with benthic invertebrates, such as corals and sponges). The objective of this study was to estimate the potential production of adult Pacific Ocean perch recruits to the exploitable population from nursery habitats and estimate the potential additive effect of coral and sponge habitat to this recruitment. The data used were collected from underwater camera surveys, bottom trawl surveys and energetics studies. The analysis also incorporated model results for the distribution of juvenile fish and the distribution of nursery habitats, as well as some simplifying assumptions. The findings indicate that on average, 257 age 2 recruits are produced per hectare of nursery habitat in the Gulf of Alaska. On average, there is roughly 1.08 kg of coral or sponge found in these habitats (per hectare). Doubling the biomass of coral and sponge could result in a doubling of Pacific Ocean perch recruitment. These results indicate the potential importance of these habitats to supporting commercial fisheries.

FIS-P5

Annual changes in distributions and abundances of dominant myctophid fishes in the Pacific side of Hokkaido, Japan

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Myctophid fishes (family, Myctophidae) are the main components of the mesopelagic sound scattering layer and play a significant role in the marine ecosystem of the Pacific side of Hokkaido island, one of the most important fishing grounds in Japan. Acoustic-trawl surveys for myctophid fishes, covering shelf edge in the Pacific side of Hokkaido, were conducted in the summer of 2014 and 2015 to know the species composition, species-specific distributions, abundances of each species, and their annual changes. In both years, Myctophidae was composed of 8 dominant species and they occupied more than 90% (in number) of all mesopelagic fish community in each trawl. Then, distributions of the dominant 8 species were estimated quantitatively by acoustic data. Target strength of each species was estimated based on the shape of the swimbladder or body and was used to allocate echo energy in the sound scattering layer among species. In both years, the biomass of myctophid fishes estimated by the acoustic method were significantly larger than previous trawling estimates, as reported by some recent studies. Horizontal distributions and biomass in each species showed different patterns between two years. It is suggested that fluctuations of dominant current structures, such as the Oyashio cold Current and warm-core rings from the Kuroshio Current, potentially affected them.

FIS-P6

Cumulative effects of size-selective fishing on size-at-age of Pacific halibut in the northeast Pacific Ocean

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The biomass of Pacific halibut (*Hippoglossus stenolepis*) in the northeast Pacific Ocean has been declining since the late 1990s, and reductions in size-at-age since the 1980s explain more than half of the observed decline in halibut biomass. For example, on average an age-20 female halibut weighed 61 kg in the 1980s but weighed <21 kg in 2014. We hypothesize that declines in size-at-age are, in part, the result of size-selective fishing. An age- and size-structured equilibrium model was developed to examine the long-term relationship between fishing mortality and size-at-age. Historical estimates of fishing mortality for Pacific halibut ranged between 0.18 and 0.60, with a mean of 0.40 over 2000-2014; fishing mortality was significantly higher in the eastern Gulf of Alaska than in the central or western Gulf of Alaska. Results suggest that fishing can explain 30-100% of the observed declines in size-at-age since the 1980s, depending on sex, age, and region. Given that length-at-age for any given cohort is highly variable, Pacific halibut are vulnerable to the cumulative effects of size-selective fishing. The most effective management action to potentially reverse trends in size-at-age would be to reduce harvest rates to diminish the intensity of size selection. Additional research is needed to better understand the potential for other mechanisms to the observed variability in size-at-age of Pacific halibut.

FIS-P7

Age and growth of damselfish *Chromis notata* (Temminck & Schlegel, 1843) in the Jeju Island, Korea

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This study was to investigate age and growth of damselfish *Chromis notata* from the Jeju Island in Korea. Samples were monthly collected by liftnet from September 2013 to August 2014. The total length of the damselfish ranged from 6.4 to 15.3 cm. The relationship between total length and Wet weight was $WW = 0.0125TL^{3.1631}$ $WW = 0.0125TL^{3.1631}$ for females, and $W W = 0.0091TL^{3.2769} W = 0.0091TL^{3.2769}$ for males. The slopes of the relationship between length and weight were not significantly different between sexes but a significant difference in intercepts. Females had more specimens than males (1.3:1). The spawning season for *C. notata* was from June to August. Age determination was conducted using otolith. Marginal increment (MI) declined in summer and winter, which suggests that two rings are formed each year. The age of the sampled individuals ranged from 1 to 5 years. The estimated Von Bertalanffy growth functions were $L_t = 19.93(1 - exp^{-0.21\,(t+0.811)})$ $L_t = 19.93(1 - exp^{-0.21\,(t+0.811)})$ for females; $L_t = 16.47(1 - exp^{-0.32\,(t+0.499)})$ $L_t = 16.47(1 - exp^{-0.32\,(t+0.499)})$ for males. The growth performance indices ($\varphi)\varphi)$ were 3.92 for female and 3.94 for male.

FIS-P8

Growth and reproduction of the Japanese mantis shrimp, *Oratosquilla oratoria* (De Haan 1844) in the coastal area of Tongyeong, Korea

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Growth and reproduction of the Japanese mantis shrimp, *Oratosquilla oratoria* (De Haan 1844), were investigated based on samples from July 2014 to August 2015 in the Tongyeong, Korea. A total of 2,621 samples was collected (1,380 females and 1,241 males) during the study period. The number of female was observed more frequently than that of male. The mean body length (*BL*) was 128.54 ± 0.38 mm in females and 126.87 ± 0.42 mm in males, respectively. The mean body weight (*BW*) was 31.23 ± 0.28 g in females and 31.06 ± 0.32 g in males, respectively. The females were larger than males in *BL*. There was a significant difference in the length-frequency distributions between females and males. A linear regression analysis was ln*BW*=2.8498(±0.0235) ln*BL*-10.4339 of females and ln*BW*=2.8727(±0.0272) ln*BL*-10.5153 of males, respectively. The gonadosomatic index (GSI) varied monthly. The GSI reached a maximum in May and a minimum in November. The highest values of the GSI coincided with the spawning period of *O. oratoria*. Larger individuals of *O. oratoria* have earlier spawning season than smaller ones. The size at sexual maturity (BL_{50}) of females was estimated as 96.5 mm. The Von Bertalanffy growth function parameters were BL_∞ = 184.5 mm, K = 0.72 year^{-1}, C = 0.36 and WP = 0.45 for females and BL_∞ = 183.75 mm, K = 0.82 year^{-1}, C = 0.38 and WP = 0.22 for males. The growth of males were slightly faster than females. We have discussed the reproduction strategy of *O. oratoria* in terms of trade-off between growth and reproduction.

FIS-P9

Effects of submarine groundwater on feeding and growth of juvenile marbled flounder P*seudopleuronectes yokohamae* in the Seto Inland Sea, Japan

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Submarine groundwater is nutritionally rich and stable in temperature throughout the year, indicating positive effects on fishery production under a variety of changes in environmental conditions including global warming. A recent study indicated that juvenile marbled flounder *Pseudopleuronectes yokohamae* were abundant around the area with high submarine groundwater discharge in the Seto Inland Sea, southwestern Japan. In order to examine effects of submarine groundwater on feeding and growth of juvenile marbled flounder, physical and biological surveys and on-site cage experiments were conducted in coastal waters of Seto Inland Sea. Fish sampling was conducted by the use of a push-net (0.3 x 1.5 m, 2 mm mesh). Invertebrates (crustaceans and polychaetes, as prey for the fishes) were collected with a bottom plankton net (0.3 x 0.4 m, 1 mm mesh) and a sediment sampler (10 x 10 cm circular cylinder). On-site experiments were made using cages (0.9 x 0.9 x 0.3 m, 5 mm mesh) with cultured juvenile marbled flounder inside. Biweekly sampling from March to May showed high juvenile abundance of in April with elevation of juvenile abundance around the area of high submarine groundwater discharge. The dependence of food webs on organic matters of terrestrial origin was examined by stomach contents and stable isotope analyses. Stomach contents of the juveniles were dominated by gammarids and polychaetes. Cage experiments showed that recent juvenile growth rates back-calculated from the otolith daily rings were higher in area with high submarine groundwater discharge.

FIS-P10

First report on an annual gametogenesis of *Hyotissa hyotis* (Linnaeus 1758), the subtropical oyster in Jeju Island off the south coast of Korea

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Hyotissa hyotis is a subtropical oyster distributed in Indo-Pacific to Eastern Pacific regions. This oyster has been extending its distribution range from tropic or subtropical to Jeju Island off the south coast of Korea, possibly due to the recent seawater temperature increase. In the present study, we first investigated an annual reproductive cycle and energy storage and use of *H. hyotis* collected from southern coast of Jeju Island, from March 2011 to February 2012. The annual gametogenesis was analyzed using histology and protein carbohydrate levels in the body and adductor muscle were determined using spectrometry. *H. hyotis* in Jeju Island were fully ripe in August, and subsequently spawned during September and November, with a spawning pulse in October. *H. hyotis* had extraordinary large adductor muscle, accounted for 47.6-55.6% of the total body weight. Ratio of the adductor muscle weight to the total body weight varied seasonally, which was negatively correlated to maturation of the gonad. Carbohydrate level in the adductor muscle was significantly higher than the level in other tissues. The carbohydrate contents in the muscle increased during spring, when the food availability was higher in the water column, then declined during spawning. Our data suggested that *H. hyotis* store the energy in the muscle and the adductor muscle is an energy storage organ.

FIS-P11

Spawning migration tracking of adult pacific herring (*Clupea pallasii*) using supersonic telemetry

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Behavioral ecology in fish spawning influences on results of fish reproductions directory should be understood for resource managements of target fishes. In Japan, resources of pacific herring (*clupea pallasii*) have been lower conditions from 1960's; many of studies about their spawning have conducted until now. However, the knowledge of behavioral ecology of adult herring including spawning migration is poor, because of the difficulty of behavioral monitoring for such small pelagic fish. In this study, we tracked spawning migration of adult pacific herring by supersonic telemetry to verify a timing of migration to spawning grounds and a behavioral process still spawning. For the acoustic tracking, living adult herring of regional group (n=23) caught by set net at Akkeshi bay in east Hokkaido in Japan were used. The survey was conducted on April that a number of herring peaks at Akkeshi. Mainly two migration patterns were found (pattern1: staying at Akkeshi bay, pattern2: rapid migration to Akkeshi lake which is brackish water lake adjacent the bay). On the pattern1, individuals stayed within the bay during 1–3days; after that, they dispersed to out of the bay. In contrast on the pattern2, individuals showed rapid migration to the lake during 24 hours. Besides, some individuals were re-capturing at eelgrass bed in the lake which is typical spawning bed for herring. From these, the pattern 2 is indicated to be for spawning, and the pattern1 is before or after spawning migration. Spawning migration span is estimated to be comparatively short, during 4–5days.

FIS-P12

Multiple-trait genetic evaluation of the Pacific white shrimp *Litopenaeus vannamei* in China

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As the primary cultivated species in the world, the Pacific white shrimp *Litopenaeus vannamei*, has accounted for more than 80% of the total shrimp production in China. A genetic improvement program was performed to increase the production and profits of *L. vannamei* culture in China. The target traits included body weight and survival at different temperatures and different densities, resistance to ammonia nitrogen and low temperature, feed efficiency, meat yield and reproductive efficiency. First, a base population of *L. vannamei* was established in 2011, and genetic relationships of several hundred founders were reconstructed using SSR markers by the maximum likelihood method. Genetic evaluation showed that heritabilities of body weight, survival, ammonia nitrogen tolerance, cold tolerance, feed efficiency, meat yield and reproductive efficiency were 0.19-0.45, 0.05-0.19, 0.08-0.154, 0.03, 0.17-0.51, 0.12 and 0.06-0.19, respectively. As the most interesting trait, body weight exhibited a low genetic correlation with survival (−0.008), high negative genetic correlation with cold tolerance (-0.77), high positive genetic correlation with ammonia nitrogen tolerance (0.83) and moderate genetic correlation with meat yield (0.32). In addition, a low genotype by environment interaction (G×E) for body weight ($K < 0.5$) and a high G×E for survival ($k > 0.5$) were found in *L. vannamei*. The results show that there are substantial additive genetic variance for body weight, survival, resistance, feed efficiency and meat yield in the Pacific white shrimp that can be exploited through multiple-trait selective breeding.

FIS-P13

Climate and feedback structures influence the populations dynamics of small pelagic fish off Chile

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The dynamics of the abundance of the small pelagic fish such as anchovies has been described as modulate by several factors such as the temperature, availability of food, oxygen, cannibalism and interspecific predation between others. In doing this, the methodological approach to identify these drivers has been to correlate environmental variables (e.g. sea surface temperature) with population variables (e.g. recruitment). Although correlation studies can be useful for detecting relationships between variables and for showing common signatures in the time or frequency domain, they can fail to provide explanations based in general and basic population dynamics principles. Here, we use the approach of dynamical systems theory to identify the ecological process underlying the dynamics of the time series of small pelagic fish populations off the Chilean coast. We assume that the population dynamics of anchovy (*Engraulis ringens*) and common sardine (*Strangomera bentincki*) are the result of the combined effect of the feedback structure (ecological interactions within and between populations), limiting factors (food limitation) and climatic and anthropogenic effects. We used R-function (realized per capita population growth rates) to understand how these endogenous and exogenous effect determine the biomass fluctuations. As proxies for food we used Chlorophyll-a and sea surface temperature. El Niño 1+2 and 3.4 temperatures and MEI index were used as climatic variables and fishing effort as anthropogenic effect. We will be presenting initial results of how these factors and the population feedback structure modulates anchovy and sardine dynamics of Chile.

FIS-P14

Age validation and growth rate of *Mactra chinensis* (Bivalvia, Mactridae) by chondrophore

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Age, growth and mortality of *Mactra chinensis* were investigated during the period from October 2012 to September 2013 in Busan, South Korea. The monthly variation of the marginal index (MI) of the shell and chondrophore showed that the ring of this species was formed once a year during July. We estimated the age of *M. chinensis* by reading the external rings on the shell and the growth bands of the chondrophore to compare growth parameters between the two growth characters. The age of this species ranged from 0 to 8 years (shell-based age reading) and from 0 to 10 years (chondrophore-based age reading). Based on external rings and growth bands of chondrophore for the same period, the von Bertalanffy growth functions were expressed by the equation, $L_t = 101.53[1-exp\{-0.15(t+0.75)\}]$ and $L_t = 90.03[1-exp\{-0.20(t+0.50)\}]$, respectively. The likelihood test showed that there was a significant difference in L_∞ ($P<0.001$), K ($P<0.001$), t_o ($P<0.001$) estimated from non-linear regression between the two growth characters. We deduced from the present study that the chondrophore growth bands method is more efficient than the external rings method for determining the age of *M. chinensis*.

FIS-P15

Ontogenetic changes and interannual variations in diet of Japanese jack mackerel (*Trachurus japonicus*) juveniles in the East China Sea

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We examined and compared the diet of pelagic juveniles of *Trachurus japonicus* [8–30 mm standard length (SL)] in the surface layer in April, and subsequent demersal juveniles (25–105 mm SL) in the near bottom layer during May to June sampled in the shelf-break region of the East China Sea (ECS) in 2005, 2008, and 2009. Diet composition of the pelagic juveniles showed a significant difference between 2005 and the other two years. That is, they preyed mainly on *Paracalanus parvus* and occasionally on *Calanus sinicus* in 2008 and 2009, while fed mainly on *Corycaeus affinis* in 2005, which corresponded with the interannual variations in the prey densities in the epipelagic layer. After habitat transitions from the surface to the near bottom layers, the demersal juveniles depended heavily on *C. sinicus* (copepodite stage Vs and females) and halocypridid ostracods, both of which stored lipid in the body, i.e. high-energy food for *T. japonicus*. There was no significant interannual variation in diet of the demersal juveniles, possibly indicating that food availability did not differ greatly among the three years. Meanwhile, the food availability for the pelagic juveniles in 2005 was considered to be markedly lower than those in the other two years, based on the diet composition, prey densities in the field, and carbon content of prey items. This corresponded with the lowest growth and survival rates of the pelagic juveniles in 2005 among the three years, and would potentially relate to the lowest recruitment level of the demersal juveniles on the ECS shelf in 2005.

FIS-P16

Changes in biomass of walleye pollock *Gadus chalcogrammus* in the East Sea: The late 1980s regime shift

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Walleye pollock (*Gadus chalcogrammus*, hereafter pollock) was one of the most dominant species in Korean waters in the late 1970s and early 1980s, but its biomass has decreased since the late 1980s and was completely collapsed in the early 2000s. Especially, in the late 1980s, the catch production of pollock in Korean waters were considerably decreased: for example, the catch production was declined by about 71 % from of 84,545 M/T in 1985 to 24,217 M/T in 1989. Such a considerable decrease has been attributed to overfishing and climate change, without concrete evidence. In this study, we investigated how the decrease in biomass of pollock was related to environmental changes in Korean waters using atmospheric data (air temperature and wind) from Korean Meteorological Administration and oceanographic data (sea surface temperature) from Korea Oceanographic Data Center). A CuSum analysis reveals that both sea surface temperature (SST) and atmospheric variables (air temperature and wind) show a regime shift in late 1980s when the pollock was significantly declined. The regime shift seems to be related with an increase in frequency of the sea surface temperature higher than 12ºC above which pollock larval survival rate may be considerably low. Our results suggest that climate changes, in addition to overfishing, could contribute to the stock collapse of pollock in the early 2000s.

FIS-P17

Growth, migration and trophic interactions role of neon flying squid (*Ommastrephes bartramii)* in the North Pacific

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The neon flying squid, *O. bartramii,* is getting a significant amount of attention not only due to commercial fisheries stock but also a keystone species in food web in the North Pacific. However, their feeding ecology and migration ecology have been mostly examined by traditional methods. Nowadays, stable isotope profiles along the gladius made of chitinous shell have been recently analyzed and seem to be a promising tool to produce a chronological record of dietary information over their lifetime. In this study, $\delta^{13}C$ and $\delta^{15}N$ values were measured along the gladius to reconstruct *O. bartramii* feeding variations and migration behavior of the autumn cohort during ontogeny. Stable isotope profiles along the gladius (internal chitinous shell) have been recently analyzed and form a promising tool to back-calculate a chronological record of changes in the diet and habitat.

The results of $\delta^{13}C$ values support previous studies which inferred differences in migratory behavior between males and females. These differences occurred from 260 mm mantle length. Based on this result, we are trying to develop a bioenergetics model for this species. Our model was based on NEMURO.FISH, using respiration and consumption terms and assumed that SST and prey zooplankton density are the determining factors of the reduction of body size. SST and prey zooplankton density are obtained from the result of NEMURO embedded in 3-D physical model, along the migration route of *O. bartramii.*

FIS-P18

Importance of early life transports for recruitment of walleye pollock *Gadus chalcogrammus* in the Sea of Japan off Hokkaido Island

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The northern Japan Sea stock (JSS) of walleye pollock *Gadus chalcogrammus* (formerly *Theragra chalcogramma*) is mainly distributed in the Sea of Japan off Hokkaido Island. Although this stock is an important fisheries resource in Japan, recruitment has been decreasing since around 1990, and recent biomass is only about 10% of its historical peak in the 1990s. Hence, an appropriate stock management in consideration of recruitment control mechanism is essential for JSS. Because strong positive correlation is observed between juvenile abundance and recruitment, it is likely that survival at egg and larval stages significantly affects JSS recruitment. In addition, the nursery ground is separated from the spawning grounds, suggesting an importance of early life transport for JSS recruitment. In this study, particle-tracking experiments using the hydrodynamic data produced by JADE (Japan Sea Data Assimilation Experiment) was conducted to investigate the influence of egg and larval transports on JSS recruitment. Particles were released at the spawning grounds, and the numbers of particles which were successfully carried into the nursery ground (hereafter “survival particles”) were computed. As a result, high positive correlation was recognized between the number of survival particles and JSS recruitment. Moreover, if particles which experienced water temperature <2ºC and >7ºC were eliminated, higher positive correlation was observed. It is suggested that passive transports and experienced water temperature during early life stages are significant for JSS recruitment.

FIS-P19

Successive recruitment of age-0 jack mackerel (*Trachurus japonicus*) in coastal areas along the Kuroshio

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Jack mackerel (*Trachurus japonicus*) inhabiting coastal areas in the temperate western North Pacific is an important fisheries resource in East Asian countries. The main spawning ground is located in the southwestern part of the East China Sea, which is thought to supply young fish to areas along the East China Sea and those along the Kuroshio and the Tsushima Warm Current. In the Pacific coastal areas of Japan along the Kuroshio, commercial catch of age-0 jack mackerel increases from early spring to summer, which apparently follows the occurrence of spawning in the main spawning ground from late winter to early spring. Although this suggests the transport along the Kuroshio, few studies quantified the characteristics of the transport and recruitment processes into the coastal fishing grounds. As there also are local populations in some of semi-enclosed coastal areas, distinguishing its contribution from that of the main spawning ground in the East China Sea is also important. In the present study, daily landing records of set net, purse-sein and dip-net fisheries for age-0 jack mackerel at seven prefectures of Japan were analyzed together with the temperature data of buoy arrays along the Kuroshio, to examine the transport and recruitment processes, including the net speed of the transport, short-term fluctuation patterns of landing, and the relevant physical oceanographic processes. The results show a propagation pattern of landing pulses along the Kuroshio from west to east. The time lags of the pulses are, however, not linearly related to the distance between the fishing grounds. In the presentation, temperature fluctuations around the landing pulses and their physical characteristics are also discussed.

FIS-P20

Biodiversity patterns and changes in the fishery ecosystem of the Yellow Sea and the East China Sea

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The Yellow Sea and the East China Sea, one of the most important ecosystems in the Western Pacific Region, are rich in species diversity and of significant service function to regional social economic development. Aimed at the important fishery resources in the Yellow Sea and the East China Sea, By taking the following research strategies as fishery resources survey, evaluation of population dynamics, molecular and chemical markers, the multivariable analysis of morphological characteristics, together with the integrated analysis to histological and experimental data of cross-strait fishery resources, the overall trend of fishery species composition and their spatial distribution was clarified. The diversity characteristics of the functional groups within the fishery ecosystem was described. , The patterns and changes of genetic diversity in those key species was revealed and the relationship between genetic patterns and marine geographical changes was elucidated. The form, distribution and spreading patterns of the key populations including *Larimichthys polyactis*, *Engraulis japonicus*, *Scomberomorus niphonius*, *Sepia esculenta* were described. The influences of paleoclimatic changes on these key populations were also analyzed. Consequently, the biodiversity patterns and changes in the fishery ecosystem of the Yellow Sea and the East China Sea were elaborated at such three levels as species, functional group and genetic diversities. The results of this study provided the scientific basis for the marine biodiversity protection and sustainable utilization of fishery resources.

FIS-P21

Bare hooks and other species interactions with benthic longline gear can influence hook-based abundance indices

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Fisheries-independent longline catches are used as an index of abundance for some benthic species. Hidden processes not observed from the longline vessel may bias the interpretation of these indices. These processes may include interspecific competition, species-specific feeding behaviours, bait defense and bait removal, both by species observed caught on the longline and species that are rarely caught or unobserved. Spatial or temporal variation in the abundance of unobserved species may influence the capture of the target species, inducing a bias in the temporal trends of the abundance index. Alternative indices that account for the catch of non-target species, like the species-specific instantaneous rate of bait removal (λ_s), can help with interspecific competition, but cannot account for processes hidden underwater. Furthermore, estimation problems arise when making assumptions about bare hooks that return with neither bait nor catch. To improve our understanding of hidden processes influencing benthic longline catch rates, we conducted an experiment using a Remotely Operated Vehicle to make underwater observations of benthic longlines fishing for inshore rockfish. We observed the sources of bare hooks underwater and searched for similar species-related patterns in the on-deck catch. We also discovered that large sea stars cover baited hooks, but 70% do not appear on the longline vessel, so we corrected the Yelloweye Rockfish λ_s index for this hidden competition, which altered the temporal trends in some areas. Understanding the hidden processes influencing longline catches helps ensure that the abundance indices driving stock assessments, and management decisions, are interpreted correctly and unbiased.

FIS-P22

Disentangling the impact of regulation and climate on vessel productivity: A case study of the Leatherback Turtle Conservation Area Closure and the California drift gill net swordfish fishery

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This research analyzes California's drift gillnet swordfish (Xiphias gladius) fishery to provide a characterization of vessel-level production and investigates the impact of a recent regulatory measure. Building on the fisheries production literature, a parametric translog approach is used for the characterization of the primal production technology of the fishery in terms of variable and fixed economic inputs, and factors such as El Nino conditions, target species biomass, and disembodied technical change. The production model is framed in a treatment-control difference-in-differences framework to investigate the effect of a regulatory time-area closure on the fishery. Estimation of production function parameters using Generalized Method of Moments facilitates the calculation of production elasticities for variable and fixed economic inputs, and other factors including El Nino conditions and target species biomass. Difference-in-Difference parameter estimates suggest the regulation has a statistically significant negative impact on productivity. These set of results provide empirical findings as to the drivers of vessel productivity; these findings may be used to bolster conservation and management efforts.

FIS-P23

Does returning sockeye salmon (*Oncorhynchus nerka*) condition vary with climate in two BC rivers?

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Knowledge of the size and condition of returning Sockeye Salmon (*Oncorhynchus nerka*) is important for understanding the timing of life history events, and may aid in predicting future stock biomass to set annual limits and catch allotments. Although condition in Sockeye Salmon is known to be influenced by inter and intraspecific interactions and environmental factors, effects are likely time and stock specific. We use historical (1914-1943) and contemporary data of length (mm), weight (g) and age data from the Nass River and Rivers Inlet, British Columbia, Canada to examine how large-scale oceanographic conditions influence condition-at-age of returning Sockeye Salmon. These populations provide a useful comparison since Nass River sockeye salmon are still harvested commercially, while the Rivers Inlet stock has not recovered from a collapse in the 1990s. We used linear regression models to explore possible relationships between condition-at-age and the Pacific Decadal Oscillation (PDO), sea surface temperature (SST), and the Aleutian Low Pressure index (ALPI). Preliminary results suggest different response of condition-at-age to climate variables in the Nass and Rivers Inlet. In the dominant age class of Nass River Sockeye Salmon (age 2.2), condition-at-age increased in response to increasing PDO values, and decreased in response to increasing ALPI scores. Condition-at-age in the dominant age class in Rivers Inlet (age 1.3) decreased in response to increases in both PDO and ALPI. Further exploration of the climatic forces influencing Sockeye Salmon condition-at-age in the two populations will contribute to the understanding of recent and future population trends.

FIS-P24

Pacific sand lance in the San Juan Islands: synthesis of research 2010-2016

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Research developed in the Pelagic Ecosystem Research Apprenticeship at the University of Washington Friday Harbor Laboratories has led to the development of a seven-year time series on Pacific sand lance in the San Juan Archipelago. Although Pacific sand lance are one of the most important forage species in Northern Hemisphere marine systems, many unanswered questions remain about their abundance, distribution, habitat, life history, population structure, diet, diel and seasonal behavior, availability to predators, and response to environmental conditions. Our research has led to several important insights. This presentation details diet composition, provides evidence of crepuscular behavior, and explores trends in diet and condition that respond to environmental conditions and season progression. Acoustic data suggests movements in relation to tides and currents and mark-recapture results and analysis of otoliths suggest movement between nearshore and offshore benthic habitats and the spatial structuring of the population according to life stage. Our field results demonstrate strong associations with sediment type, in correspondence with laboratory analyses. In partnership with collaborators at the Moss Landing Labs we map distribution for the species throughout the San Juan Channel. We also investigate the time series, providing evidence for cyclical dynamics and suggesting the importance of age-structure in the recruitment dynamics of this important forage fish species. The intent of this talk is to communicate results related to this research program, explore possibilities for collaboration, and determine how this ongoing program might address information needs and related to forage fish in the North Pacific.

FIS-P25

Quantifying and evaluating implications for trawlable and untrawlable habitat

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NOAA bottom trawl surveys provide crucial fishery-independent data on the relative abundance of stocks and life history parameters for a wide range of marine taxa. Survey data are used to assess species abundance and distribution, understand physical conditions and biological interactions, support retrospective analyses, and better inform ecosystem structure and manage marine resources. Despite the broad coverage and high utility of this data, not all bottom types or oceanographic conditions accommodate this survey method. Understanding what bathymetric features, substrate types, and physical conditions preclude successful trawls is important to efforts to determine potential biases in survey data and the relative accessibility of various habitat types and species to this survey method. Using National Ocean Service smooth sheets soundings and sediment observations, we evaluated physical attributes associated with habitat in the Gulf of Alaska that supports bottom trawl surveys and contrasted that with habitat designated untrawlable. Random forest methods were used to evaluate the relative influence of a suite of benthic terrain (e.g., depth, slope, rugosity, curvature, sediment) and oceanographic predictors (e.g., current, aspect). We examined the marginal importance of each physical predictor, quantified the response gradient, and applied a piecewise regression to determine threshold breakpoint values. On the basis of these thresholds and their interactions, predictive maps of trawlable habitat have been developed. This work also details the characteristics of trawlable and untrawlable habitat and the implications for the relative availability of particular habitat types and species to resource assessment surveys.

Section on Human Dimensions Contributed Poster Session

S-HD-P1

Linking traditional knowledge and ecological studies to improve understanding of paralytic shellfish poisoning and enhance sustainability of shellfish harvest in Southeast Alaska.

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Paralytic Shellfish Poisoning (PSP) is a persistent problem in Alaska that threatens human health and availability of shellfish resources. Shellfish are an important traditional food for many Alaskans, but regular outbreaks of PSP caused by the toxic marine alga, *Alexandrium sp.*, make recreational and subsistence harvest unsafe. Within the last 5 years, there have been 35 reported cases of PSP in Alaska, including 2 fatalities. This study aims to enhance sustainability of shellfish harvest in Southeast Alaska by examining natural and human dimensions of the PSP problem. We conducted interviews and mapping exercises with recreational and subsistence harvesters to document local and traditional knowledge (LTK) about how communities experience and respond to PSP and inform ecological research efforts. Timing and locations of safe and unsafe shellfish harvest have been passed on orally within communities through generations. Distinct spatial patterns of shellfish toxicity in the Icy Strait region of Southeast Alaska were revealed from interviews. Longtime (>30 years) harvesters did not report any noticeable changes in shellfish toxicity over time. This LTK was used to investigate benthic populations of *Alexandrium* cysts in an intensive regional-scale effort to identify potential sources of toxic blooms. The expansive coastline and routine shellfish harvest in rural communities impose significant challenges for biotoxin management and research in Alaska. Integration of LTK and ecological inquiry is one approach to overcome these challenges and can provide insight on long-term toxicity patterns, identify community adaptation strategies, and determine the social and ecological features that support sustainable shellfish harvest.

S-HD-P2

Implementation of ecosystem-based fisheries management in U.S. Fisheries

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Ecosystem-based fisheries management (EBFM) is a systematic approach to fisheries management that recognizes the combined physical, biological, economic and social interactions among the affected fishery-related components of the ecosystem, and specifically addresses how competing objectives and cumulative impacts should be used to optimize benefits across a diverse set of societal goals. For over twenty years, the U.S. National Marine Fisheries Service (NMFS) has made great strides in advancing the science behind EBFM and implementing management measures that align with the principles of EBFM. However, documentation of these successes has been lacking.

This poster will identify the extent to which NMFS and U.S. Regional Fishery Management Councils (Councils) have been implementing the principles of EBFM in its management efforts. This information is critical as NMFS moves forward with implementing EBFM and discussing EBFM issues with policy makers, scientists, managers and our stakeholders. This poster will feature case studies documenting the implementation of key guiding principles of EBFM within U.S. fisheries.

S-HD-P3

Ecological service value assessment and distribution of seaweed aquaculture in China using GIS

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According to the FAO statistics in 2013, large-scale seaweed aquaculture of China has become the most important part of the world, accounting almost 50% to seaweed aquaculture yield. In addition to its great economic value, seaweed aquaculture has huge value of ecosystem services. Seaweed is considered as the most promising biofilter, which can utilize carbon dioxide and release oxygen through the process of photosynthesis, improve PH and take advantage of the water-soluble inorganic nitrogen and phosphorus. Moreover, seaweed aquaculture can relocate plant production from land to the ocean, which avoids a suite of impacts and costs associated with agriculture such as loss of ecosystem services from transformation of ecosystems into crop and pasture land, consumption of freshwater and application of pesticides and fertilizers, which are rarely considered in the researches of seaweed ecological service value assessment. Considering the importance of ecological service of seaweed and the imperfection of current evaluation system of ecological service value of seaweed, what this study aims to do is as follows: Firstly, to establish more systematic evaluation model to evaluate ecosystem service value of seaweed in China, by which to analyze value changing of seaweed ecological service from 2000 to 2015. Secondly, to establish a model of regional spatial distribution in which statistical data and district correspond to each other by integrating GIS and Chinese fishery statistics yearbook. Thirdly, to conduct field investigations of several representative districts so as to verify the accuracy of the model which is mentioned above in the second aspect.

S-HD-P4

Valuing the loss of ecological benefits of wetland reclamation in Jiaozhou Bay based on choice experiments

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This paper aims to evaluate the loss of ecological benefits, caused by wetland reclamation, based on choice experiment method in Jiaozhou Bay. By reviewing literature and consulting experts, we divide the wetland restoration attributes into four parts: wetland area, vegetation cover rate, water quality and biodiversity in the wetland. By sampling 293 residents in Jiaozhou Bay at random, we also evaluate the willingness to pay about different wetland restoration attributes in Jiaozhou Bay: the willingness to pay is RMB 321.78 per year in order to restore each attribute to the baseline level. Then we can figure out that the loss of ecological benefits caused by wetland reclamation in Jiaozhou Bay is RMB 767 million per year. The result further shows that the change of wetland area is the first most important concern of local residents, while the improvement of water quality is the second most important concern. Therefore, the government should make a proper restoration policy in which enlarging the wetland area should be the key point.

Keywords: Jiaozhou Bay; Reclamation; Choice experiments; Willingness to pay; Loss of Ecological services

S-HD-P5

Alaska's sablefish fishery after Individual Fishing Quota program implementation-A bioeconomic analysis

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Alaska is the world's principal supplier of Sablefish Anoplopoma fimbria a buttery-flavored whitefish greatly prized in Japan. Sablefish are distributed from Baja California to western Japan but the majority of commercial catches are from the Gulf of Alaska and the Aleutian Islands off Alaska. Landings volume and value of this long-lived demersal fish are comparable to those of the better-known Pacific Halibut Hippoglossus stenolepis. Like Pacific Halibut, Alaska region catches of Sablefish are managed under an Individual Fishing Quota (IFQ) program implemented in 1995. We present a simultaneous equation market model for Sablefish and use the model to examine linkages between landings volume and exvessel prices and revenues including the sensitivity of Alaska exvessel price and revenue to changes in landings, to changes resulting from the implementation of IFQs and to changes in the Japanese economy. Model simulations indicate that markets could absorb substantially more Sablefish than can be sustainably harvested from the current stock of Alaska region Sablefish. However, sluggishness in the Japanese economy has resulted in overall downward pressure on Alaska region Sablefish exvessel prices. Model simulations indicate that IFQ implementation in this fishery significantly increased exvessel revenues, beyond what they would have increased, as a consequence of longer seasons that resulted from an end of the race-for-fish. In addition, we find that IFQ implementation has helped buffer the fishery against revenue losses associated with reduced catch limits triggered by the decline of Sablefish biomass in the Alaska region.

S-HD-P6

Evaluation of sustainability of fisheries products around Japan: Sustainable, Healthy and "*Umai*" Nippon seafood (SH"U"N) Project

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The SH"U"N project, launched by the Japan Fisheries Research and Education Agency (FRA), will deliver a comprehensive and peer-reviewed evaluation on the sustainability of the fisheries products around Japan. Based on the four science-based essential pillars for fisheries sustainability, i.e., stock dynamics, ecosystem, socio-economic influences, and governance performances, a transparent evaluation procedure was designed following the criteria of the United Nation's Food and Agriculture Organization's Code of Conduct and eco-labelling guidelines. The SH"U"N Project will provide comprehensive information on the sustainability of Japanese fisheries products, and serve as an outreach tool of FRA's research activities for the general public (consumers) and the stakeholders of Japanese fisheries (producers, processors, retailers, etc.).

MEQ Contributed Poster Session

MEQ-P1

Evaluation of organic matter and trace metal contamination in Korean coastal sediment using geochemical assessment techniques

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We measured grain size, organic matter (IL, COD, AVS), and trace metals (As, Cd, Cr, Cu, Fe, Hg, Mn, Pb and Zn) in surface sediment collected at 218 stations in 2014 to evaluate the organic matter and metal contamination in Korean coastal sediment. Surface sediments are composed of various sedimentary types from muddy gravel to clay. The southern coast consists mainly of finer sediments, whereas coarse sediments are dominated in the eastern coast and western coast. The concentrations of organic matter and trace metals in sediment were relatively higher in southeastern coast where many industrial complexes and large-scale fish and shellfish farms are concentrated, indicating that the metal concentrations in the sediment are influenced by anthropogenic inputs associated with human activities in the coastal zone. Even though there no significant anthropogenic sources, the high concentrations of As, Cd, Hg, and Pb were also observed in eastern coast. This may be related to coarser sediment (i.e. gravel and sand) with high natural metal concentrations and atmospheric deposition. According to the results of sediment quality guidelines (SQGs), enrichment factor (EF), and geoaccumulation index (I_{geo}), Korean coastal sediments were little polluted for Cd and moderately polluted for As. Based on the overall distribution of organic matter and trace metals and the results of pollution load index (PLI) and ecological risk index (ERI), the surface sediment in the southeastern coast were significantly polluted for organic matter and most of all metals and these high concentrations could have an adverse impact on the benthic organisms.

MEQ-P2

Rapid determination of organochlorine pesticides in fish using selective pressurized liquid extraction and gas chromatography–mass spectrometry

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A rapid automated extraction and cleanup method using selective pressurized liquid extraction was developed and validated for 14 organochlorine pesticides in fish. The lipid-removal efficiencies achieved by adding alumina, Florisil, acid-treated silica gel, and silica gel to the extraction cell were determined and optimized. In the optimized method, fish (2.3 g) was placed above alumina (30 g) in the extraction cell, then the sample was extracted using a 7:3 mixture of hexane and dichloromethane. The method was validated using certified reference materials (NIST SRM 1946 and 1974c), spiked fish, and four lipid-rich fish samples. The mean low- and high-concentration spike recoveries were 91% and 93% with RSD < 20%, respectively. Measured concentrations of target OCPs showed good agreement with the certified concentrations in certified reference materials. It suggests the good accuracy and precision of the SPLE method. The proposed method met the most important requirements of an extraction and cleanup procedure, including having a short preparation (cleanup and concentration) time and minimal sample contamination and being able to be automated.

MEQ-P3

Estimation of carrying capacity for oyster farming in Korea and its economic benefits

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Mean production quantity from coastal aquaculture system of Korea as a function of coastal length is over 500 kg/km/year which is the best in the world with China (FAO, 2009). The growth rate of mariculture organisms has been decreased in Korea due to an intensive aquaculture over the food quantities of organisms. And so, estimation of ecological carrying capacity is required in Korean mariculture system to make a sustainable development and an integrated management based on ecosystem.

We estimated an ecological carrying capacity of Geoje-Hansan Bay where intensive Pacific oyster (*Crassostrea gigas*) aquaculture is prevailing. Scenario analyses using an ecological model show that about 136 million dollars of additional economic benefits are obtained in 10 years if we reduce 25% of present oyster facilities in G-H Bay. To adopt this research results on the fields, we need to resolve conflicts among stakeholders and make policy decisions of management authority.

MEQ-P4

Sediment oxygen consumption rate and hydrogen sulfide release by dissolved oxygen depletion in hypoxic area of the Gamak Bay, Korea

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This study investigated sediment oxygen consumption rates and geochemical characteristics of sediment in hypoxic area of the Gamak Bay based on the chamber experiments and geochemical analyses. The organic carbon contents of surface sediment in the Gamak Bay showed that the inner bay area has higher organic carbon content than those of the outer bay. They toward the outer bay, contents dropped off. The vertical profiles of calcium carbonate (CaCO3) content at piston core sediment assumed that the hypoxia have been frequently occurred during past century in the northern inner bay. The benthic chamber experiments were conducted in February, May, August and November 2010, 2011 in the hypoxic area of the Gamak Bay. In the sediment incubation experiment with chamber at site C3 in the northern inner bay and site C17 in the southern outer bay, the sediment oxygen consumption rate ranged from 3.98 mmol m^{-2} d^{-1} to 12.43 mmol m^{-2} d^{-1} and 3.28 mmol m^{-2} d^{-1} to 8.18 mmol m^{-2} d^{-1}, respectively. When the oxygen was completely depleted, the toxic hydrogen sulfide was released with 1.38 mmol m^{-2} d^{-1} and 1.3 mmol m^{-2} d^{-1}, respectively.

MEQ-P5

Modeling pollution contribution rate for watershed management in Masan Bay

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TMDL (Total Management Daily Load) might be the best management practice for heavily coastal pollution, but sometimes need complement to improve water quality of specific area. An eco-hydrodynamic model was used to assess marine pollution contribution rate of land-based loading in Masan Bay, Korea. We conducted to water quality response analysis targeting COD and TP as actual contribution rate comparison. The model shows north regional streams impact on inner bay and SWTP (Sewage Waste treatment Plant) effect on entire in Masan Bay. However, the contribution rate of north streams on inner bay is COD 20 % and TP 62 %, respectively. SWTP on inner bay is COD 3% and TP 0.2%, respectively.

To improve water quality in the inner bay, it is necessary to reduce the nutrient pollution loading. Marine pollution contribution rate could help to improve pollution in specific area by assessing the contribution rate rather than quantitative terms.

Thus our research offers necessary scientific foundation to the priority of watershed management efforts in this area.

MEQ-P6

Estimate the contribution of submarine groundwater discharge to the biological productivity in coastal waters by the stable isotope signal recorded in the shell

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Submarine Groundwater Discharge (SGD) is often characterized by high concentration of nutrients and documented as an important pathway between land and sea contributing to the biological productivity in coastal waters. However, to our knowledge, no scientific information about the relationship between environmental conditions of SGD and the extent of biological productivity of the primary consumers is available. The carbon stable isotope composition of dissolved inorganic carbon ($\delta^{13}C_{DIC}$) is generally different between SGD (low $\delta^{13}C_{DIC}$) and sea water (high $\delta^{13}C_{DIC}$). Bivalves record chemical and biological environment-signal in their shell. In this study, to examine whether the $\delta^{13}C$ of bivalve shell ($\delta^{13}C_{SHELL}$) reflect the $\delta^{13}C_{DIC}$ of the ambient water or not, we conducted the rearing experiments of Manila clam *Ruditapes philippinarum* under laboratory and field conditions. Manila clam was reared at three different salinity regimes in the laboratory. There was a high positive correlation between $\delta^{13}C_{DIC}$ and salinity ($p<0.001$). Although the significant difference among different salinity was not found ($p>0.05$), the $\delta^{13}C_{SHELL}$ reared at low salinity was tend to be lower than that at high salinity. The field experiment was carried out at 6 sites under different SGD condition in Obama Bay, Japan from July to August 2013. There was a high negative linear relation between $\delta^{13}C_{SHELL}$ and Radon 222 (^{222}Rn) concentration of each rearing site ($p<0.01$) ,which is a useful tracer of SGD. In conclusion it seems that the $\delta^{13}C_{SHELL}$ shows some possibility of being proxy for environmental reconstitutions of submarine groundwater discharge.

MEQ-P7

The design of an integrated Sino-Vietnam marine and island environment information management system deployed in Beibu Gulf

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The Beibu Gulf is a transnational bay between China and Vietnam. It raises Sino-Vietnam marine coordination and management issues. To support the requirement of improving the understanding of its status on marine environment and ecology, enhancing the capacity on marine environment management, and providing information and technical support for marine environmental & ecological protection and pollution accident response in Beibu Gulf, an integrated Sino-Vietnam Marine and Island Environment information management System (BGMIES) is designed in this paper. The collected and processed satellite remote sensing data, drone image shoots, and other basic geographic information of Beibu Gulf, also the oilspill diffusion simulation and ecological risk assessment models would be involved to form the basic system data base and model base. The 2D and 3D GIS, and 360 degree panoramic display techniques are synthetically employed to form a perspective system user interface. On account of different business requirements, such as Marine Environment Risk Early Warning, and Marine Ecological Risk Assessment, BGMIES would be separated into different subsystems. While it is ultimately put into use, BGMIES would be extremely expected to provide comprehensive marine environment information to service the public, the nature reserve management departments and the government departments in the Beibu Gulf RIM area.

MEQ-P8

The Levels of Total Phosphorous, Total Nitrogen, in sediments from ST06 areas, South Sea, China

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The marine biogeochemistries of carbon, nitrogen and phosphorous have come under increased scrutiny because of their close involvement in climate change and coastal eutrophication. The present study aims to contribute to the knowledge of their status through investigating the level and distribution of TN, TP of the surface sediment samples from ST06 areas, South Sea, China. The analysis results show that the contents of TN and TP in the sediments were 0.74-12.48 and 0.071-0.45 mg/g, respectively, the average values were 6.05 and 0.29 mg/g, respectively. The distribution trend of Total nitrogen and total phosphorus presented obviously the same matter, namely, the concentrations from offshore samples were lower than that from nearshore samples. The highest value of total nitrogen appeared at the station ZD MJK 563,while the highest value of total phosphorus occurred at station ZD MJK 542. The sites are located in coastal area, suggesting the impact of human activities on the marine environment. TN:TP in the surface sediments are in the range of 6.02-31.7, the average is 20.7, which is significantly higher than that of Redfiled than 16:1. According to the C:N ratio, it could be deduced that nitrogen mainly came from terrigenous nitrogen, similarly, phosphorus mainly came from terrigenous phosphorus. In addition, the change trend of TN, TP and TN:TP in sediment was consistent with the change of nutrient content in water.

MONITOR Contributed Poster Session

MONITOR-P1

Distribution of the CDOM(Chromophoric Dissolved Organic Matter) in spring of 2012-2014 at southwestern East(Japan) Sea

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CDOM (Chromophoric Dissolved Organic Matter) is known to play a variety of roles in the ecosystem and biogeochemical cycles of the ocean as well as the climate change as a new CO2 source. The studies about CDOM in Korean coastal waters are scarce. We measured the concentration of CDOM at the southwestern East sea(Japan Sea) in spring in order to find distribution pattern of CDOM and controlling factor of CDOM dynamics. The average of absorption coefficients (a355) at the surface water in May 2012~2014 were 0.161 ± 0.042 m-1(range:0.067~0.265 m-1)(2012), 0.280 ± 0.098 m-1(range:0.071~0.445 m-1)(2013), 0.336 ± 0.087 m-1(range:0.198~0.523 m-1)(2014). The a355 in May 2014 was 109% higher than that in May 2012. The average of spectral slope (S300-500) at the surface water in May 2012~2014 were 20 ± 2 μm-1(range:17~23 μm-1), 16 ± 2 μm-1(range:13~21 μm-1), 14 ± 2 μm-1(range:10~17 μm-1). The S300-500 at surface water in May 2014 was 30% lower than that in May 2012, those values are general. The CDOM concentration tends to decrease toward offshore. Vertical distribution of CDOM showed typical features that decrease with increasing depth and show highest values at subsurface waters. The correlation among CDOM and other environment factors (temperature, salinity, Chl *a*) were examined to find the main controlling factors affecting on CDOM dynamics.

MONITOR-P2

How ocean observations work for you: A perspective from the U.S. IOOS Regional Association serving Southern California

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The regional observing systems work to collect, integrate and deliver coastal and ocean observations in order to improve safety, enhance the economy and protect the environment. The primary goal of the Southern California Coastal Ocean Observing System (SCCOOS) is to provide observations and products to a diverse stakeholder community of managers and planners, operational decision makers, scientists, and the general public. As the regional observing system for Southern California, SCCOOS has developed the capabilities to support short-term decision-making and long-term assessment by implementing and leveraging biological, chemical, and physical observations and models, many of which are available in near real-time.

The focus themes, as designated by IOOS, highlight these priorities and are designed to improve safety, enhance the economy and protect our environment.

- Marine Operations: Enhance products for safe and efficient marine commerce and transportation, search and rescue, homeland security and events such as oil spill response.
- Coastal Hazards: Improve coastal resiliency through accurate, geo-specific and validated flooding models and critical shoreline information with the long-term goal of improving coastal safety, reducing natural hazards and environmental change impacts and protecting coastal economics.
- Climate Variability and Change: Improve the understanding and track secular ocean change including sea level rise, ocean temperatures, and other climate trends in the Southern California Bight.
- Ecosystems, Fisheries and Water Quality: Provide physical, geochemical and biological monitoring, including harmful algal blooms (HABs) forecasts, fisheries management, and water quality pathogen and ocean acidification tracking to promote and sustain living marine resources.

POC Contributied Poster Sesssion

POC-P1

Sea ice detection for the Bohai Sea using MODIS data

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Bohai Sea is a seasonal ice covered semi-enclosed basin located in the northeast coast of China. Sea ice in the Bohai Sea creates serious threat to marine navigation, off-shore constructions and fishery industry. Monitoring of the Bohai sea ice is of great importance in preventing of sea ice disasters and better management and planning of offshore activities. Sea ice parameters retrieved from satellite remote sensing technology include sea ice extent, ice edge, concentration, and thickness classifications. MODIS' spatial resolution and wide spatial coverage enable it to be more available for representation for the distribution and thickness of ice, and more useful in sea ice detection and forecasting than other sensors. In this study, MODIS Level 1B data is used to supply the sea ice extent and thickness. Based on the spectral characteristics of sea ice and threshold segmentation method, sea ice extent is retrieved. Level ice thickness was calculated using MODIS ice surface temperature and an ice surface heat balance equation. The retrieved ice thickness agreed reasonable well with in situ observations from two off-shore oil platforms. The MODIS results under cold conditions (air temperature < -10ºC) also agreed with the estimated ice growth from Lebedev and Zubov models. Our method is feasible for the Bohai Sea operational ice thickness analyses during cold freezing seasons. These results are important information source for monitoring sea ice in the Bohai Sea and providing initial data for sea ice forecasting. It is also a good reference for verifying sea ice forecasting.

POC-P2

Ocean acidification on coast of the Korea

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The objective of this study is to analyze the status and impacts by regional coast (eastern, southern, western). Ocean acidification poses a significant threat to ocean-related ecosystem and communities reliant on marine fisheries, aquaculture, and coral reef. Korea coast fisheries based largely aquaculture of finfish (mainly rockfish and flatfish and seabream) and shellfish (mussels and oysters). As part of an effort to NIFS (National Institute of Fisheries Science) Serial Oceanographic observations (NSO), research is being conducted in eastern, southern, western coast of the Korea on April, August, October of 2015. In this study, the focus is on describing spatial patterns of aragonite saturation state ($\Omega_{AR} = [Ca^{2+}][CO_3^{2-}]/K_{SP\text{-}ARG}$). This parameter is an indicator of ecosystem health, in particular for calcifying organisms. Our results showed the lowest Ω_{AR}(2.5>) at western coast on spring and fall, High Ω_{AR}(4.5<) at southern coast on summer due to decreasing carbon dioxide by red tide blooms. These results are an initial step toward a fully integrated understanding of impact of ocean acidification and could be used to focus future research like empirical model.

POC-P3

Enhanced responses of sea surface temperature in offshore China to global warming and hiatus

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After an accelerated global warming in the second half of 20th century, the warming hiatus occurred since the late 1990s. The response of sea surface temperature (SST) in the offshore of China and its adjacent seas (hereafter referred to as offshore China) to global warming hiatus remains unclear. In the present study, we assessed and compared the SST trends, during accelerated warming period (1958-1998) and hiatus period (1998-2014), between offshore China and other ocean regions of interest as well as global mean surface temperature based on four SST datasets. The results revealed enhanced SST responses in offshore China to the global warming and hiatus. The change of SST in offshore China shows faster than the global mean rate during the accelerated global warming (hiatus) epochs before (after) 1998 with the rising (cooling) rate up to 0.6ºC (− 0.05ºC)/decade, which is 5 times faster than the global warming. Additionally, the interdecadal SST variability in offshore China is closely linked to the Pacific Decadal Oscillation (PDO), consistent with the positive (negative) phase of PDO. It is suggested that SST changes in offshore China may be greatly affected by the PDO through the impacts of East Asian Monsoon and Kuroshio Current on interdecadal timescales.

POC-P4

Cross-isobath exchange in Bering Canyon

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Shelf-basin exchange is widely recognized as having an important influence on the ecosystem of the eastern Bering Sea. Transport of nutrient-rich oceanic water across the shelf-break fuels primary productivity over the shelf. Transport of basin-origin zooplankton taxa is critical to the zooplankton prey base structure over the continental shelf, and the vulnerable young of several commercially important fish species require transport from spawning grounds over the slope to nursery habitats over the shelf for successful growth and survival. However, shelf-basin exchange in the Bering Sea is highly heterogeneous, with enhanced cross-shelf transport associated with submarine canyons. We combine *in situ* physical oceanography measurements and numerical simulations to examine shelf-basin exchange over Bering Canyon, the southernmost canyon along the eastern Bering Sea shelf-break, and compare results with observations of zooplankton and ichthyoplankton community structure and transport. Both observations and modeling results suggest more on-shelf flux of dense basin water during summer/fall than during winter/spring with implications for the flux of nutrients and biota onto the shelf. Our goal is to identify key processes that control cross-isobath flow, nutrient flux and larval transport, and how these processes vary episodically and seasonally.

POC-P5

The impact of monsoon winds and mesoscale eddies on the South China Sea western boundary current

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We deployed 5 pressure-recording inverted echo sounders (PIES) along a section in the northern South China Sea (NSCS), and estimated well the distributions of temperature, salinity and velocity across the section. Applying the empirical orthogonal function (EOF) method, we found that variability of the estimates is dominated by two modes: one named the seasonal mode affecting strongly on the hydrographic distribution with explained variability of temperature/salinity by 62.9/72.2 %; the other named the eddy mode, corresponding to the arrival of mesoscale eddies, affecting strongly on the circulation pattern with explained variability of velocity by 63.2 %. Temporal variation of the seasonal mode is highly correlated with the monsoon winds southeast of Vietnam, suggesting a nonlocal forcing mechanism. Case studies looking at the structures and evolutions of three captured eddies, whose impacts were well quantified by the eddy mode. The monsoon (eddies) significantly affects temperature, salinity and velocity shallower than 635 m (860 m), 160 m (150 m) and 1055 m (920 m), respectively. The monsoon (eddies) can induce maximum temperature, salinity and velocity anomalies up to -1.6─2.1 ºC (-2.5─2.2ºC), -0.11─0.14 psu (-0.13─0.27 psu) and -0.31─0.46 m/s (-0.40─0.38 m/s), respectively. Mean volume transport (VT) across the section is 1.0 Sv (positive to the northeast). Seasonal VT (with eddy impacts removed) is -4.6 Sv, 11.4 Sv, -5.1 Sv and -4.1 Sv for spring, summer, autumn and winter, respectively.

POC-P6

Comparison between two types of moored vertical profiler

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Moored vertical profiler is a device for collecting profiles of ocean data while its moving up and down. Two different types of profiler were deployed in the East/Japan Sea by KIOST in 2014-2015. The POPPS is composed of a moored subsurface winch system including battery packs and a profiling buoy installed with sensors. When the profiling buoy is released from the winch system to start measurements, it moves up to the surface freely by its own buoyancy and then the winch winds it back to the subsurface original position. It floats briefly at the sea surface to transmit the real-time profile measurements. The winch system consumes relatively large battery power, which limits its depth to ~300 m. The Aqualog is composed of a moored wire and a carrier which contains sensors, a glass buoy, battery packs, and an electric motor. The motor moves up and down the carrier that is pre-adjusted to have a neutral-buoyancy in the ocean, thus it consumes relatively small battery power. To make the moored wire as straight as possible, a relatively huge buoy (subsurface or surface) should be attached at the top of the wire. The carrier can dive up to 1000-m depth, but it typically misses the near surface layer shallower than ~5 m. In this study we present the observation results in the East/Japan Sea from the two types of moored vertical profiler and provide guidance for users in choosing an optimal moored profiling platform depending on their research objectives.

POC-P7

Mean sea level (MSL) trends around the Korea Peninsula with tide gauge and altimeter data

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This research was intended to investigate mean sea level (MSL) rise trend and characteristics in the Korea coast. For this study, we analyzed the tide gauge records for 40 years (1975~2014) from 18 tide stations of the Korea Hydrographic and Oceanographic Agency (KHOA), along with altimeter data by TOPEX/POSEIDON for 12 years (1993~2014) in the Korea coasts. The zonal rates of MSL rise using annual MSL data combined with tide gauges and altimeter data during same periods have been estimated. The ranges of MSL rise values obtained in the altimeter data set are comparable to those of the tide gauge. According to the time-series analysis results by tide gauge records, the average rates of MSL rise are 1.31 mm/yr in the west coast of Korea, 2.05 mm/yr in the south, 2.69 mm/yr in the east, and 4.56 mm/yr around Jeju area. Especially, it shows that rising rate of sea level in Jeju is comparatively rapid and seems to be caused by the complex results of the sea water temperature rise, port development, and land subsidence. Moreover, characteristics of sea level variation by climate change showed weak negative correlation between PDO index and mean sea level around the Korea coasts. Future studies will be required to understand the characteristics of MSL variations in Korea coasts using numerical model.

POC-P8

Regional characteristics of global warming: Linear projection for the timing of unprecedented climate

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Given an external forcing globally uniform, the corresponding climate change and impacts differ by region. Thus the detection of global warming signal against internal variability has been made on a regional scale as well as on a global average. The purpose of this study is to estimate a timing of unprecedented climate due to global warming and to analyze the regional differences therein. Unlike previous studies that used model output, we used an observational dataset to estimate a magnitude of internal variability and a future temperature change. We calculated a linear trend in surface temperature using a historical record since 1880 and a magnitude of internal variability as the largest displacement from the trend. A timing of unprecedented climate was defined as the first year when a predicted minimum temperature exceeds the recorded maximum and remains as such since then. Presumed that the linear trend and the maximum displacement will be maintained in the future, an unprecedented climate would come within 200 years over the Indian Ocean, parts of the Atlantic and high-latitude regions but after thousands of years over the eastern tropical Pacific and the middle-latitude North Pacific where an internal variability is large. As such, a timing of an unprecedented climate over the ocean is highly affected by large internal variability except for the high-latitude regions with a significant warming trend. Therefore, when planning a climate change mitigation and adaptation policy, we need to consider an internal variability as well as a warming rate.

POC-P9

Recent cooling trend in the Yellow and East China Seas and the associated North Pacific climate regime shift

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The Yellow and East China Seas (YECS) are widely believed to have experienced a robust, large-scale warming during the last few decades. After the warming reached its peak in the late 1990s, sea surface temperature (SST) reveals a basin-scale cooling trend in the YECS. To understand a mechanism of decadal transition in SST from a warming to a cooling trend, this study investigates its relationship with the large-scale climate changes around the YECS by using a cyclostationary basin mode from the satellite-based optimum interpolation SST for 1982–2014. The time series of the leading principal component varies coherently with the Pacific decadal oscillation index during the warming period before the late 1990s, however, its correlations decrease dramatically to an insignificant level after the late 1990s. This result indicates that a potential regime shift occurred in dynamical linkage between the YECS and North Pacific. During the cooling period after the late 1990s, the winter SST in the YECS is more closely associated with the variation of Siberian High (SH) along with an intensification of SH, suggesting that the intensified SH pressure system in recent decades plays an increasing role in determining states of the YECS compared to North Pacific oceanic processes. These observations highlight that the decadal variability in the YECS should be understood as a selective response from the oceanic processes in the North Pacific to atmospheric circulations in the continent across the North Pacific climate regime shift.

POC-P10

Long-term changes of South China Sea surface temperatures in winter and summer

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Utilizing available atmospheric and oceanographic reanalysis data sets, the long-term trend in South China Sea SCS) sea surface temperature (SST) between 1950 and 2008 and the governing processes are investigated. Both winter and summer SST increased by comparable amounts, but the warming patterns and the governing processes were different. Strong warming in winter occurred in a deep central area, and during summer in the southern region. In winter the net heat flux into the sea increased, contributing to the warming. The spatial pattern of the heat flux, however, was different from that of the warming. Heat flux increased over the coastal area where warming was weaker, but decreased over the deeper area where warming was stronger. The northeasterly monsoon wind weakened lowering the shoreward Ekman transport and the sea surface height gradient. The cyclonic gyre which transports cold northern water to the south weakened, thereby warming the ocean. In summer however, the net surface heat flux decreased and could not contribute to the warming. Over the southern part of the SCS, the weakening of the southwesterly summer monsoon reduced southeastward Ekman transport, which is parallel to the mean SST gradient. Southeastward cold advection due to Ekman transport was reduced, thereby warming the surface near the southeastern boundary of the SCS. Upwelling southeast of Vietnam was also weakened, raising the SST east of Vietnam contributing to the southern summer warming secondarily.

POC-P11

Ferry based monitoring in the NEAR-GOOS Area

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The Ferry based monitoring is an automated system for measuring of physical and bio-geochemical parameters in surface waters. It is mounted on 'ships of opportunity', such as ferries or container ships, on their regular routes across the Sea or on shore-based installations. Water is pumped from a subsurface inlet into the measuring circuit of multiple sensors. Data are transmitted and made available after each transect via the Internet.

An instrumented ferry made two transects per day across two current systems which are the northward East Korean Warm Current (EKWC) and southward North Korean Cold Current (NKCC) since August 2012 from Gangneung to Ulleungdo and Dokdo in the southwestern boundary area of the East Sea. Another route from Incheon to Bakryeongdo in the middle eastern boundary area of the Yellow Sea also made transects since February 2016. Sea surface water properties of these transects were measured with high spatial and temporal resolution for an extended period of time.

In near future, we have plan to establish 4 monitoring ferry routes such as Jeju Strait, Korea Strait, Donghae(Korea)-Vladivostok(Russia) and Donghae-Sakaiminato(Japan). The principal goal of this ferry based monitoring is the construction of a long-term observatory within the NEAR-GOOS area.

POC-P12

Nuclear bombs and coral: Guam coral core reveals operation-specific radiocarbon signals from the Pacific Proving Grounds

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To perform fish age validation studies in the western Central Pacific, radiocarbon (^{14}C) analyses were performed on a coral core from Guam to provide a regional chronological reference. Analyses on this coral core revealed anomalous peaks in the early bomb ^{14}C record. The typical marine bomb ^{14}C signal, one that is phase lagged and attenuated relative to atmospheric bomb ^{14}C, is present in the coral core and is consistent with other North Pacific records. However, ^{14}C levels that are well above what can be explained by air-sea diffusion alone punctuate this pattern. This anomaly has been demonstrated to a limited extent in other coral cores of the Indo-Pacific region, but is unmatched in magnitude and temporal resolution in the Guam coral core. In most cases, the early $\Delta^{14}C$ peaks were small and hypothesized to have originated from the thermonuclear test series "Operation Castle" in 1954, but the Guam coral $\Delta^{14}C$ record provided three strong pulses in 1954-55, 1956-57, and 1958-59. Each of these peaks was directly linked to close-in fallout from thermonuclear testing in the Pacific Proving Grounds at Bikini and Enewetak atolls of the Marshall Islands. The measurable lag in reaching Guam was tied to ocean surface currents and was traced to other locations with current modeling as distant as Okinawa, Palmyra, and the Indian Ocean.

POSTERS-OBSERVING ORGANIZATIONS

Argo

Argo in 2016: sustaining core Argo and implementing recommended enhancements

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Currently, over 3900 Argo floats are deployed in the world ocean. The original global Argo array was limited by technical reasons in the seasonal sea-ice zones and in marginal seas. Thanks to both two-way communication and ice-sensing algorithms, these technical limitations are largely mitigated. The concept of Argo is of a spatially complete global array, therefore, including seasonal sea-ice zones and marginal seas moves the target number of Argo floats from 3000 to 3800. Despite more active floats than this new target, there remain some areas of the ocean that are sparsely populated and need to be filled with additional floats, while others are over-populated. At present, sampling of the high latitude Southern Ocean is progressing, and in some areas, such as the Kuroshio region and the Mediterranean Sea, Argo is fully operational.

In addition to the globalization of Argo, the additional enhancements include Deep Argo, Biogeochemical Argo (BGC Argo), and increased density of sampling in western boundary current regions and in equatorial regions. For each of these, one or more regional pilot arrays is already in place and others are pending. The process for reviewing these pilots and obtaining approval as enhancements to Argo should parallel that of the original Argo and should include consideration by the OOPC, GODAE Ocean View, and the CLIVAR Global Synthesis and Observations Panel (GSOP). This timetable leaves several years to study the outcomes of the pilot deployments which will lead to OceanObs'19.

CLIVAR

Coordinated international activities on the climate study of ocean-atmosphere interactions

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CLIVAR and PICES have developed a stronger partnership in the last few years. Historically CLIVAR, as one of the World Climate Research Programme's (WCRP) core projects, has worked towards the coordination of regional and global scientific projects directed at increased understanding and prediction of the physical processes that control the ocean's role in atmospheric climate. These studies include timescales from subseasonal to centennial. The current collaboration with PICES is focused on climate impact on ecosystems in the North Pacific, and future activities are being co-designed through a PICES "Study Group on Climate and Ecosystem Predictability" which has active participation from members of the CLIVAR community. Many scientific challenges still remain and the setup of CLIVAR's Research Foci (RF) will address some of those, with activities organised for the next 3-5 years. Of particular interest to PICES would be the Decadal Climate Variability and Predictability (DCVP) RF, the Eastern Boundary Upwelling Systems (EBUS) RF, ENSO in a changing climate RF, and the Regional Sea Level Change and Coastal Impacts RF (also a WCRP Grand Challenge). These topics are cross-cutting, and will draw expertise form several CLIVAR panels. CLIVAR is also developing its new Science and Implementation Plan, that will guide and focus the developments of climate research for the next 5-10 years.

More detailed information can be found on CLIVAR's website

(http://www.clivar.org/science/clivar-research-foci)

IAMSLIC

International Association of Aquatic and Marine Science Libraries and Information Centers (IAMSLIC)

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The International Association of Aquatic and Marine Science Libraries and Information Centers (IAMSLIC) is an association of individuals and organizations interested in library and information science, especially as these are applied to the recording, retrieval and dissemination of knowledge and information in all aspects of aquatic and marine sciences and their allied disciplines. The association provides a forum for exchange and exploration of ideas and issues of mutual concern. Is your librarian a member of IAMSLIC?

IATTC

The IATTC's research program on the reproductive biology and early life history of tunas in the eastern Pacific Ocean

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Since 1986, the Inter-American Tropical Tuna Commission (IATTC) has conducted research on the reproductive biology and early life history of tunas at the Achotines Laboratory, located on the Pacific coast of the Republic of Panama. From 1986 to 1996, research was focused on the larval ecology and rearing of coastal scombrids. Beginning in 1996, a broodstock of yellowfin tuna was developed in landbased tanks at the Achotines Laboratory, and multiple generations of these broodstock have been spawning nearly daily for 20 years. Yellowfin larvae hatched from eggs spawned at the Achotines Laboratory are routinely used in a variety of laboratory experiments designed to investigate the effects of key environmental and biological factors on pre-recruit survival. Successful rearing methods have also been developed for juvenile yellowfin, with juveniles reared in captivity up to 158 days after hatch. In this poster presentation, experimental results from major topics of yellowfin larval research will be summarized. These include studies of larval growth variability, effects of wind-induced microturbulence on larval survival, the effects of ocean acidification on larval survival, and comparative studies of the early life history of yellowfin and Pacific bluefin conducted in Panama and Japan.

IMBER

The Integrated Marine Biogeochemistry and Ecosystem Research (IMBER) project

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The aim of the Integrated Marine Biogeochemistry and Ecosystem Research (IMBER) project has been to develop a comprehensive understanding of, and thus an accurate predictive capacity of, ocean responses to accelerating global change and the consequent effects on the Earth system and human society. Understanding the changing ecology and biogeochemistry of marine ecosystems and their sensitivity and resilience to multiple drivers, pressures and stressors is critical to developing responses that will help reduce the vulnerability of marine-dependent human communities. Now, after ten years of successful interdisciplinary research, the IMBER community has developed a new science plan and implementation strategy to guide the next decade of IMBER research. The intent is to provide evidence-based knowledge and guidance for policy decision makers, managers and marine related communities in order to secure or transition towards sustainability of the marine realm under global change.

This presentation provides a synthesis of IMBER scientific achievements and plans for future activities which focus on understanding and quantifying marine ecosystem functioning, developing scenarios, projections and predictions of future states of marine and human systems at multiple scales, and thus fostering successful and sustainable ocean governance.

NANOOS

NANOOS: Northwest Association of Networked Ocean Observing Systems

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The Northwest Association of Networked Ocean Observing Systems, NANOOS, is the Pacific Northwest Regional Association of the U.S. Integrated Ocean Observing System (IOOS). Now over 10 years old, NANOOS (www.nanoos.org) has developed substantially thanks to its diverse scientific partnerships and stakeholder-driven focus. Established by charter in 2003, NANOOS has engaged representatives from diverse sectors who are directly involved in the definition and execution of NANOOS within the region. Partners contribute to and help define our subsystems: observations, modeling and forecasts, data management and user products, outreach and engagement, and education. Focus areas include: 1) Climate: NANOOS provides climatology and anomaly products from regional buoy, satellite time series, and shoreline change statistics to improve understanding of climate variation and change. 2) Ecosystem Assessment: NANOOS also provides time-series and real-time observations and data products used to evaluate, and in some cases forecast, HABs, hypoxia, ocean acidification, and water quality. 3) Fisheries and Biodiversity: NANOOS's forecasts and data on the bio-physical environment permit better-informed management decisions by fishers (from tuna fishers to shellfish growers) and regional managers. 4) Maritime operations: NANOOS provides water, wave and weather observations and forecasts to ship and boat operators for safe operations and planning. 5) Ocean Literacy: NANOOS provides learning tools, real-time data lesson plans and other education materials to formal and informal educators to increase ocean literacy. The NANOOS Visualization System, NVS (http://nvs.nanoos.org/), is the portal to this bounty of coastal ocean information.

NPAFC

International Year of the Salmon: From idea to launch

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The North Pacific Anadromous Fish Commission (NPAFC) has joined forces with the Atlantic Salmon Conservation Organization (NASCO) to lead a new initiative—International Year of the Salmon (IYS). The IYS is conceived to raise awareness of what humans can do to better ensure salmon and their varied habitats are conserved and restored against the backdrop of increasing environmental variability, and thus the overall theme is '*Salmon and people in a changing world*'. The target IYS year is 2019, with some activities that will start before and continue afterwards. IYS will stimulate an investment in research and leave a legacy of knowledge, data/information systems, tools, and a new generation of scientists better equipped to provide timely advice to inform rational management of salmon. The first of several IYS scientific activities will be a symposium in the latter half of 2018 dedicated to a hemispheric-wide review of salmon stock status and an appraisal of what knowledge is needed to better protect and manage salmon in the future. A partnership exists between PICES and NPAFC through the Framework for Enhanced Scientific Cooperation in the North Pacific Ocean, and PICES has actively participated in scoping the potential of the IYS initiative. As a next step, NPAFC is hopeful that PICES will join with other partnering organizations and be a dynamic contributor to IYS planning, research, and outreach activities.

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