Biophysical gauntlet regulating young walleye pollock survival in the Gulf of Alaska and other study cases:

Emphasis on meso and submesoscale eddies

Carolina Parada
Department of Geophysics, University of Concepcion-UDEC

Outline

Biophysical gaunlet regulating young walleye pollock survival in GOA

- Models at different resolutions
- Connectivity patterns
- Exploration of physical indices
- Summary

Expanding the conceptual model of Jack Mackerel in the South Pacific

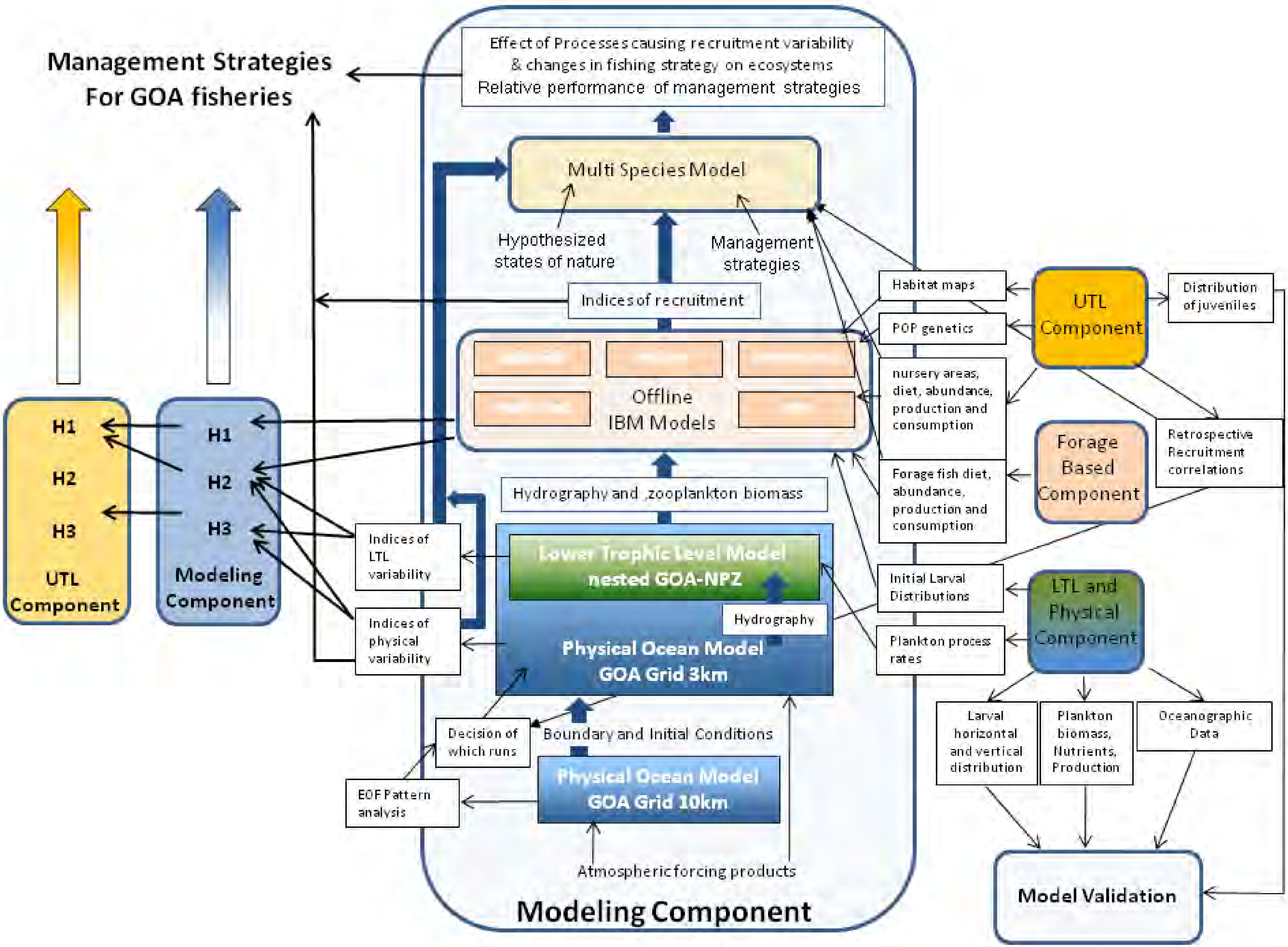
- Model experiments
- Logbook data from Russian cruises
- Stationary eddies in seamount region
- Summary

Gaps, Challenges for the future

Biophysical gauntlet regulating young walleye pollock survival

Carolina Parada, Albert Hermann, Sarah Hinckley, Carol Ladd,
Ken Coyle, Georgina Gibson, William Stockhausen

GOAIERP: Modeling component



GOAIERP Hypotheses

The Gauntlet

The primary determinant of year-class strength for marine groundfishes in the GOA is early life survival.

This is regulated in space and time by climate-driven variability in a biophysical gauntlet comprising offshore and nearshore habitat quality, larval and juvenile transport, and settlement into suitable demersal habitat.

Regional Comparisons

The physical and biological mechanisms that determine annual survival of juvenile walleye pollock and forage fishes differ in the eastern and western GOA regions.

Interactions

Interactions among species (including predation and competition) are influenced by the abundance and distribution of individual species and by their habitat requirements, which vary with life stage and season.

Questions associated to the early life history of walleye pollock

How conditions experienced along the trajectories will impact young fish growth, survival and mortality?

Are any strong connectivity pattern (spawning-nursery relationships) associated to the GOA?

What is the role of Eddies (different scale) in relation to transport and connectivity in the GOA?

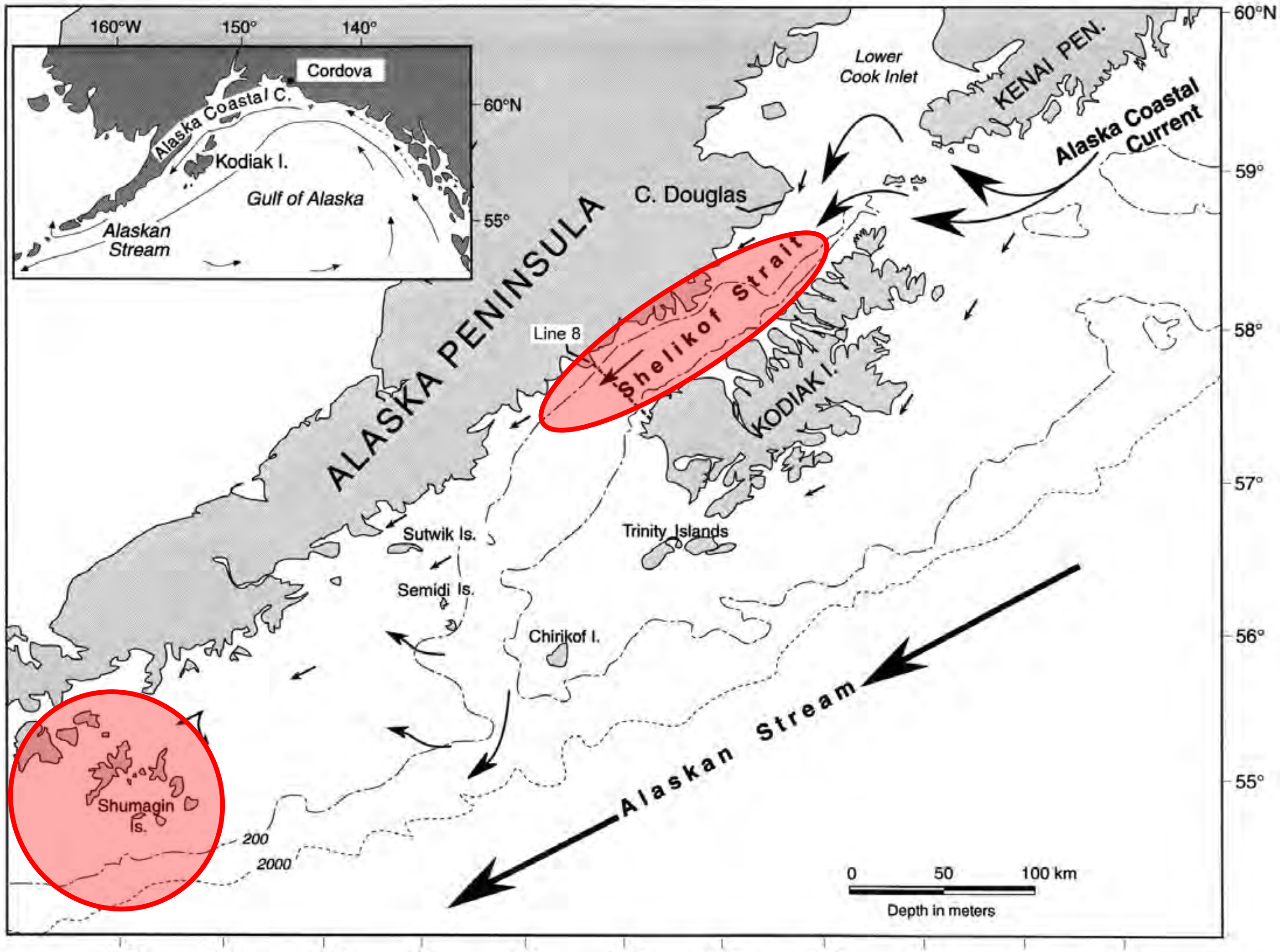
Are these features realistic in the model?

Are there any connectivity between GOA and BS?

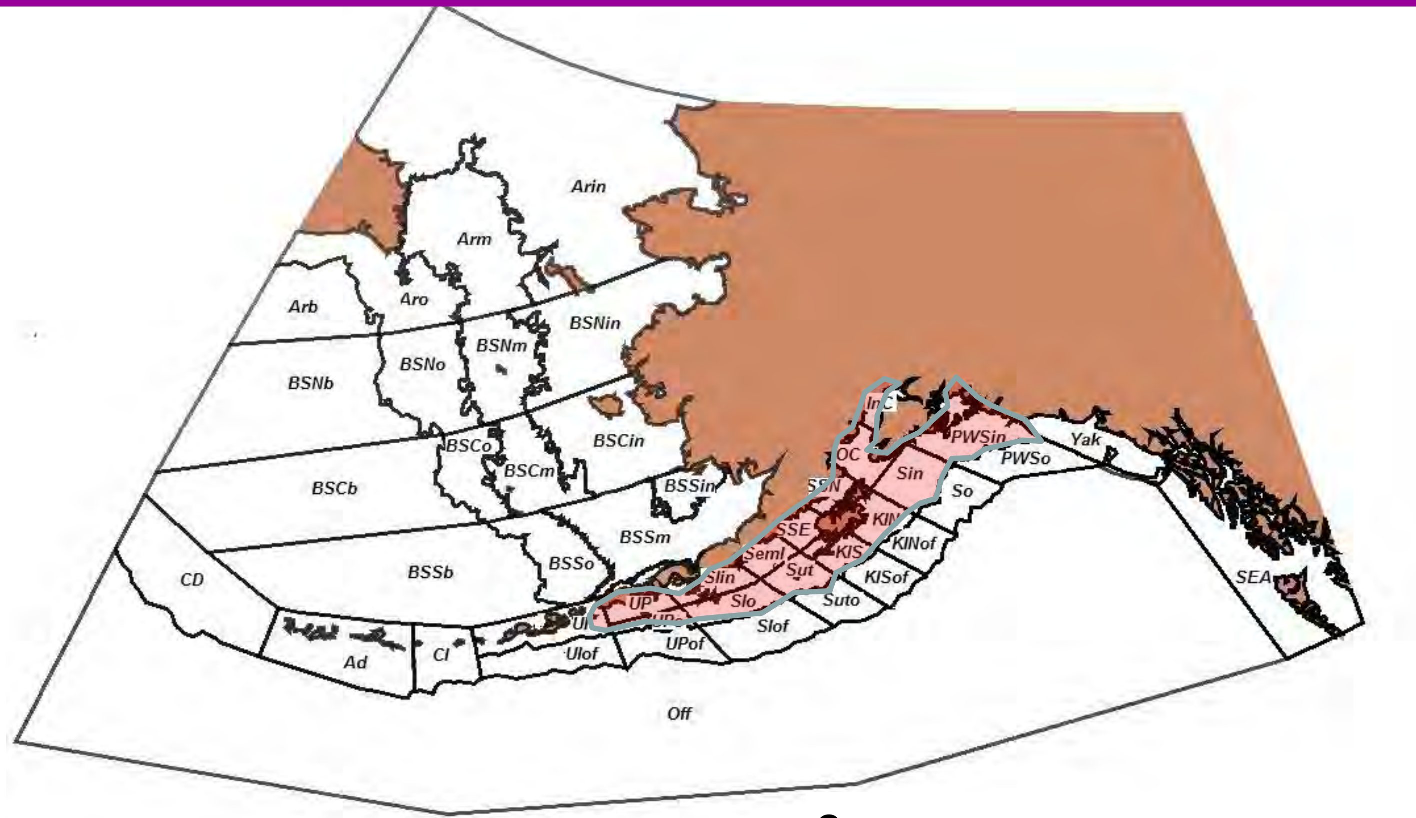
How to assess the role of predation?

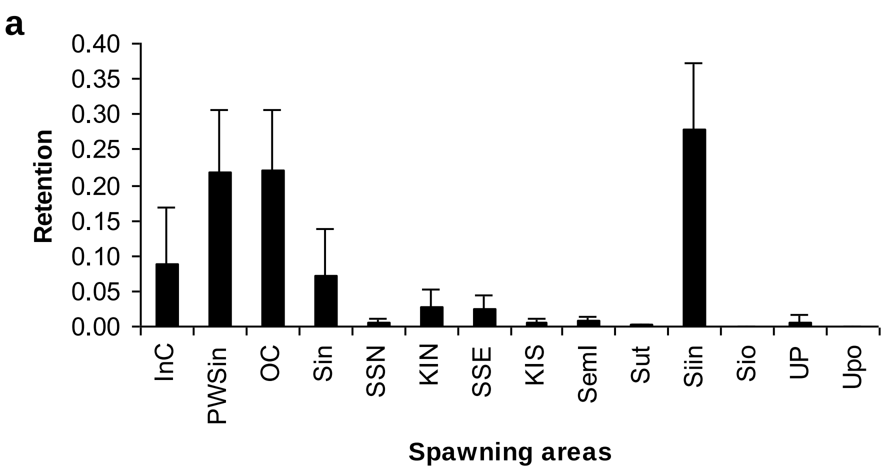
Connectivity in GOA and Low resolution model

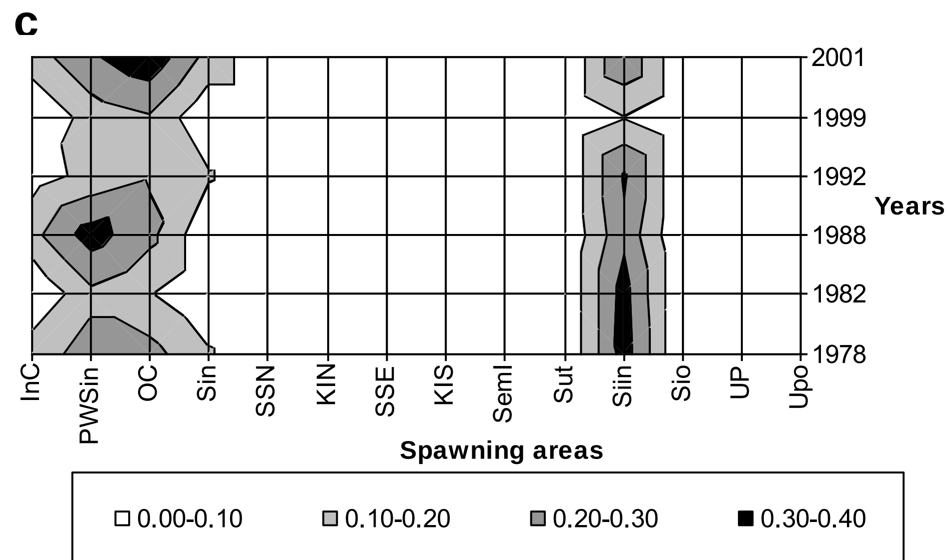
Spawning-nursery area in GOA



Retention in GOA: low resolution model







Connection to BS and potential nursery grounds

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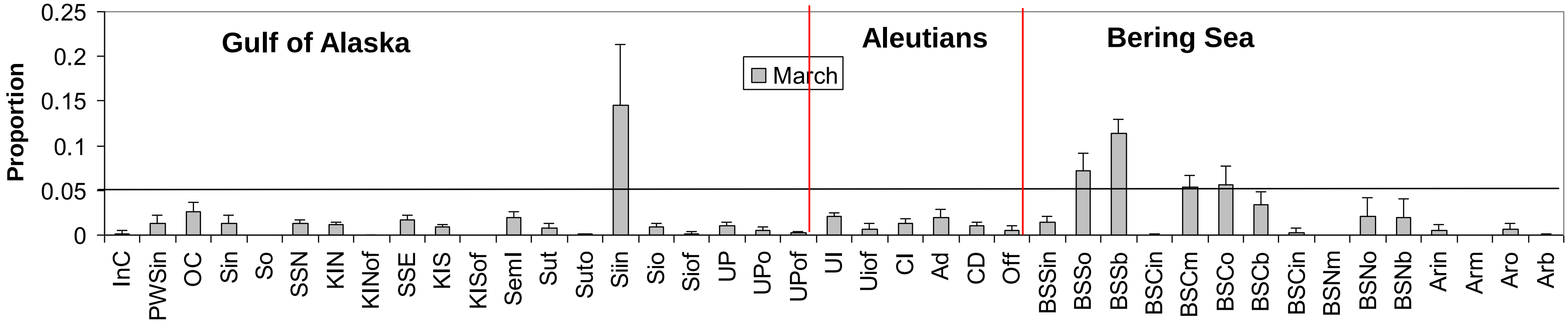

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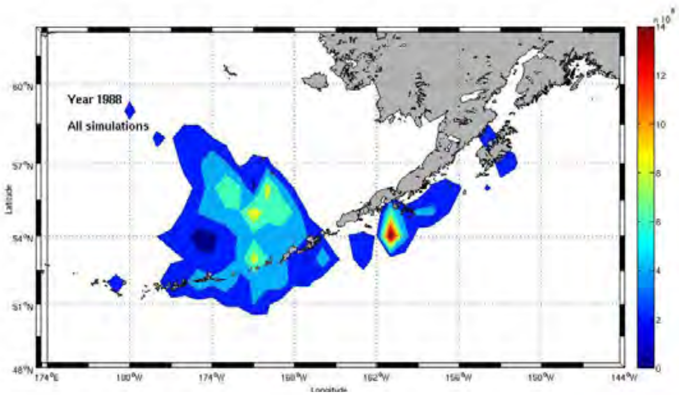
Proportion



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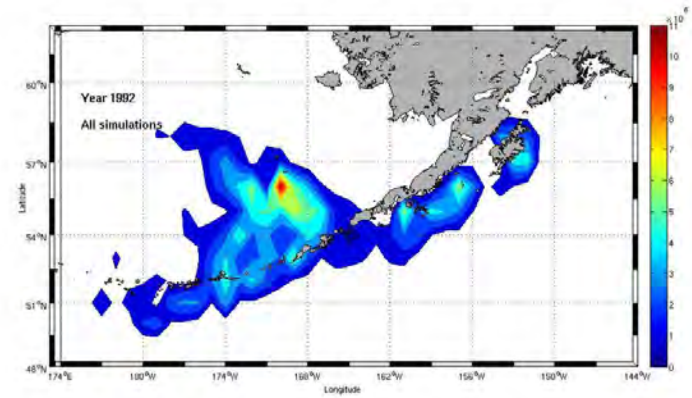

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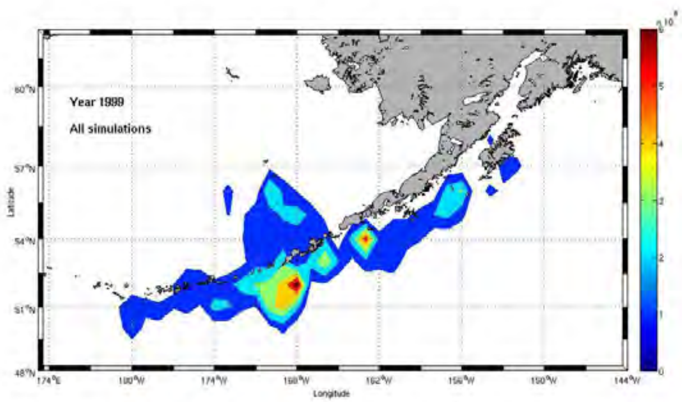

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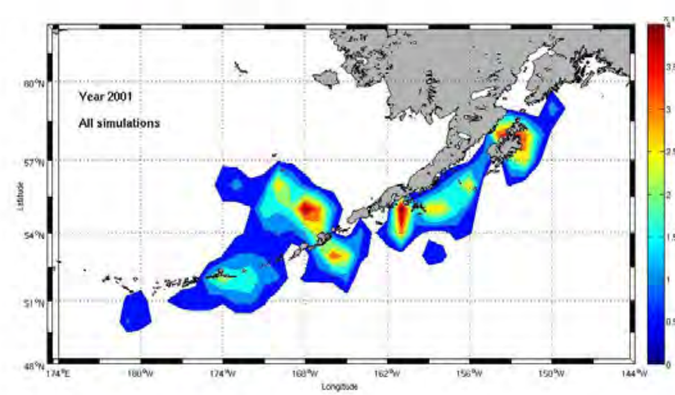
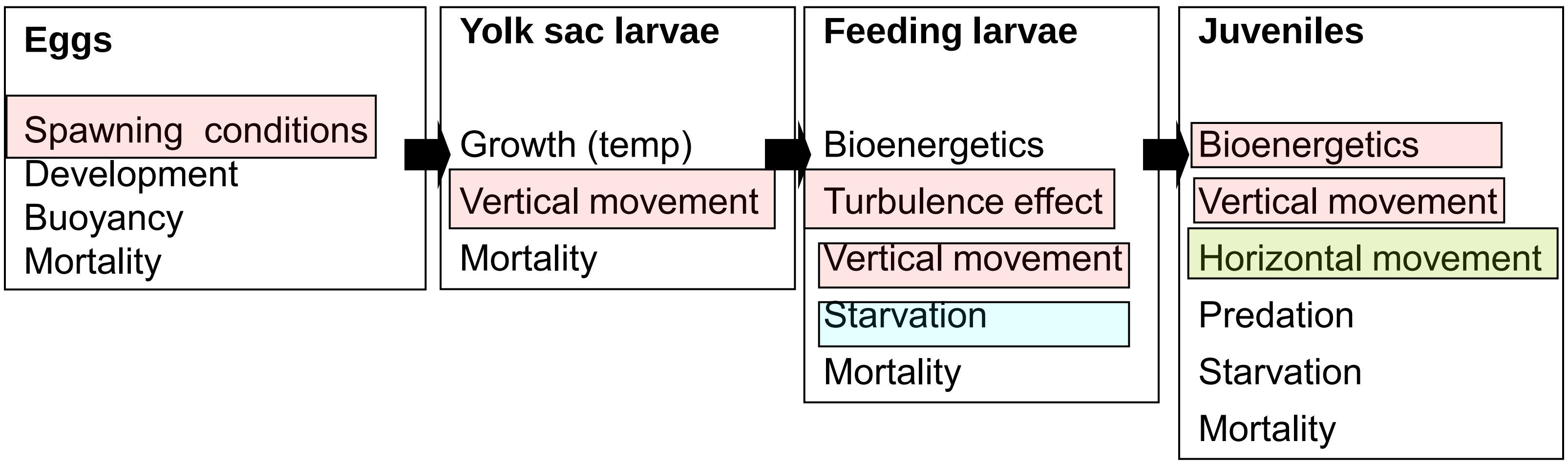
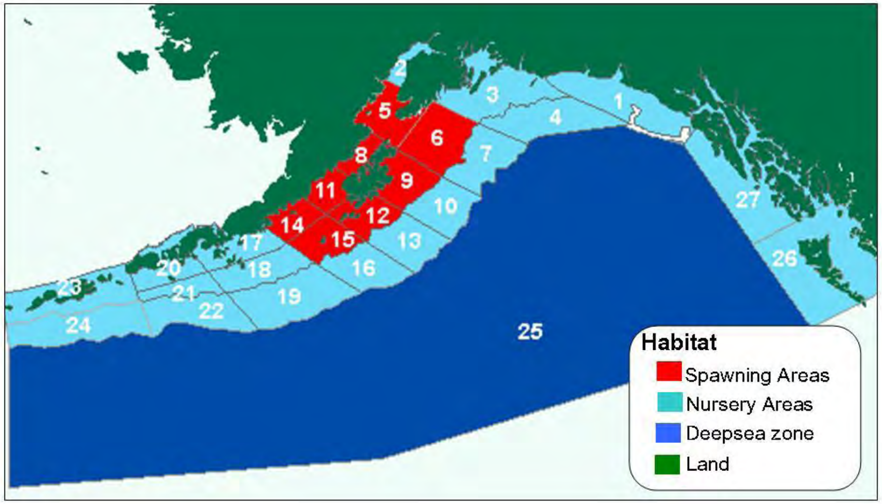


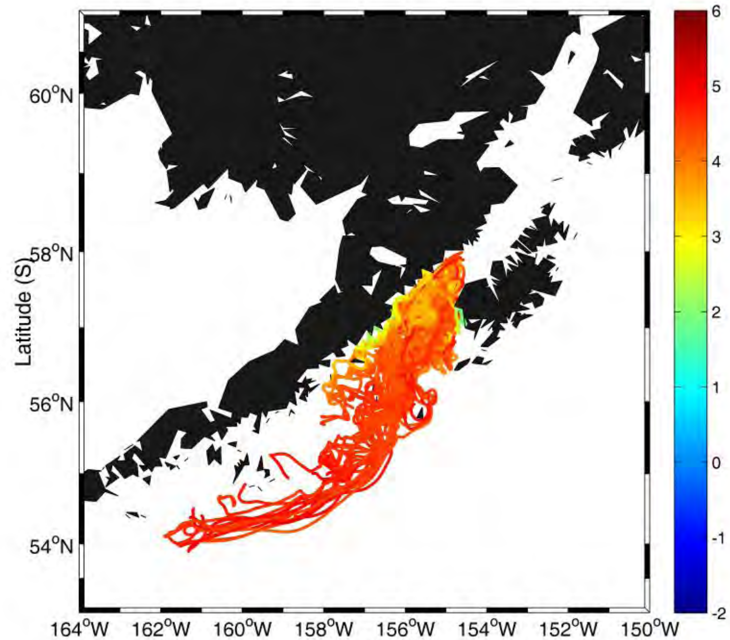
Transport and connectivity within the GOA: high resolution model

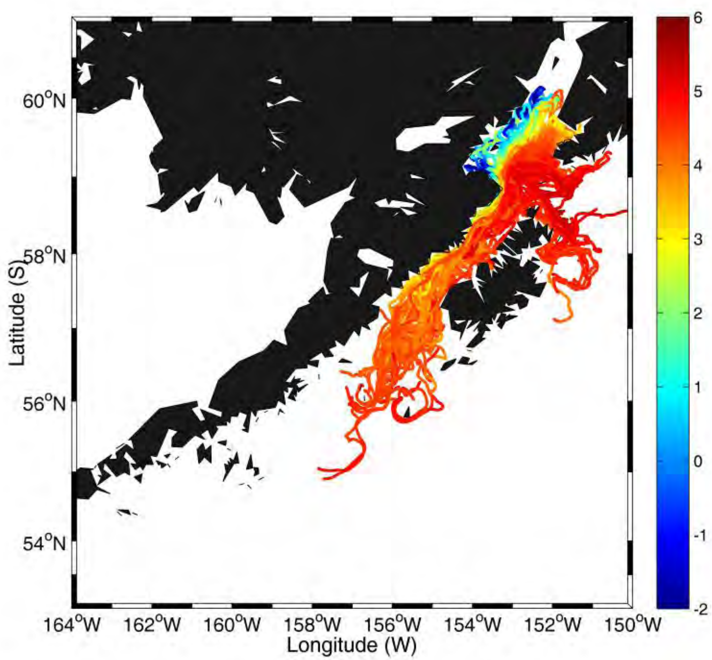
Walleye pollock IBM compartments

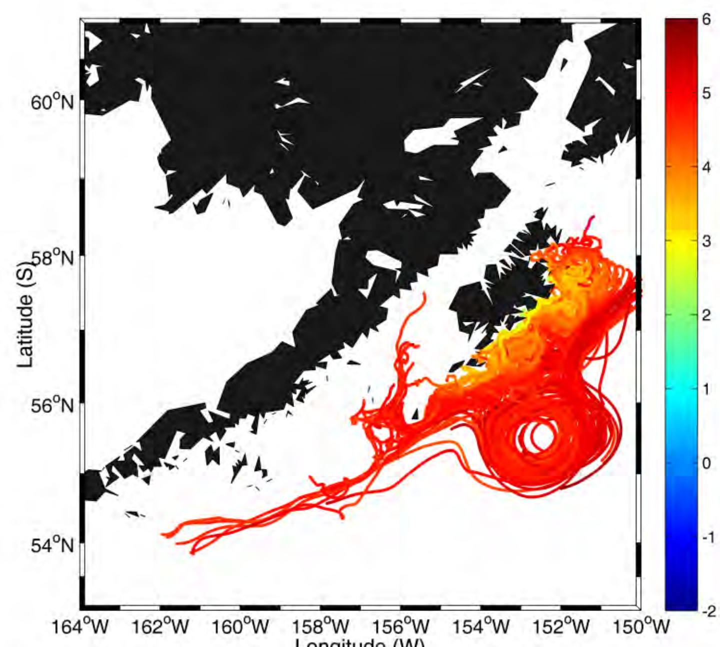


Transport and Connectivity

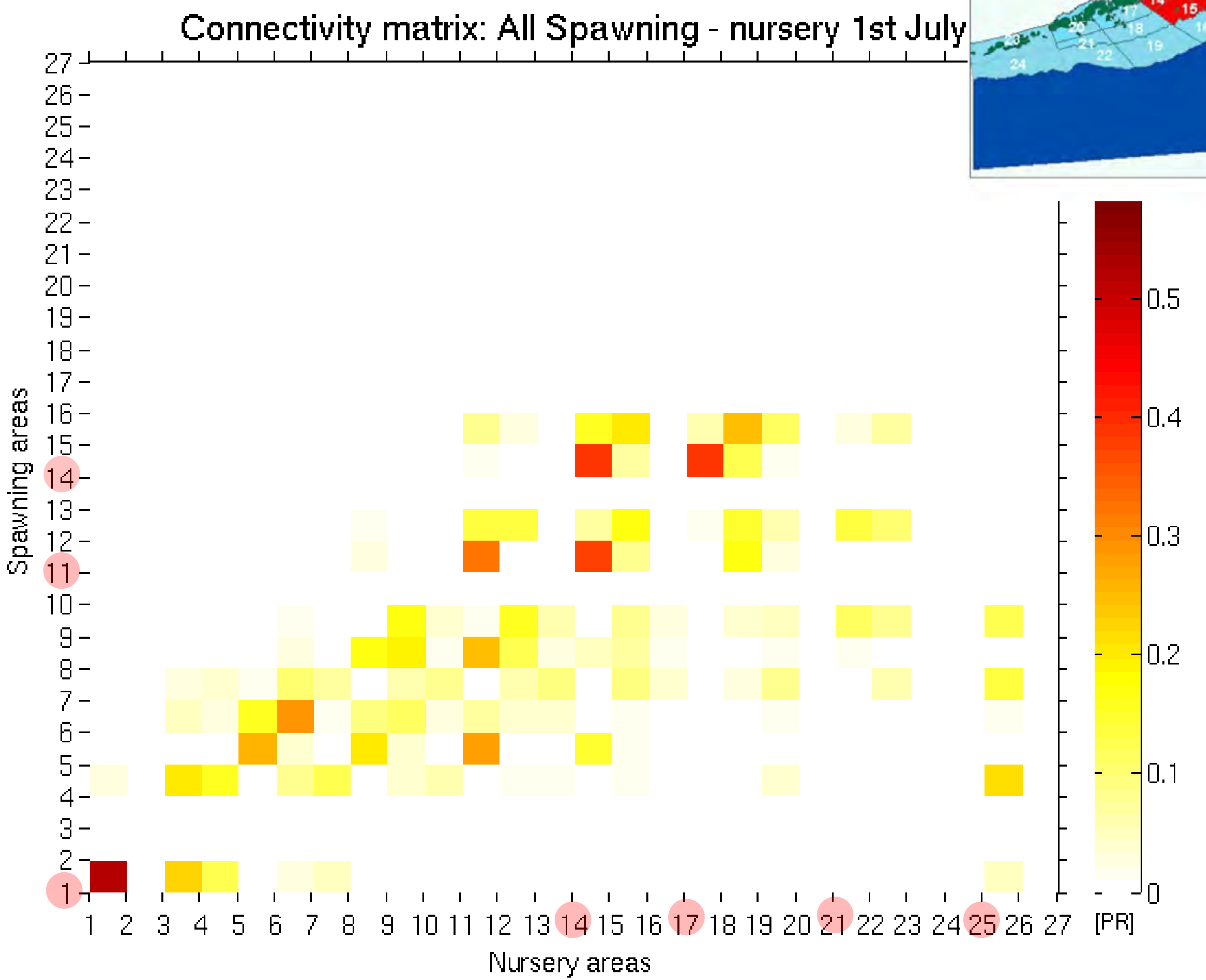


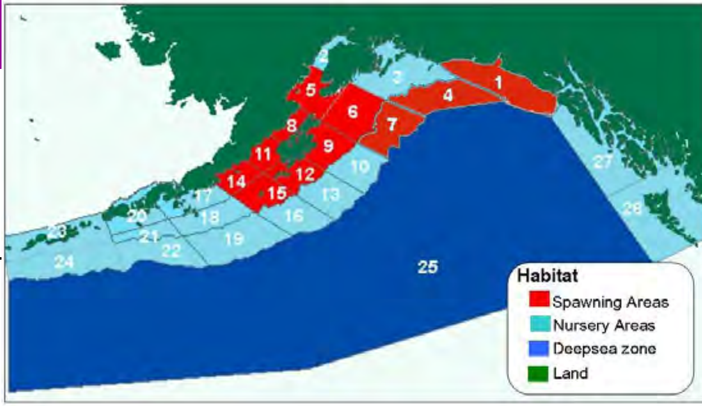




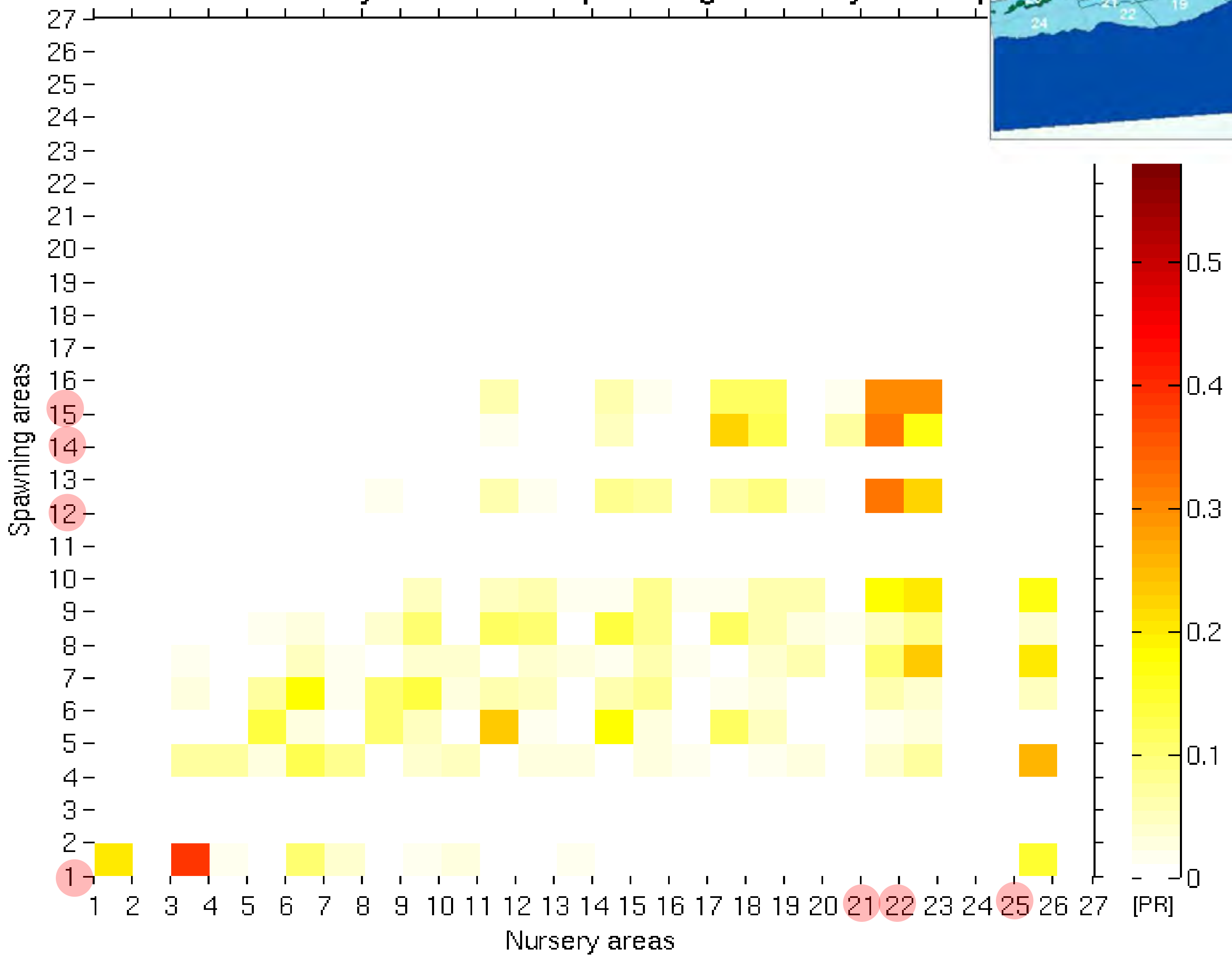


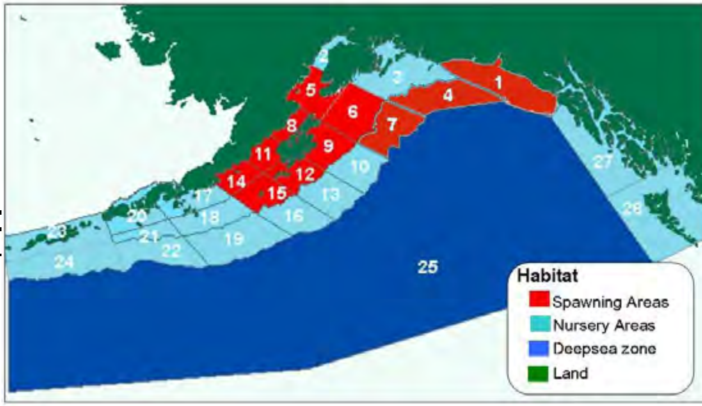
Transport and Connectivity



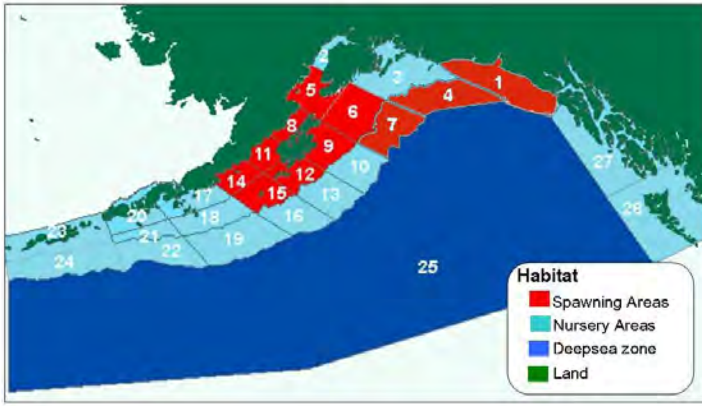


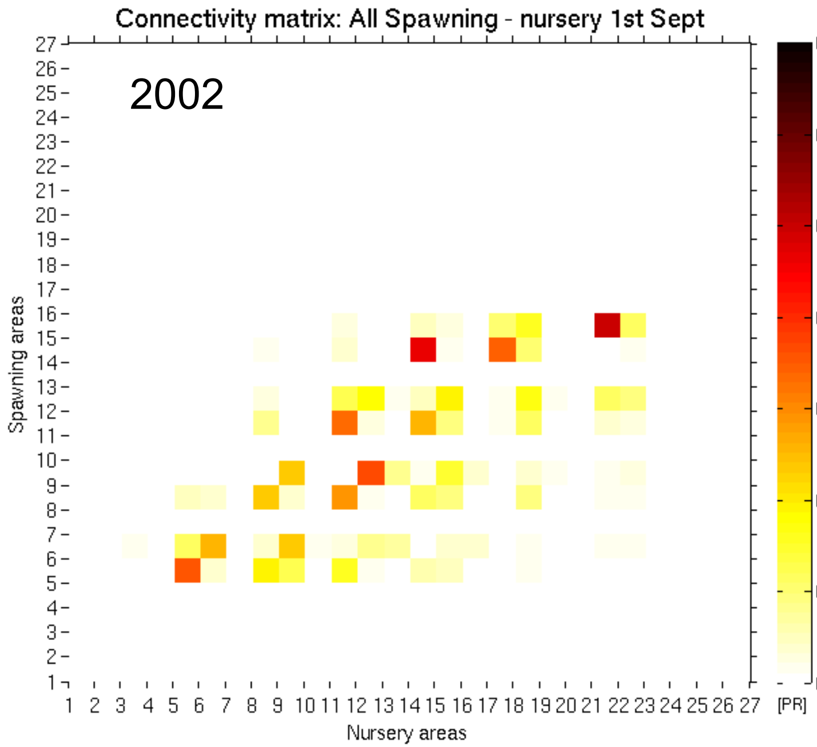
Connectivity matrix: All Spawning - nursery 1st Sep

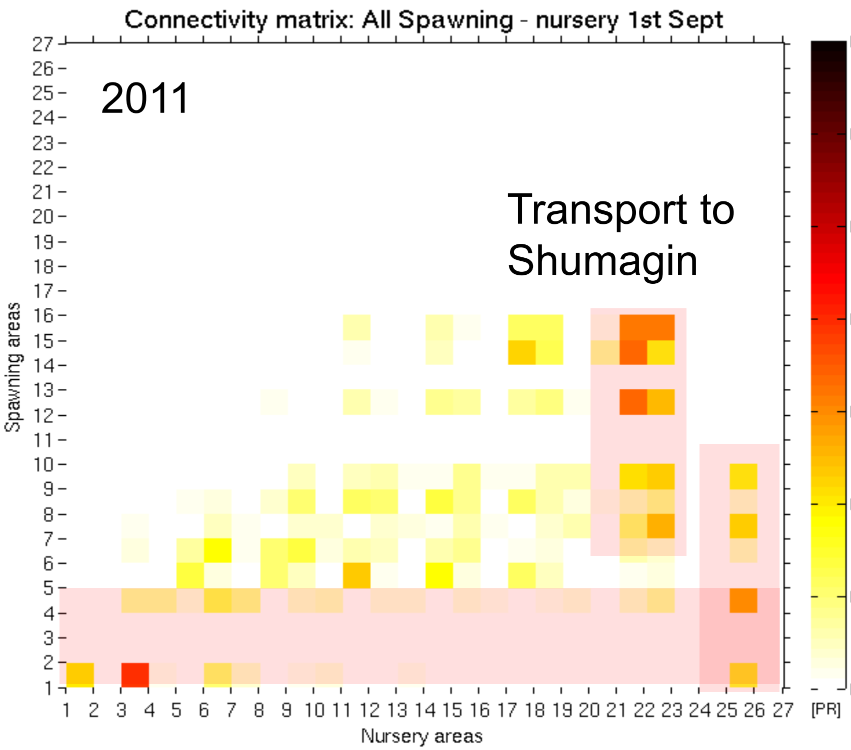




Comparison 2002 - 2011





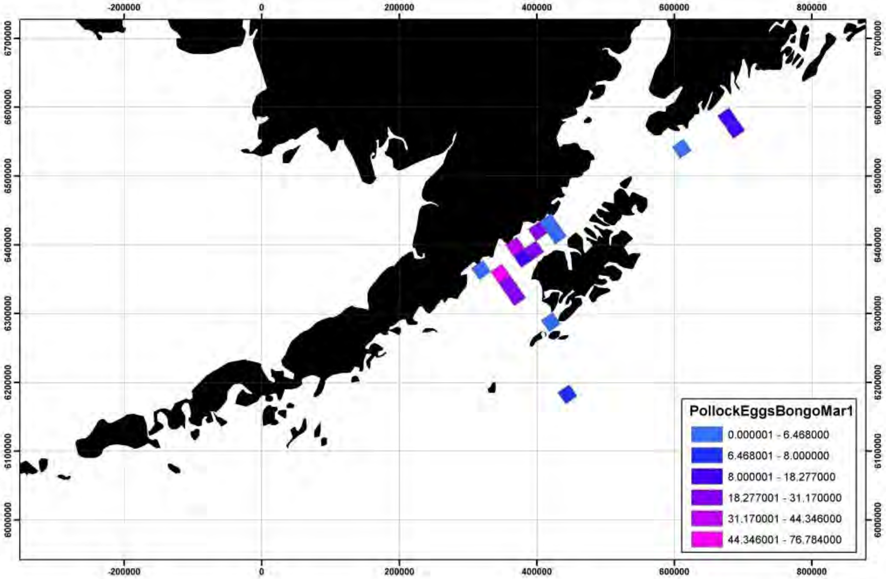


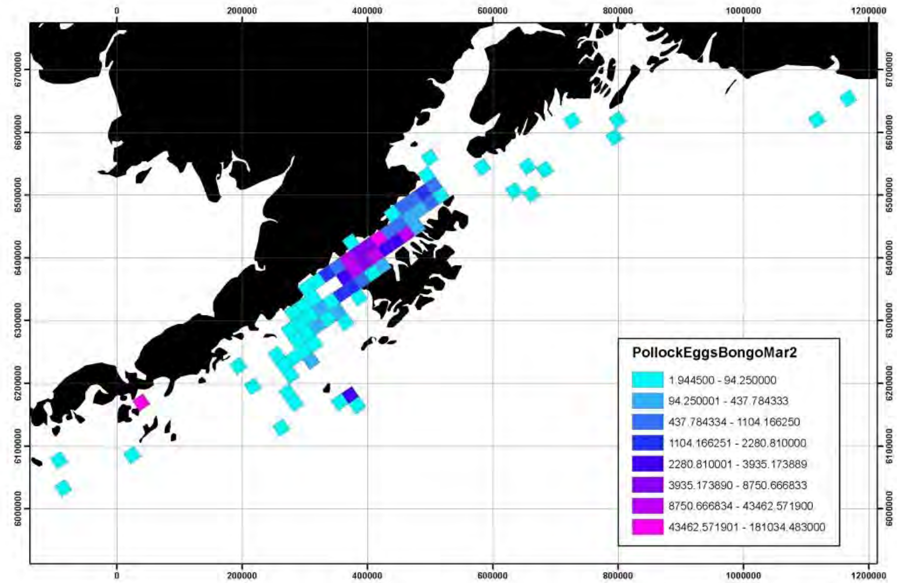
Retention and transport in EGOA

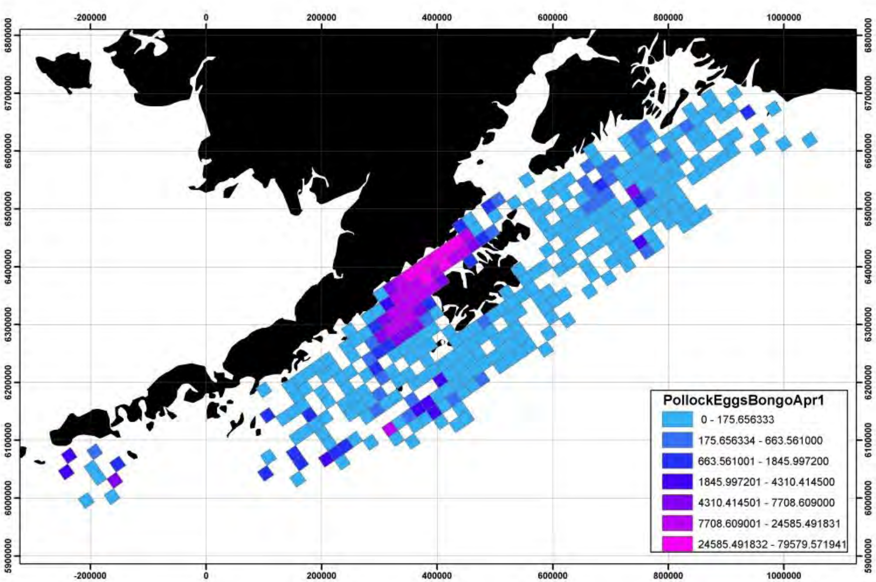
Advection to the basin

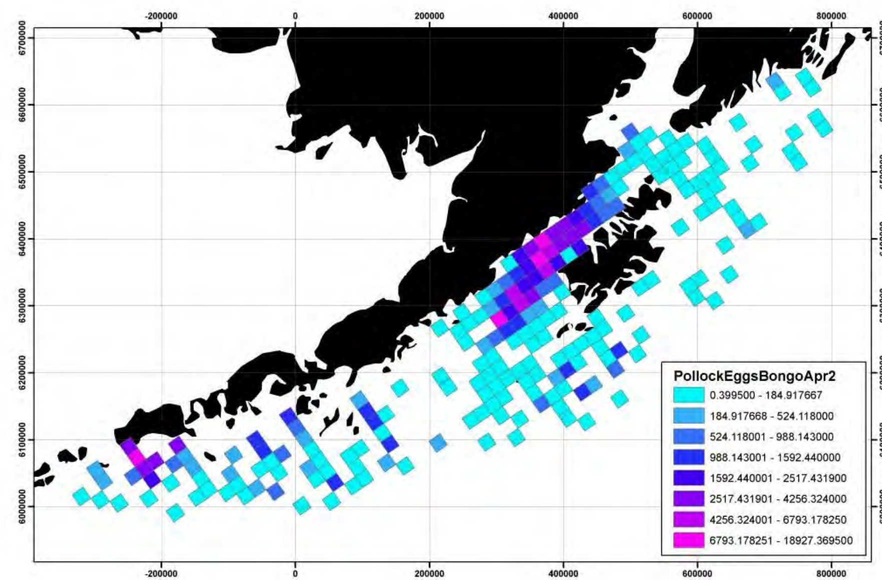
More realistic initial conditions

Climatological initial conditions from Myriam Doyle

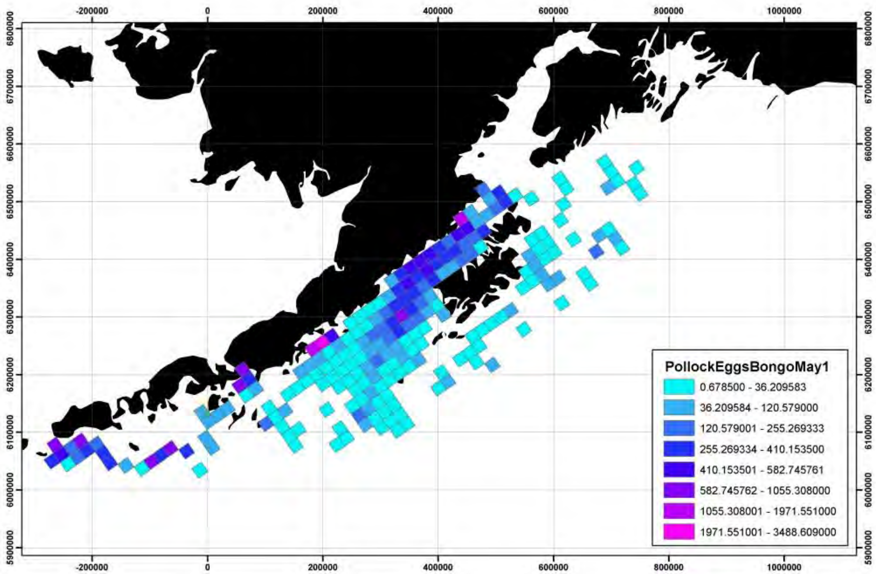


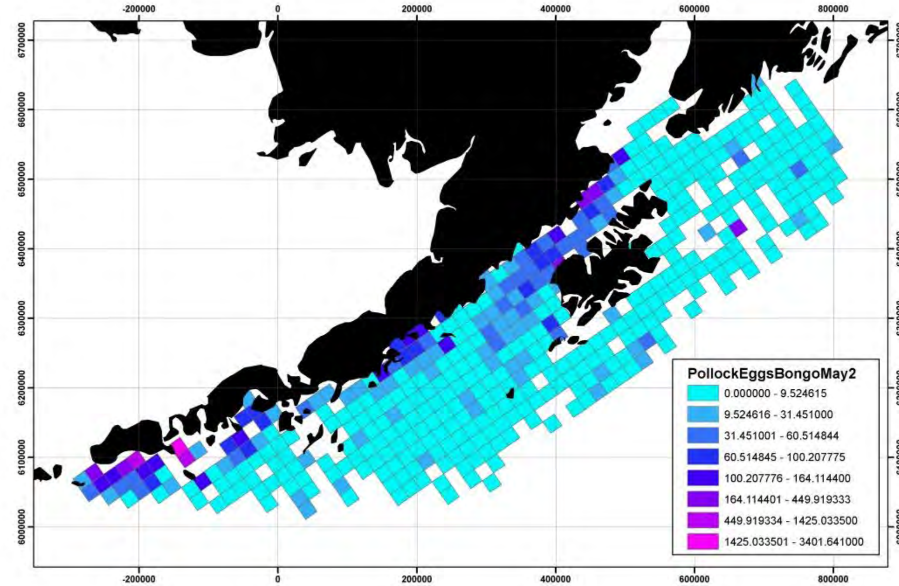


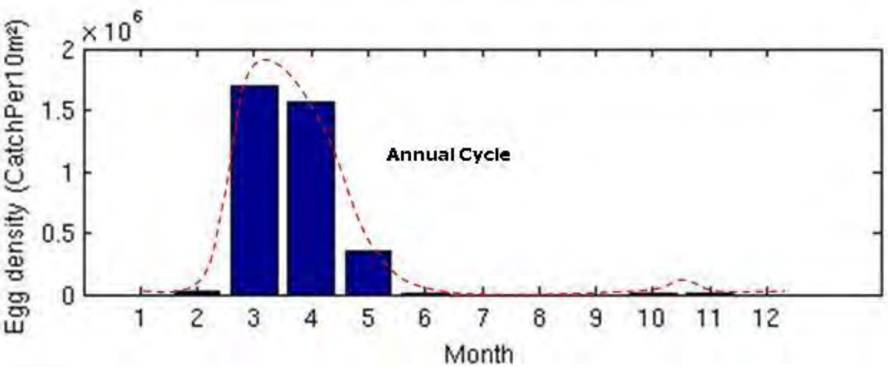


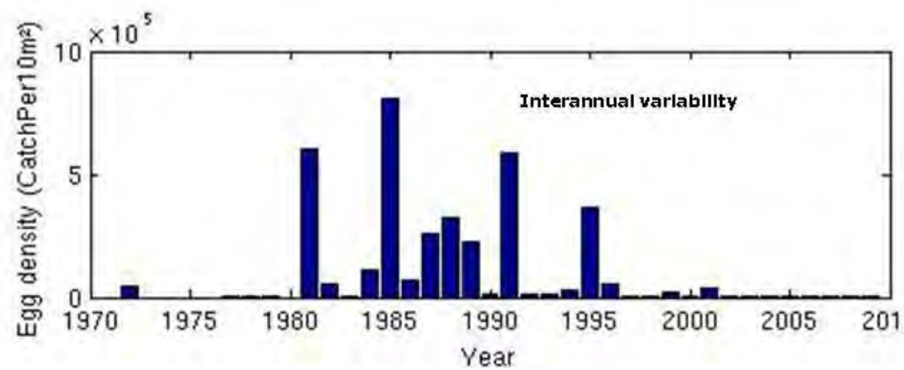


Climatological initial conditions



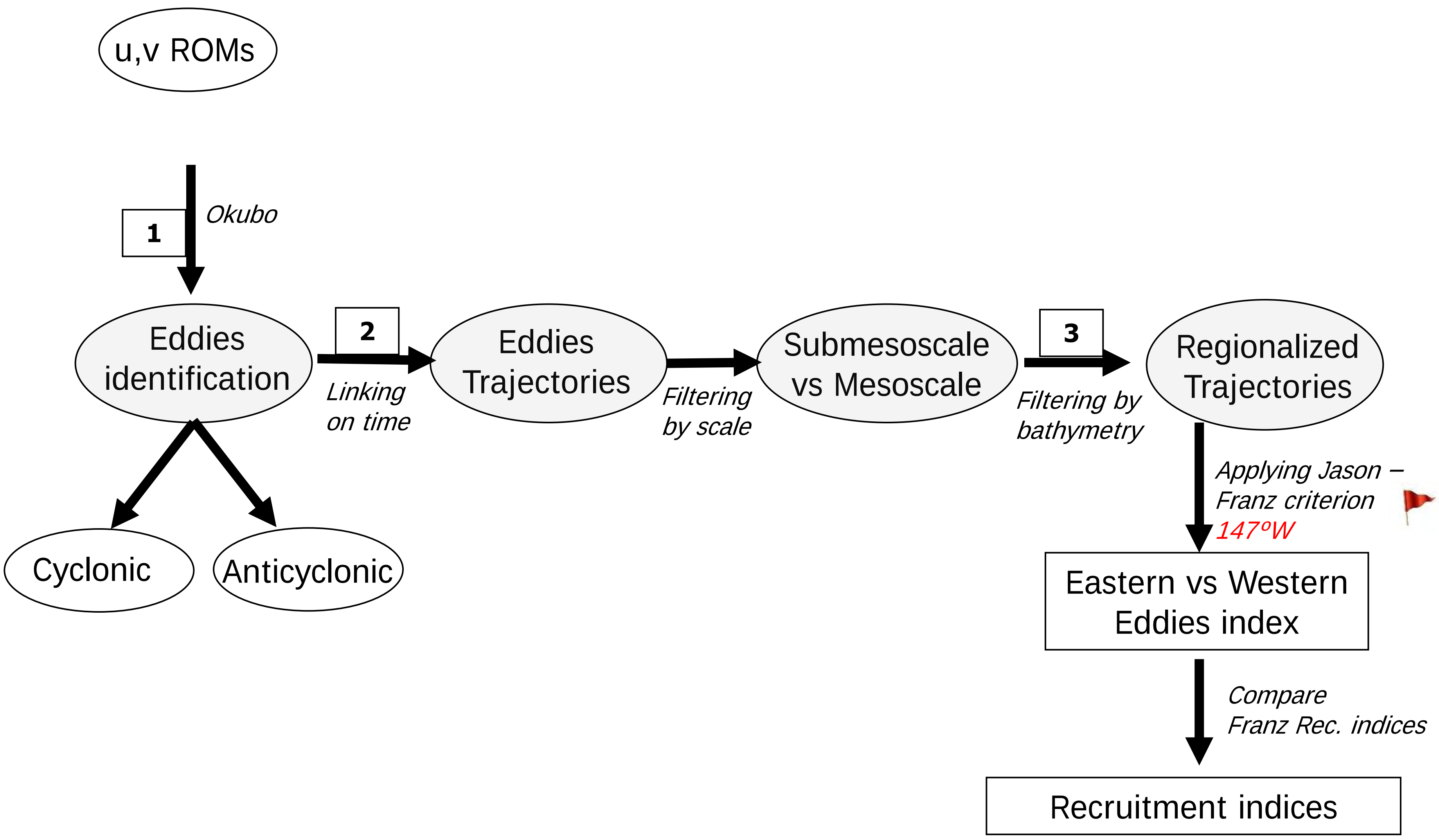




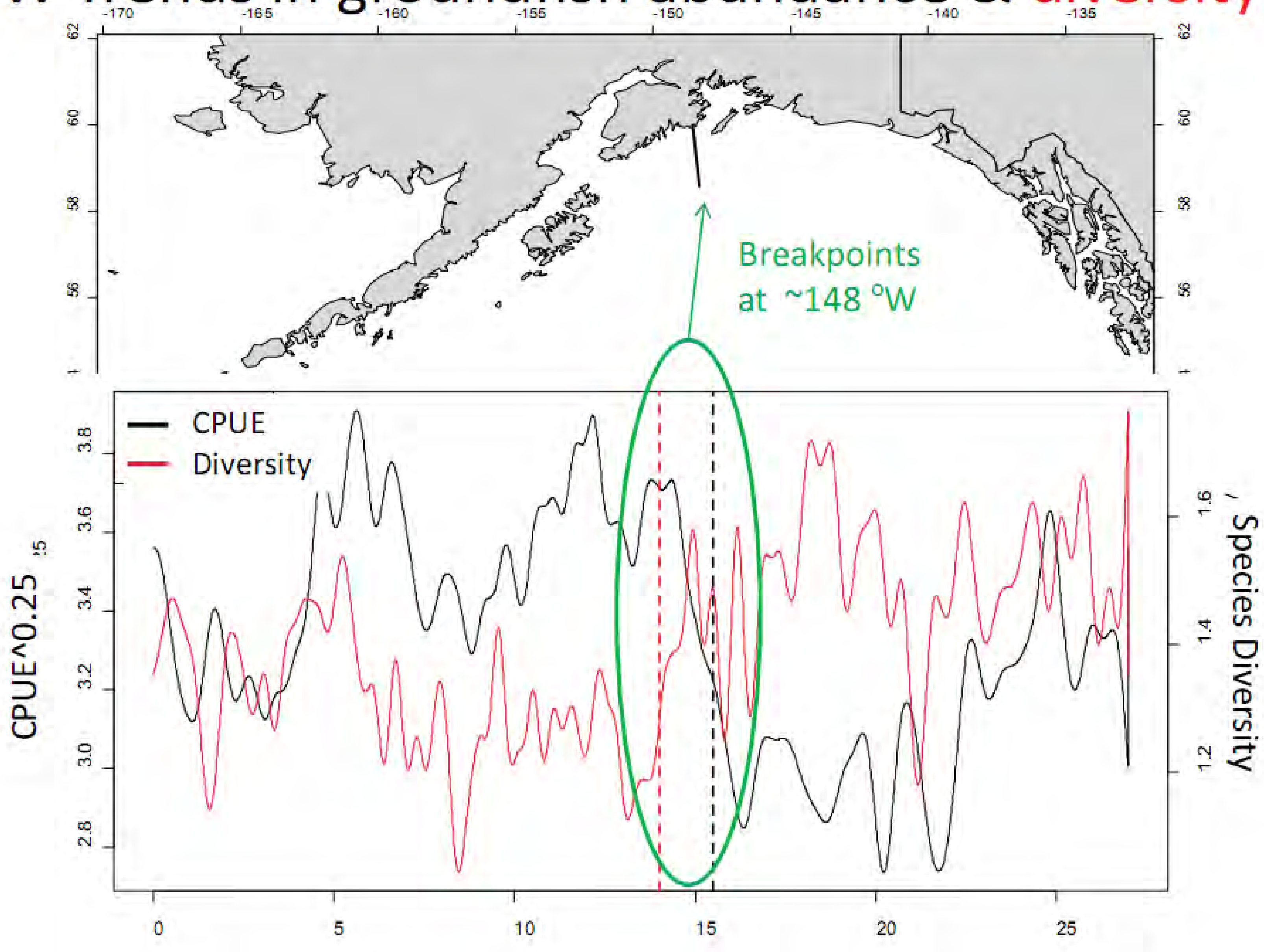


Describing Eddy activity and young pollock habitat

Identify eddies and generate indices



E-W Trends in groundfish abundance & diversity

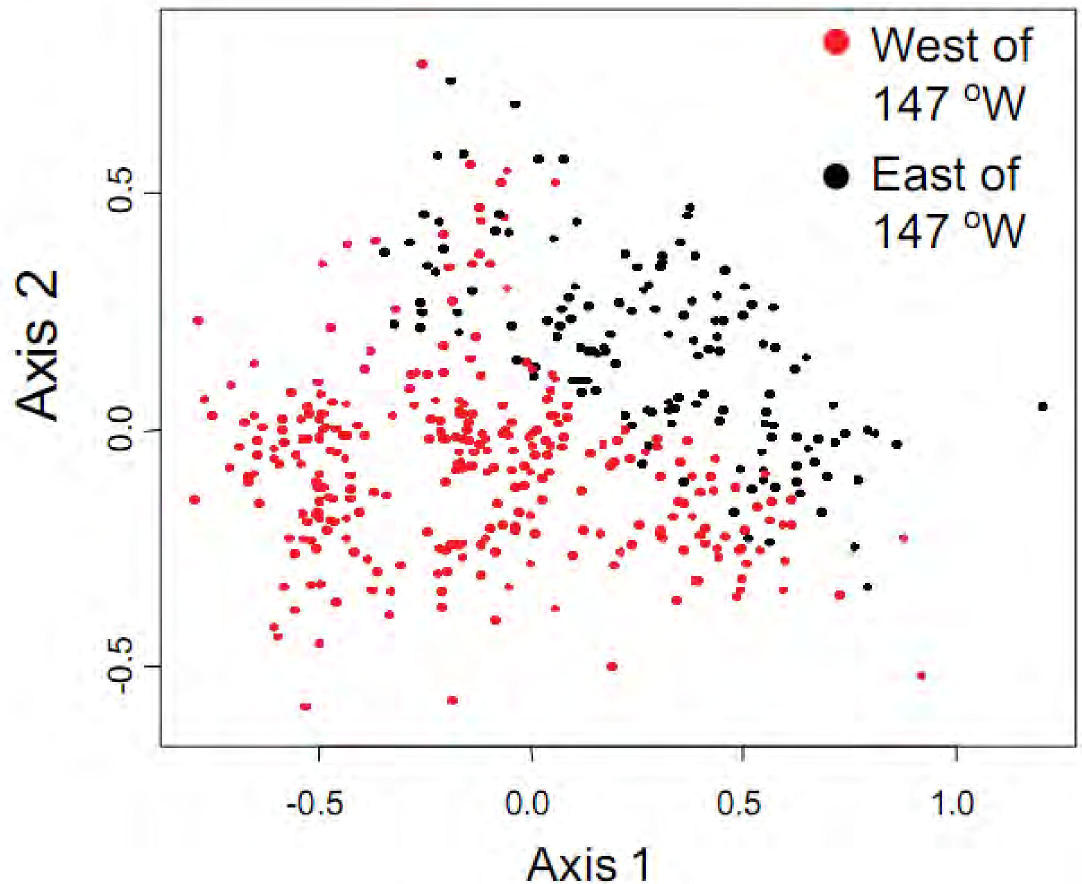


Spatial patterns

Hypothesis: Breakpoint in physical and biological characteristics around 147 °W

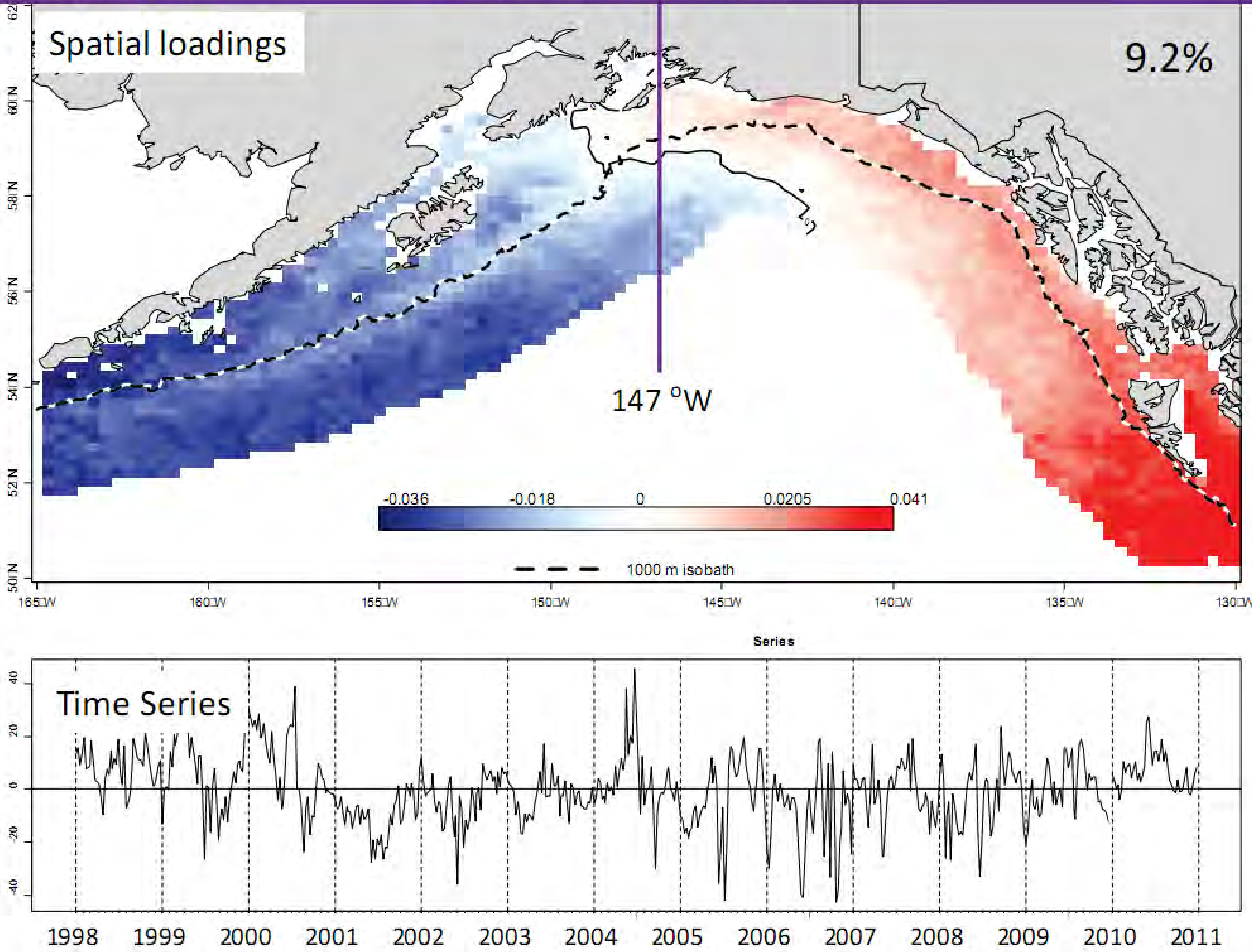
Motivation

Pronounced differences in species composition east and west of 147 °W (Mueter & Norcross 2002)

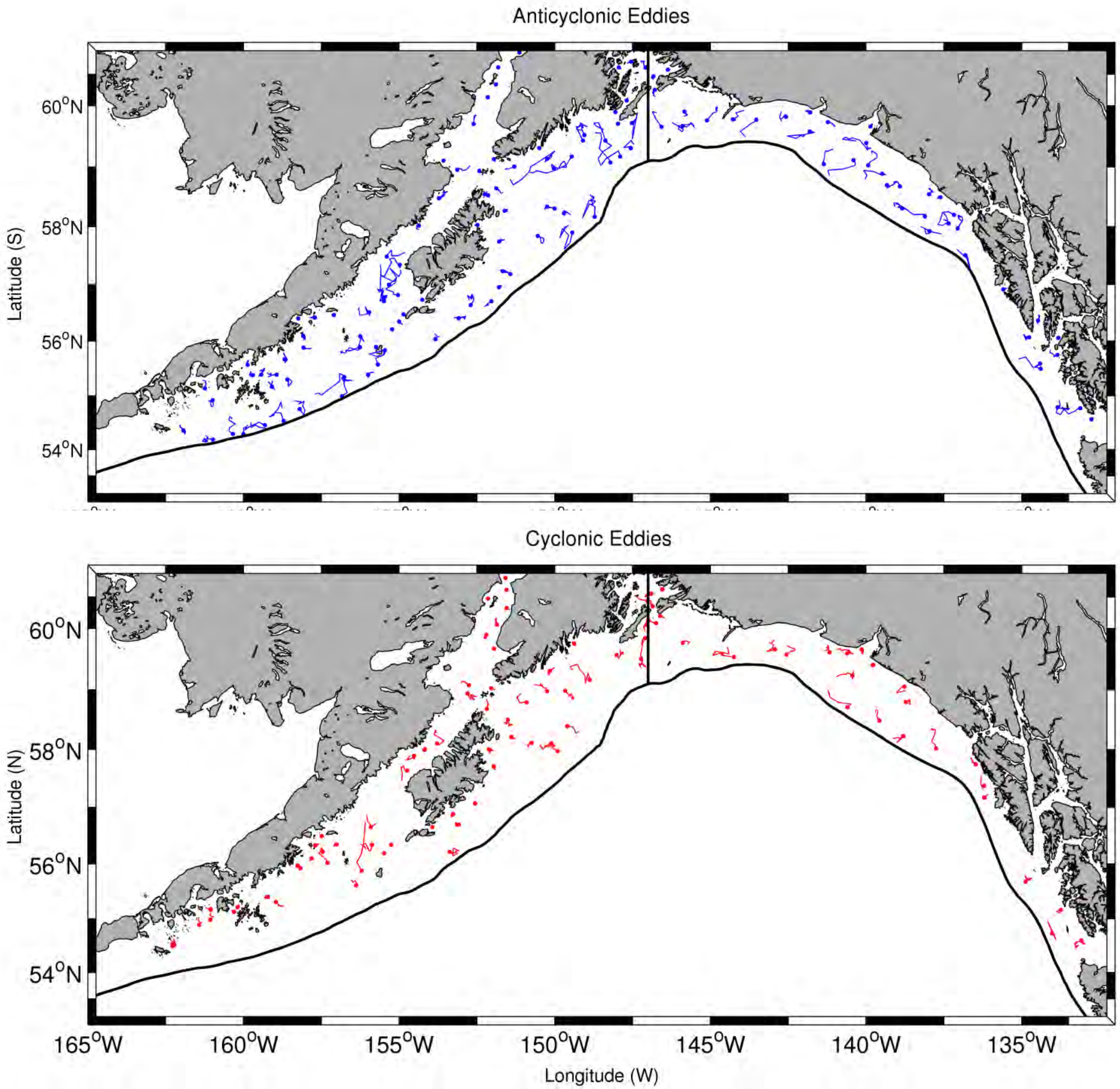


Updated from Mueter & Norcross (2002)

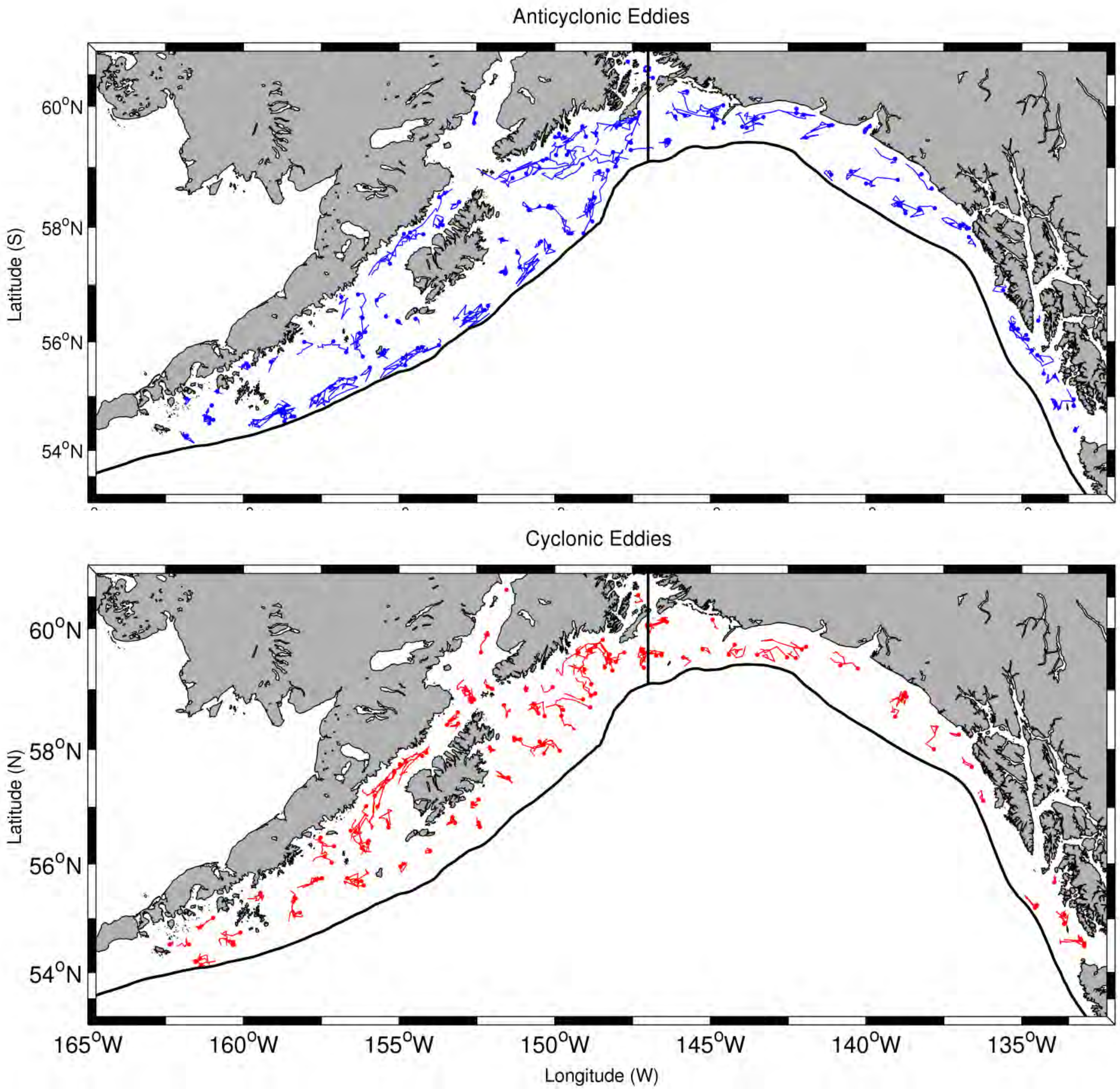
Spatial patterns: Second EOF mode of SST



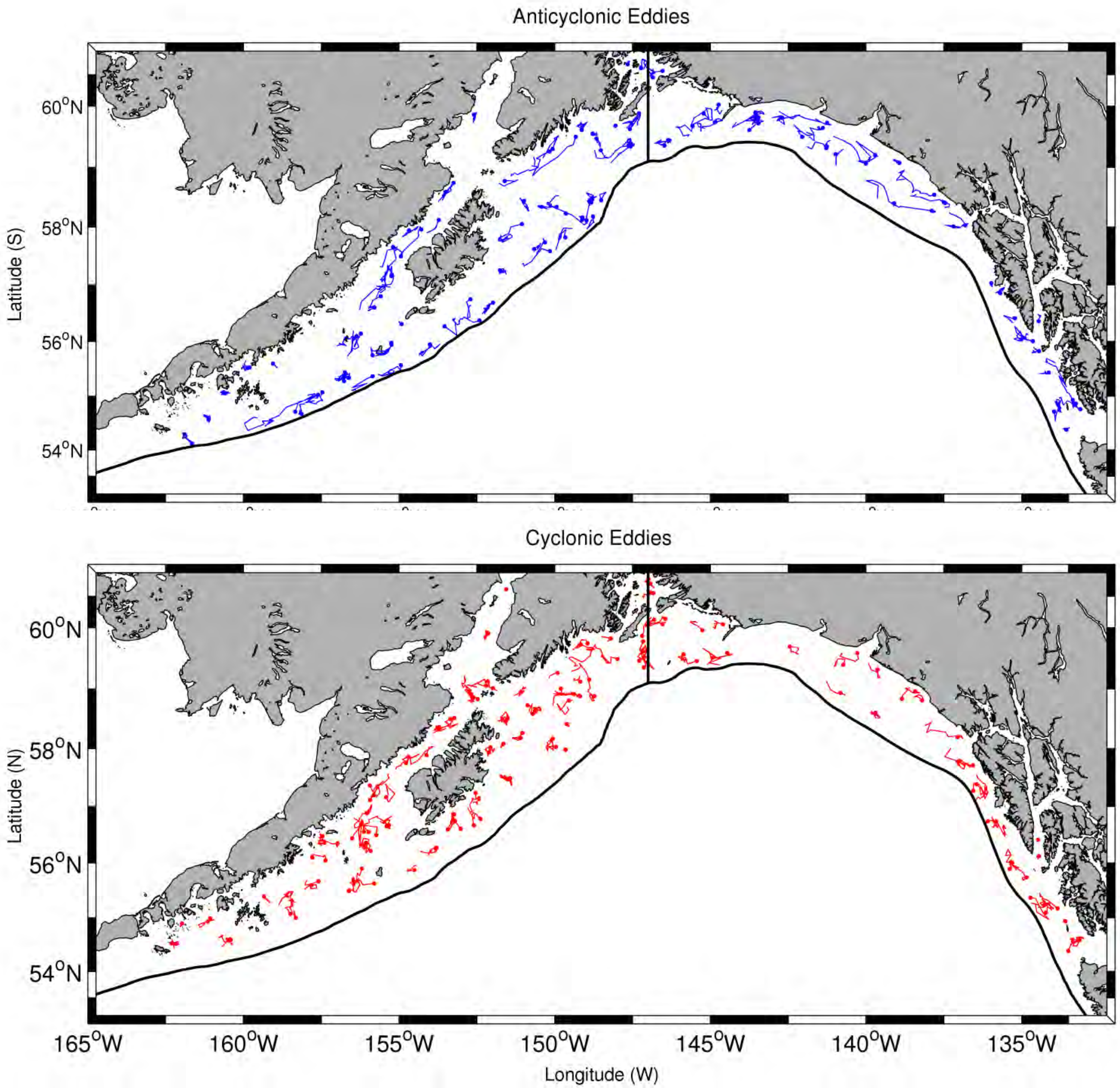
Submesoscale Eddies 2002: Cyclonic vs Anticyclonic



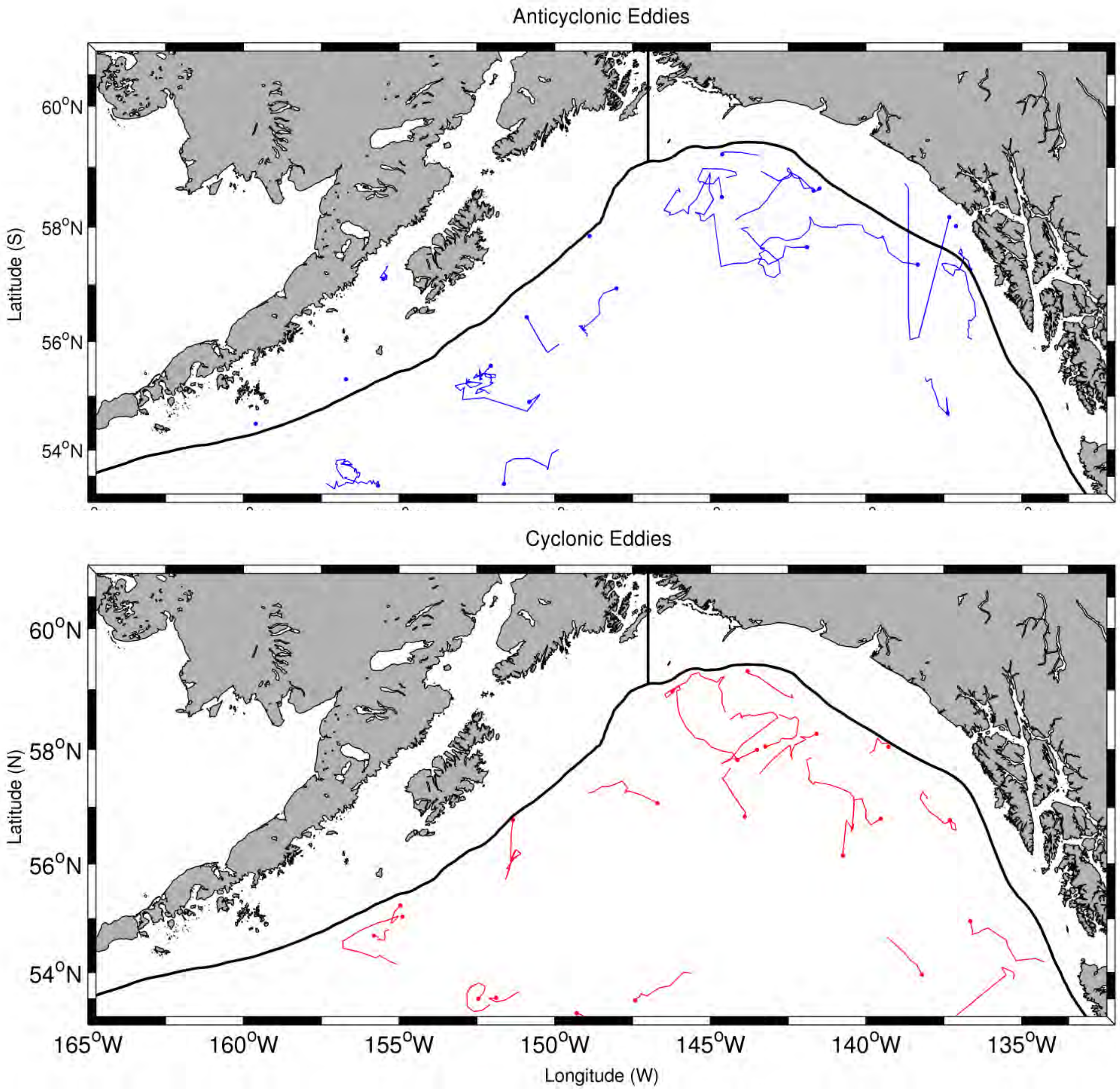
Submesoscale Eddies 2004: Cyclonic vs Anticyclonic



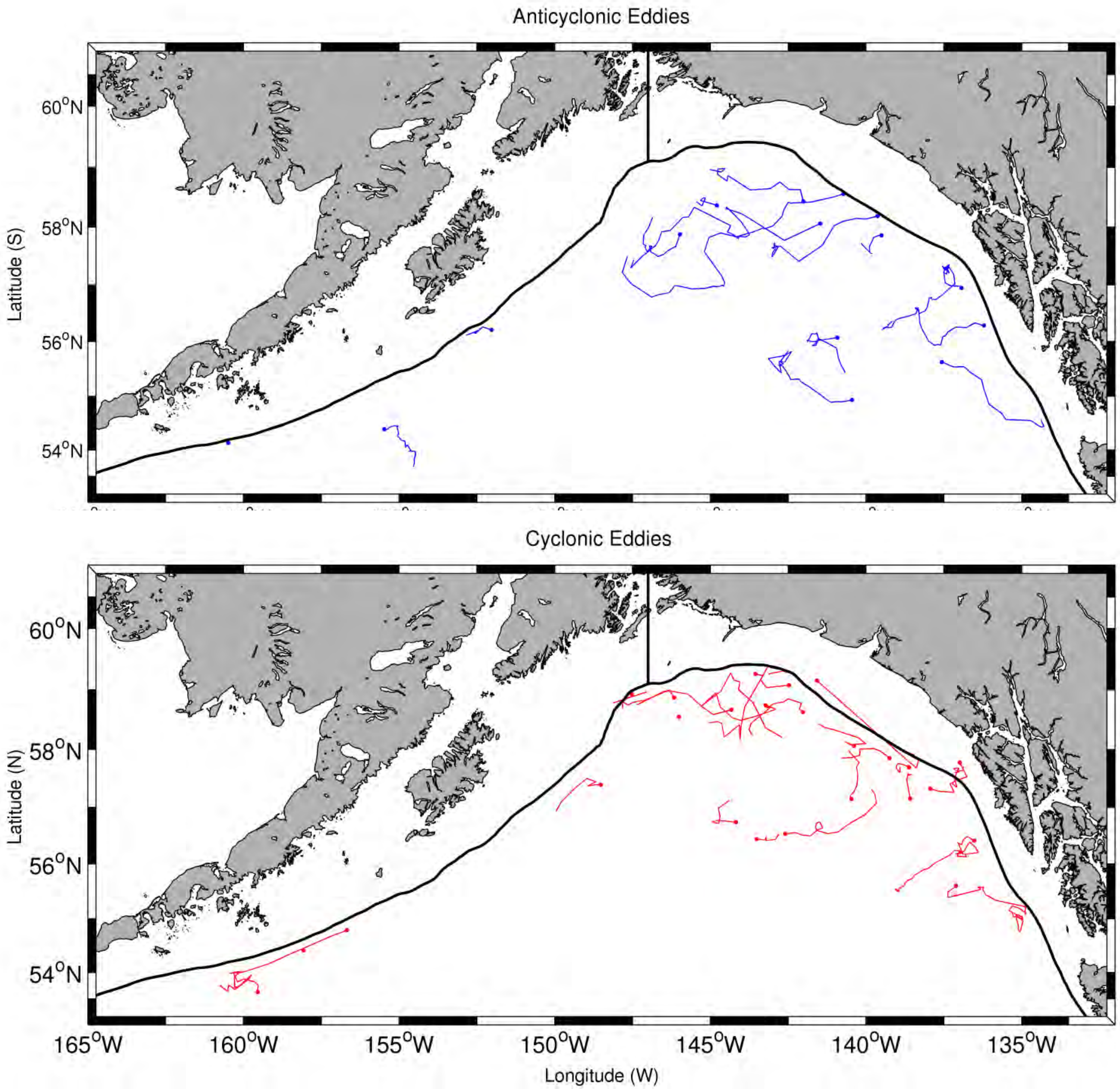
Submesoscale Eddies 2011: Cyclonic vs Anticyclonic



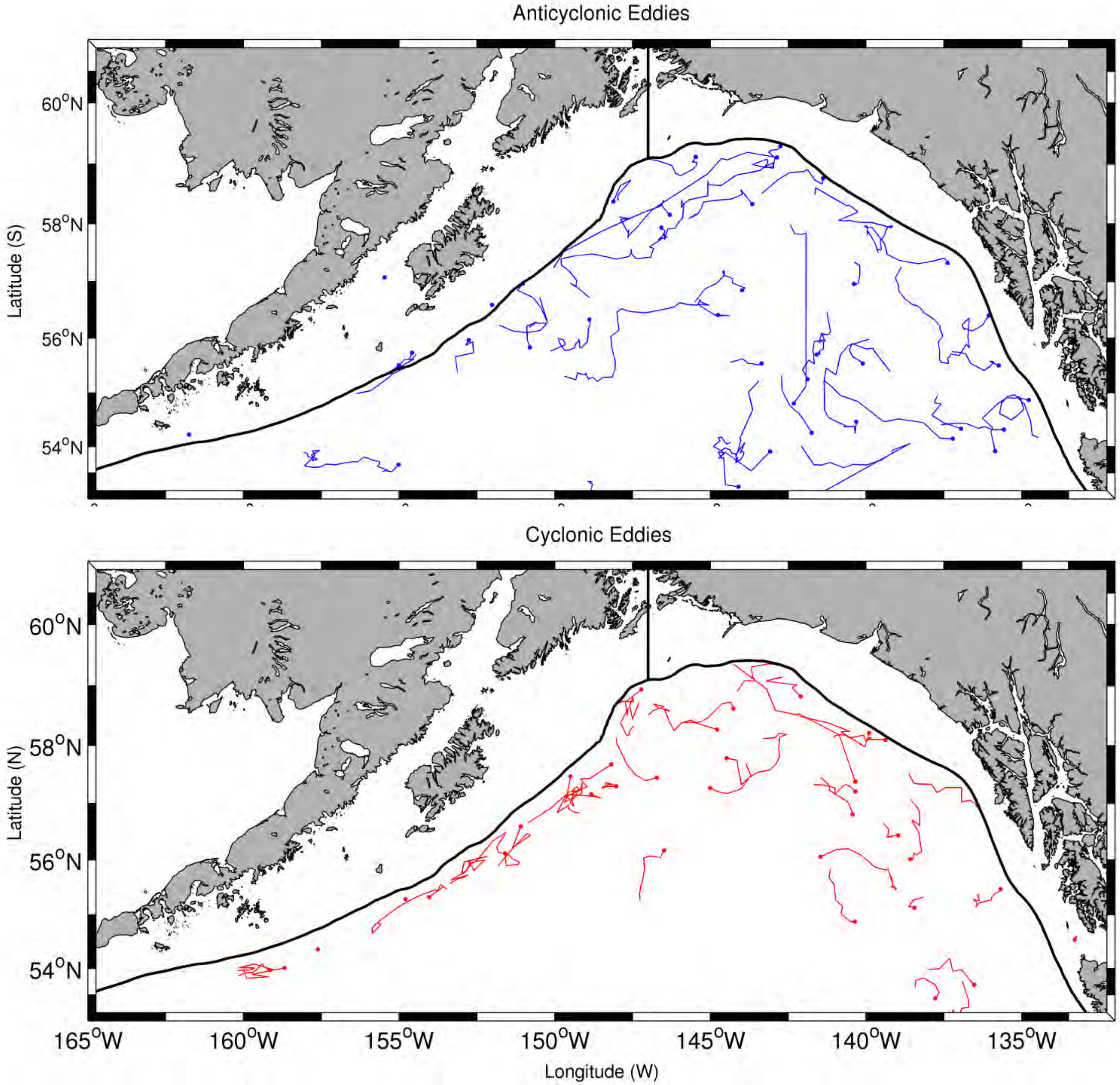
Mesoscale Eddies 2002: Cyclonic vs Anticyclonic



Mesoscale Eddies 2004: Cyclonic vs Anticyclonic



Mesoscale Eddies 2011: Cyclonic vs Antyciclonic



Eddies Statistics:

Number of Eddies

Eddies day

Bathimetry : 500, >500

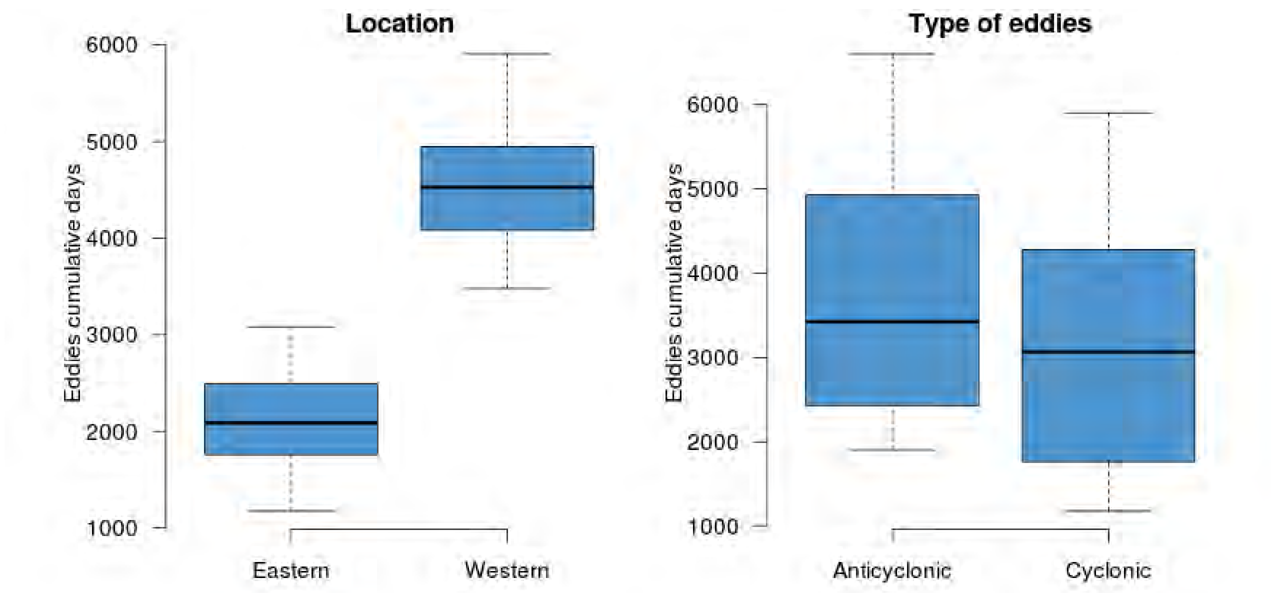
Eddies Scale: <=100m >100m

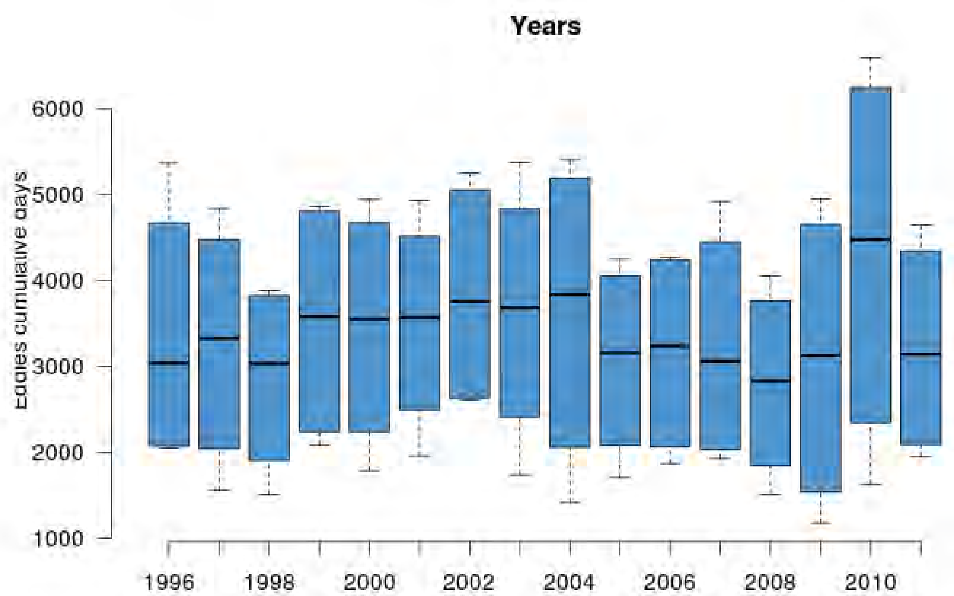
Region : Western, Eastern

Gyre :Cyclonic, anticyclonic

			Ne= Number of eddies				Ed=Eddies_day			
			Western		Eastern		Western		Eastern	
Bathimetry	Eddies Scale	Year	Cyclonic	Anticyclonic	Cyclonic	Anticyclonic	Cyclonic	Anticyclonic	Cyclonic	Anticyclonic
500m	0-100	2002	65	90	27	41	2735	3955	1030	1680
		2004	97	98	34	57	4980	5405	1415	2700
		2011	89	74	42	43	4645	4050	1945	2235
	>1000	2002	0	1	1	0	0	65	40	0
		2004	0	3	0	0	0	105	0	0
		2011	0	1	1	0	0	40	50	0
>500m	0-100	2002	10	13	14	18	410	575	600	790
		2004	33	20	42	46	1360	1105	2295	2395
		2011	34	30	74	55	1470	1890	3570	2915
	>100	2002	9	9	19	13	485	900	1035	1235
		2004	4	5	21	17	200	440	1280	1460
		2011	11	9	31	34	640	630	1385	2555

Eddies indices

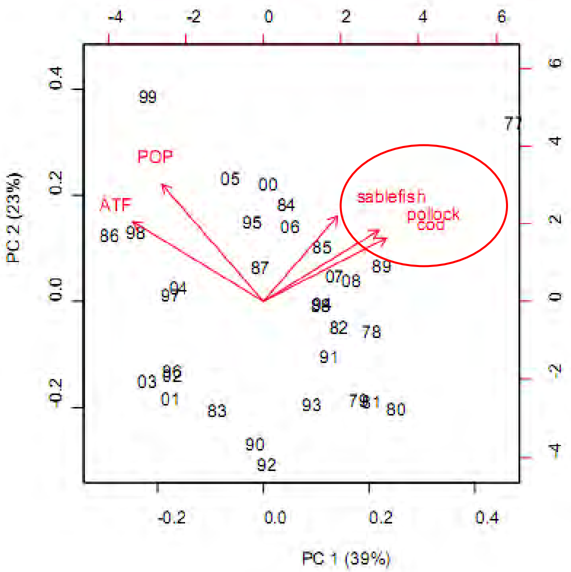


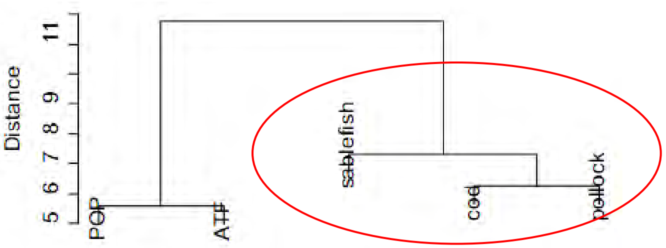


Refine indices
Food availability

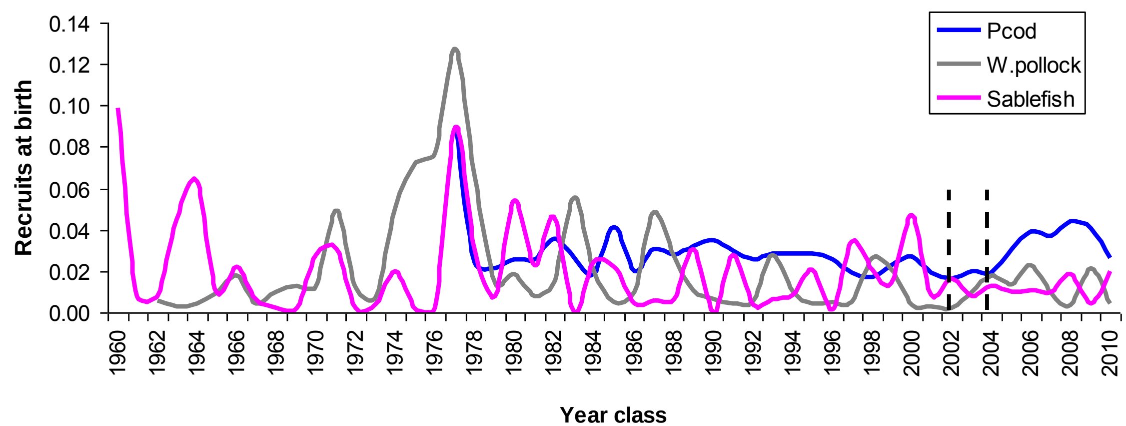
Comparing with Recruitment indices

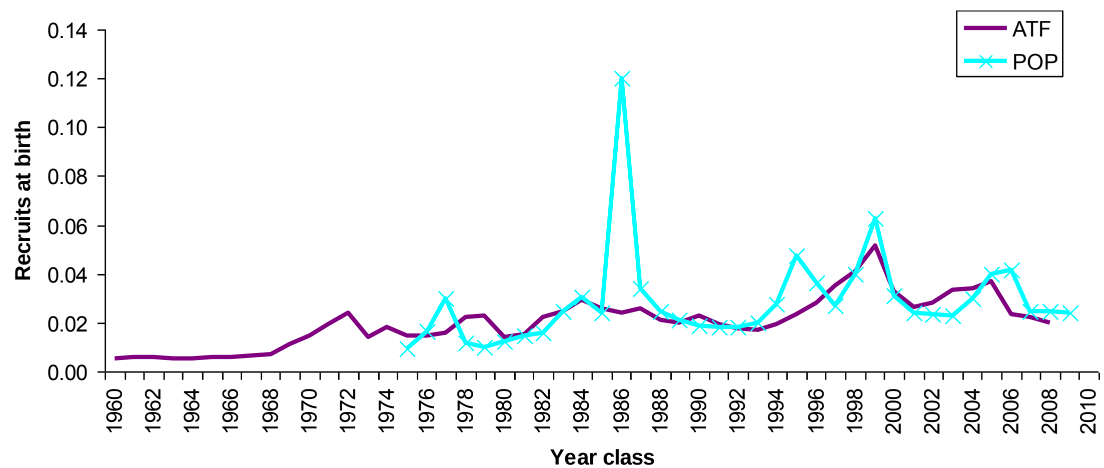
Franz PC and cluster analysis





Recruitment Indices



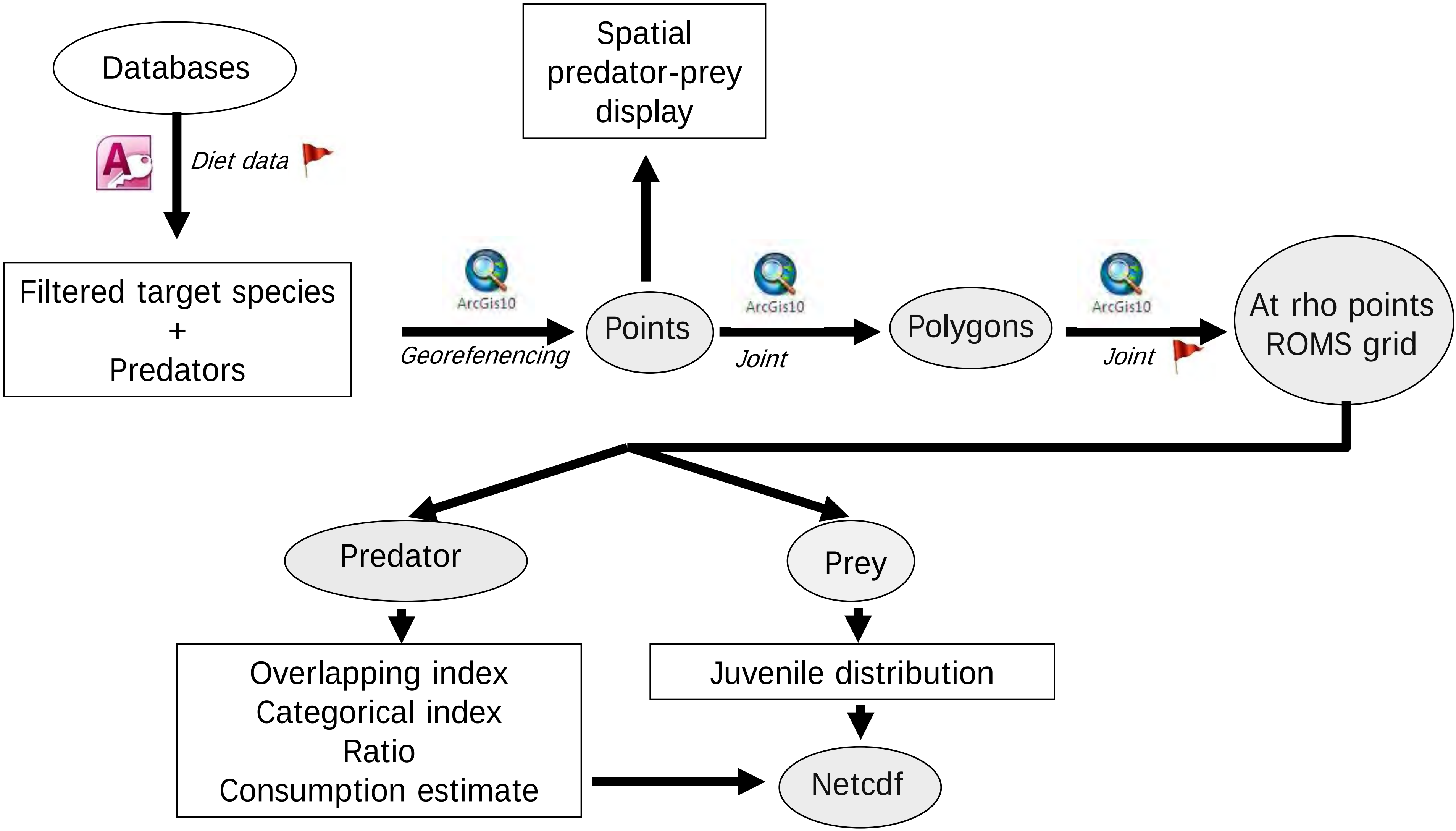


How to integrate predation data into the models?

Description of databases available for predation

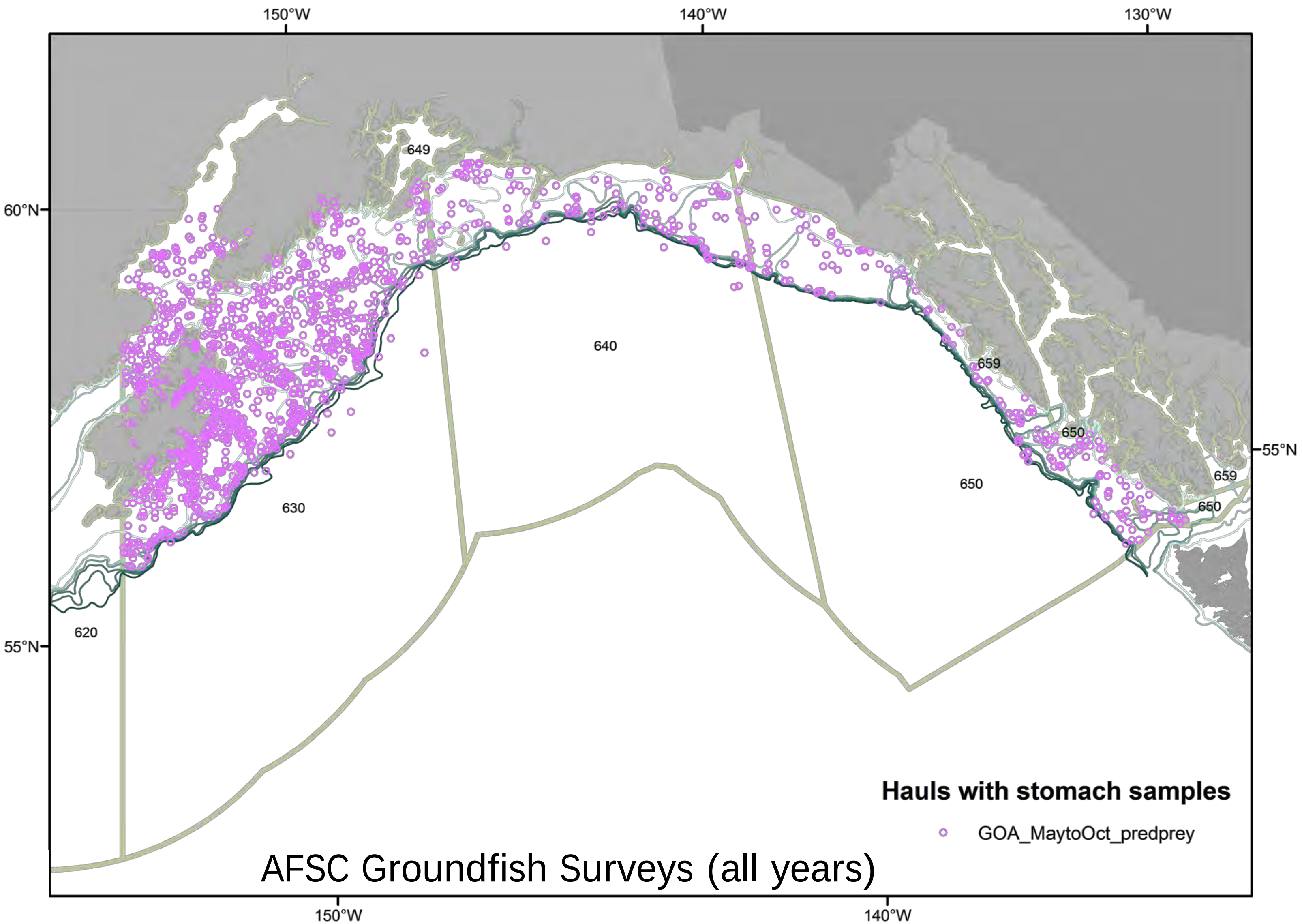
- **AFSC Groundfish cruises**: Stomach samples, prey length, predator length, sex, frequency, years 1981, 1984-1987,1990-2007,2009,2011. Survey catch data for identified groundfish predators on focal species
- **Small mesh trawl databases:** Survey catch data for identified predators on focal species. Forage fish collected for length, weigh, catch, sex, stomachs, restricted to between Kodiak to Unimak region, years 1953,1954, 1957,1963,1967-2010,
- **Large mesh trawl databases**: Survey catch data for identified predators on focal species Total weight of fish caught, sex, length, number of fish caught, years 1988-2011
- **MACE surveys**: Catch data for identified predators on focal species from pelagic trawl catches from reference trawls during Midwater Acoustic surveys.
- **Observer data:** Commercial catch data for identified predators on focal species, 1995 to present

Filtering – processing - outcomes



Diet Data

Where information is available?



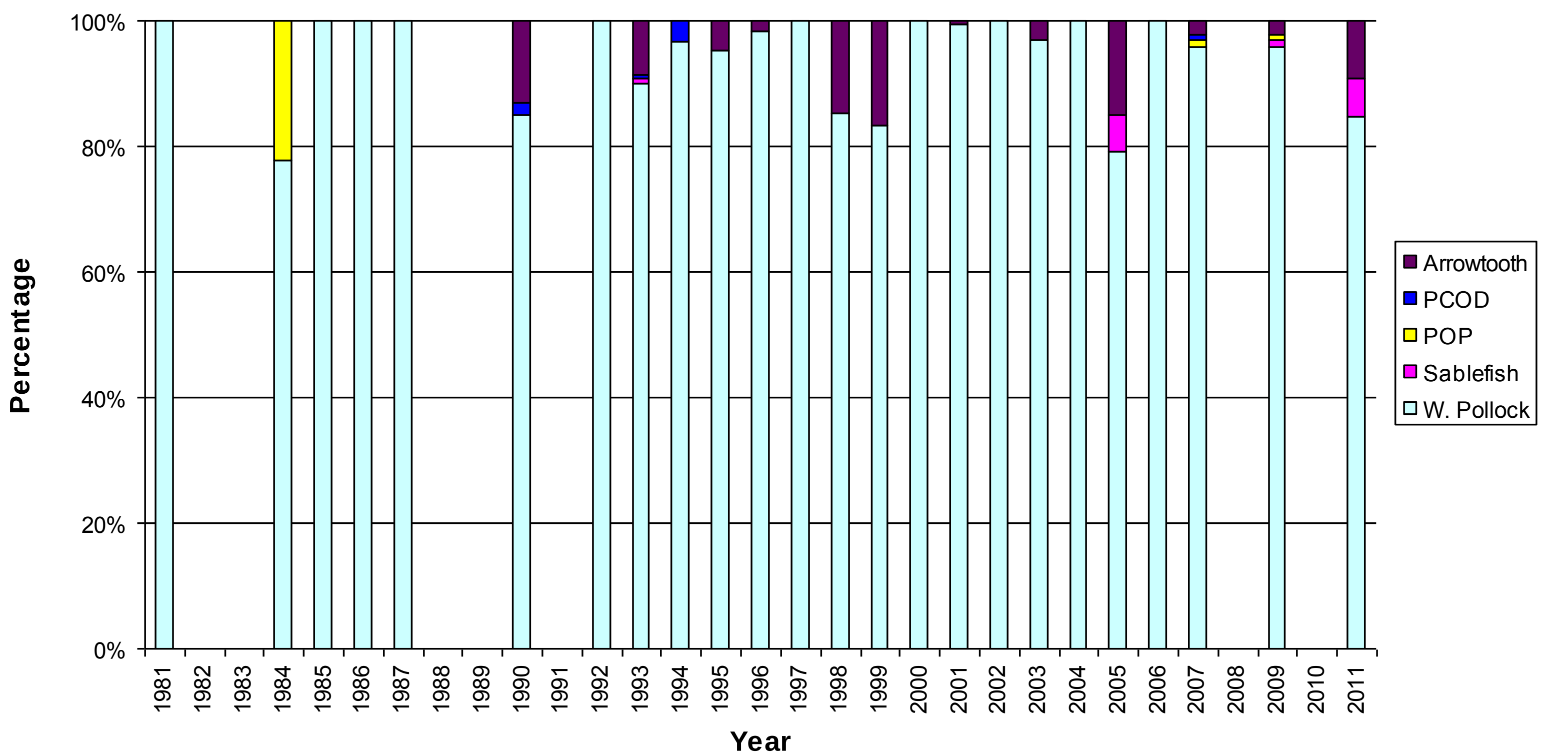
AFSC Groundfish Surveys (all years)

Diet Data

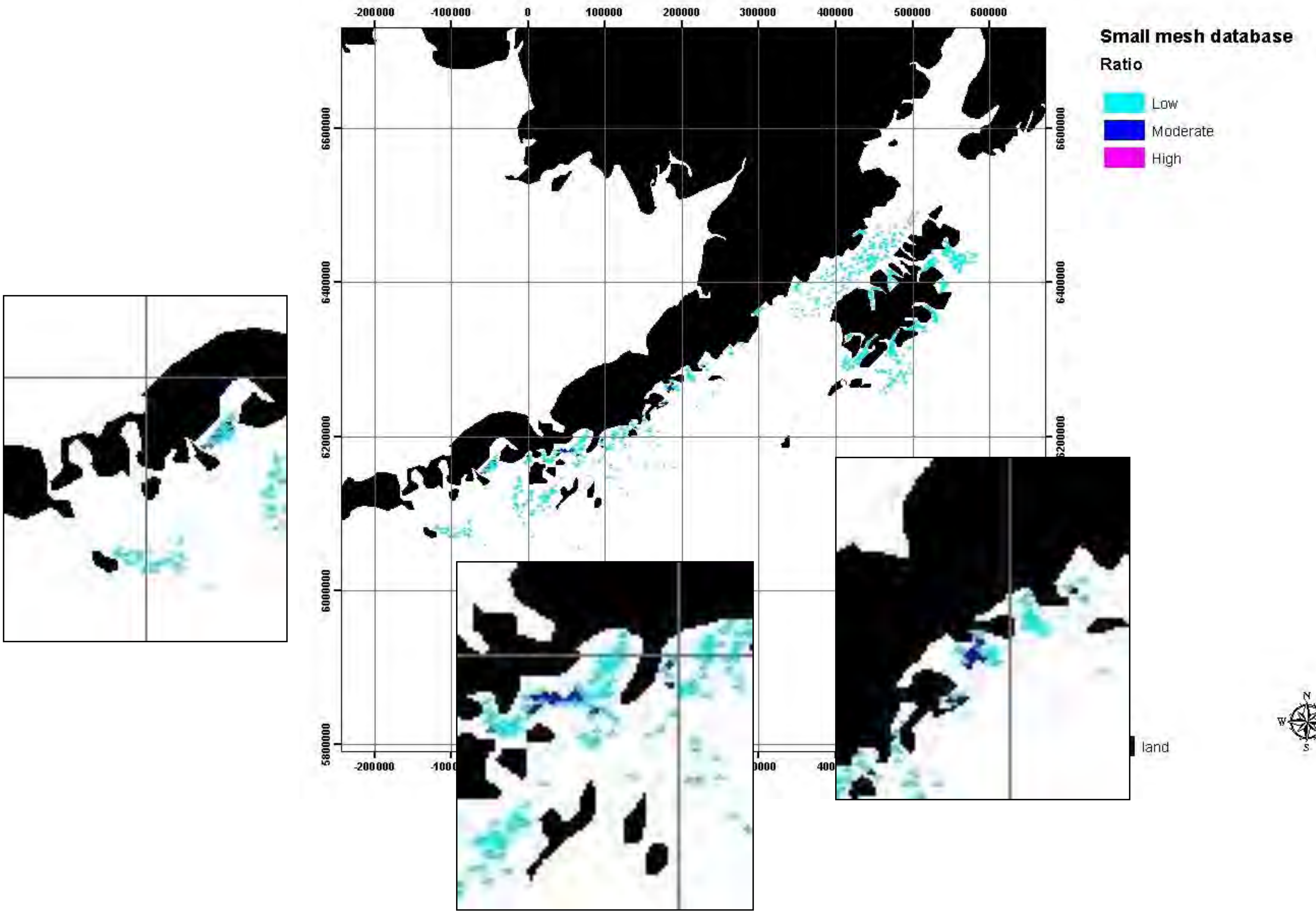
What predators?

PREDATOR	PREYS ARROWTOOTH	PCOD	POP	SABLEFISH	POLLOCK
Aleutian Skate	X				X
Arrowtooth	X	X	X		X
Big Skate	X				
Northern Rock	X				
P. Cod	X		X		X
P. Halibut	X			X	
POP	X				
Rougheye Rock	X				
W. Pollock	X	X	X		
Sebastes				X	
Lingcod				X	X
Bering Skate					X
FH Sole					X
Hake					X
S Rock Sole		X			

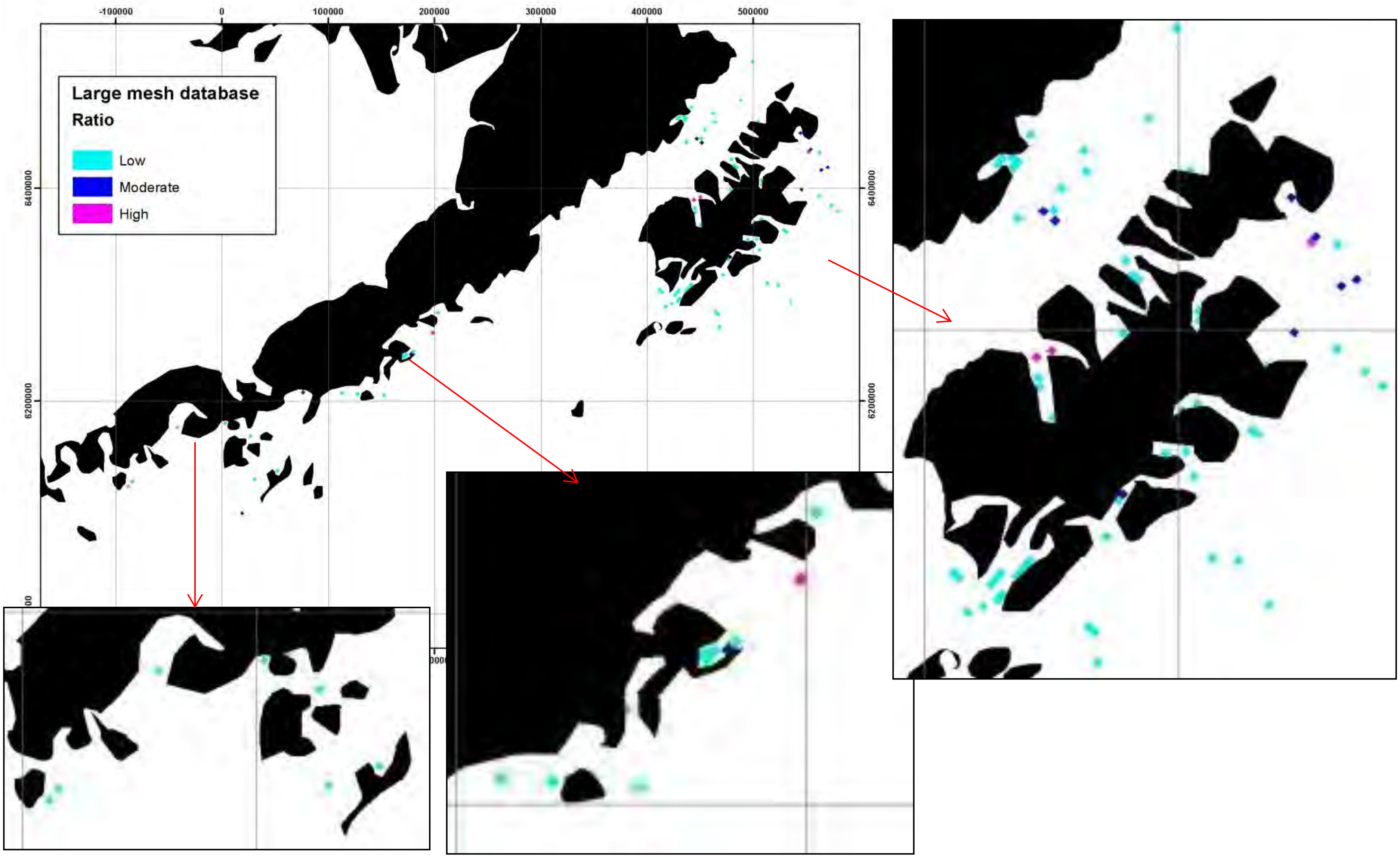
What years available?



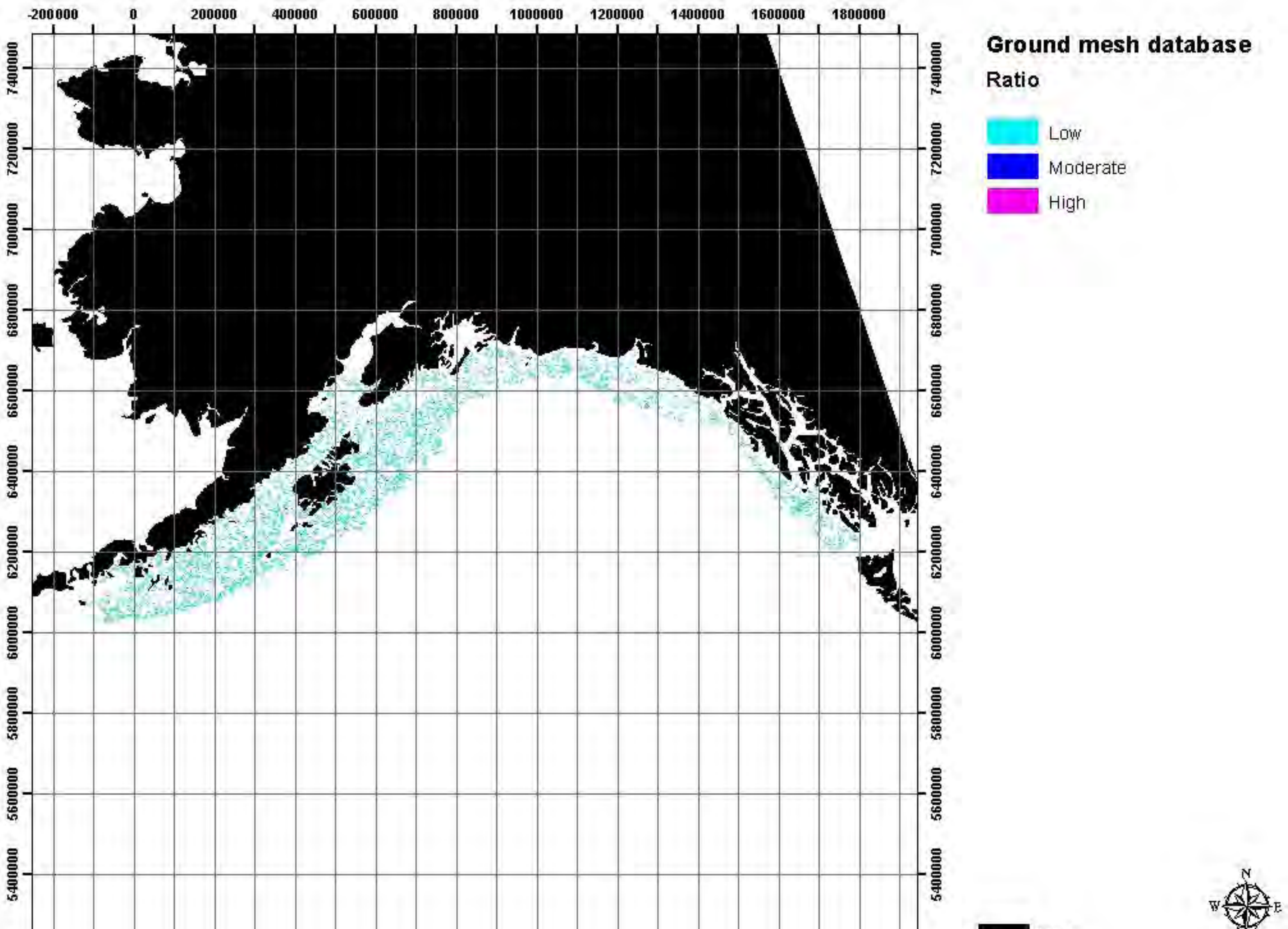
Overlap - Categorical Ratio - Consumption estimate small mesh pollock



Overlap – Categorical ratio – Consumption estimates Large mesh pollock



Groundfish database Walleye pollock



IBM requirements

Predation on YOY by older fish, birds & other community members

Products to the IBMs

HIGH

Data Availability

LOW

- Spatially explicit predation mortality estimates with interannual variability
- Predation mortality estimates with interannual variability
- Spatially explicit predation mortality estimates
- Relative indices indicating high, medium, low, none predation risk

Problems - limitations

- Integration of data collected at different spatial scales (intensive small scale vs large scales samples)
- Unbalanced spatial sampling across the Eastern and Western GOA
- Unbalanced temporal sampling, mainly from summer
- Lack of temporal resolution to appropriately represent interannual variability in most of target species

Summary

- Low resolution model reproduces observed features of GOA in terms of spawning-nursery grounds

- High resolution model showed submesoscale oceanographic structures playing an important role on transport and connectivity within GOA. how realistic are those?

- GOA and BS seem to be connected, this requires to be explored as well as the potential implicances on stock structure concept

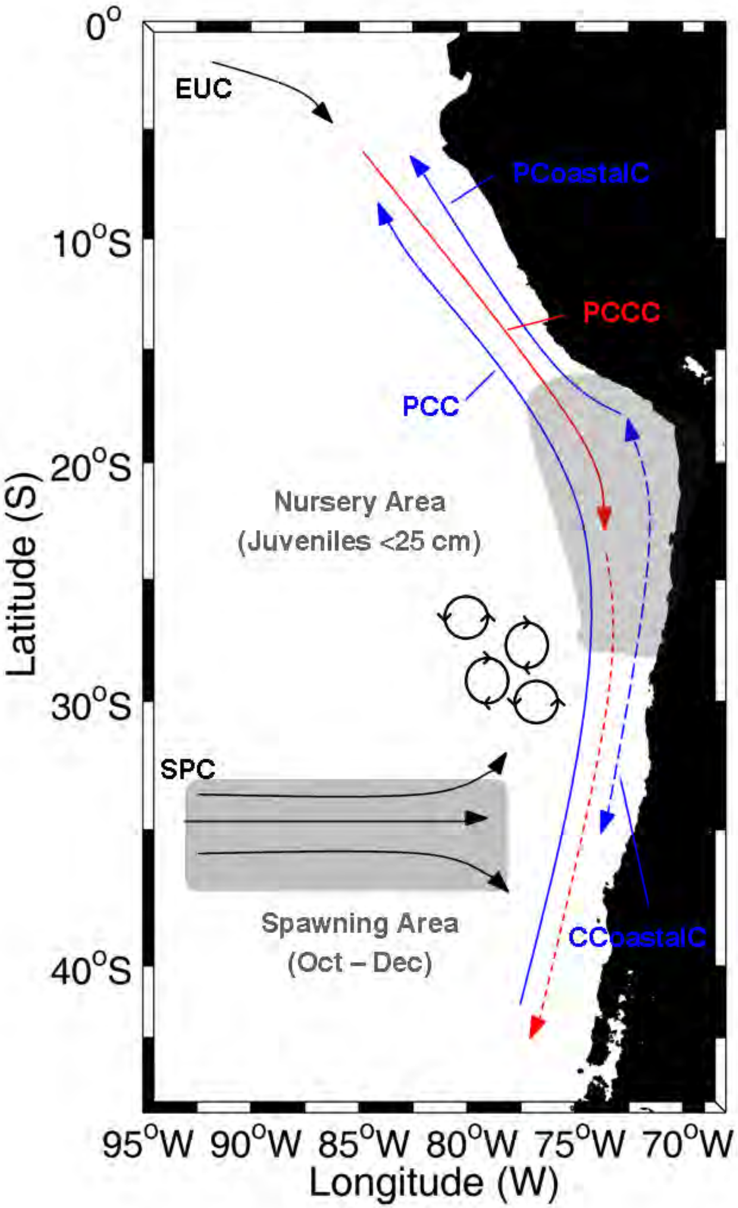
- The western GOA showed a significant larger amount of submesoscale eddies than eastern GOA

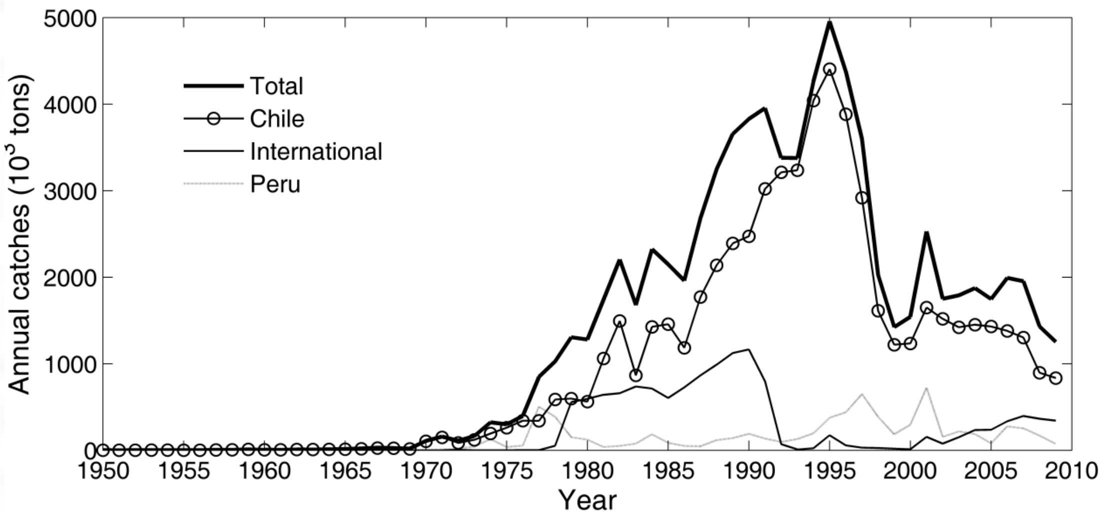
- Spatially, predation indices are patchy. Not enougth data to reproduce temporal variability. That migth be critical in the attempts to model recrutiment variability (as well as other sources of mortality).

Expanding the conceptual model of Jack Mackerel in the South Pacific

Carolina Parada – Sebastián Vásquez – Emuanuelle Di Lorenzo – Billy Ernst

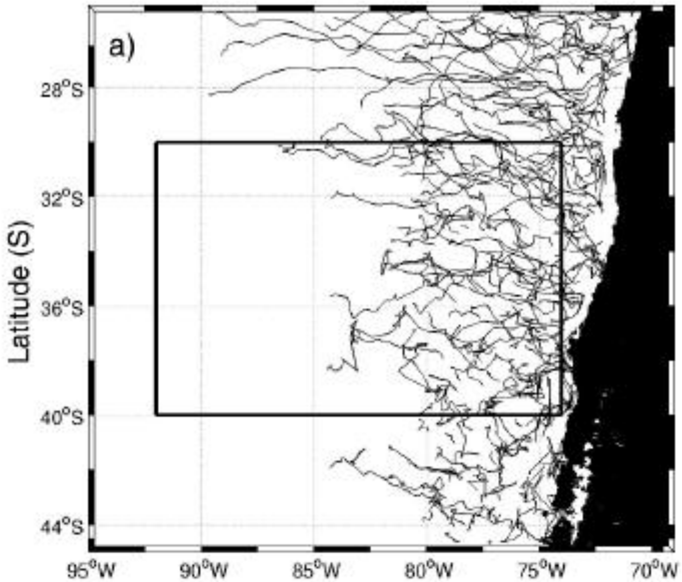
Jack Mackerel conceptual model and hypothesis

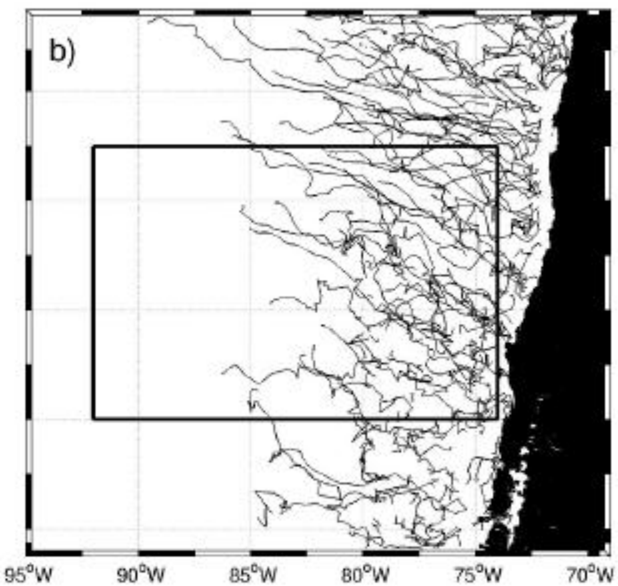


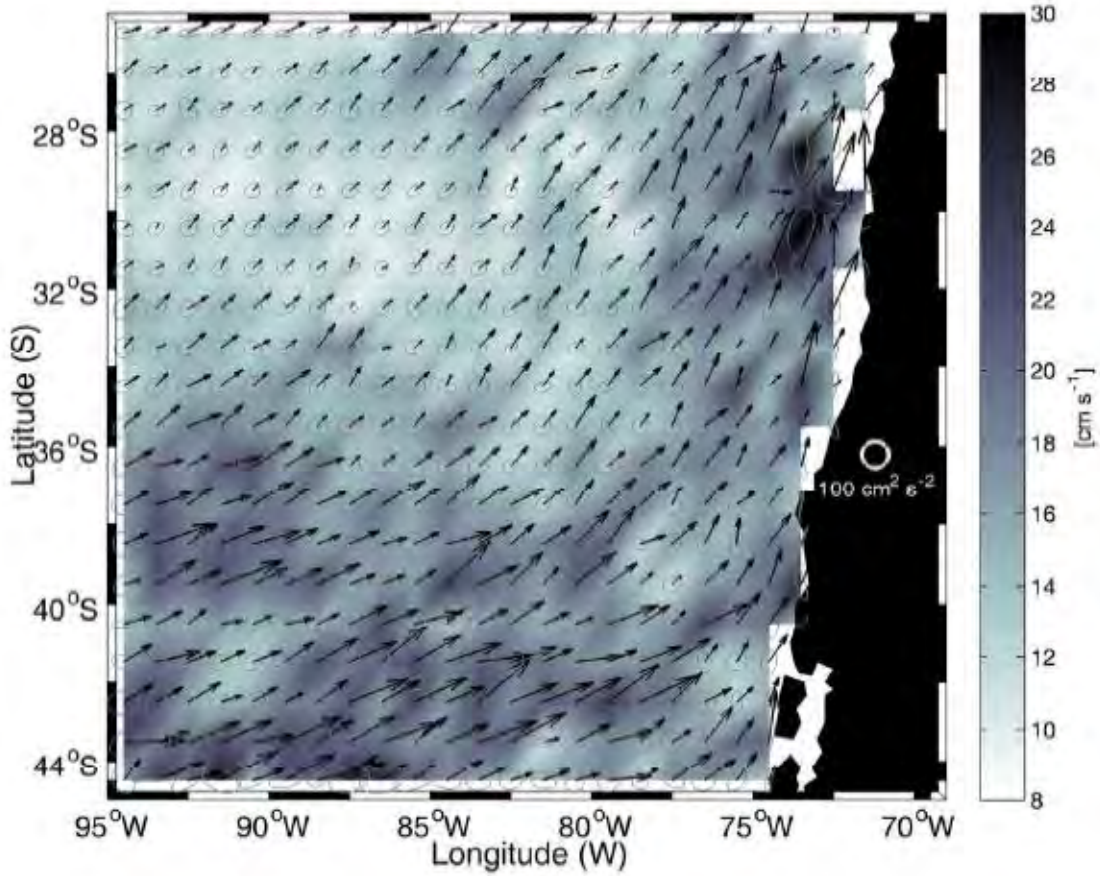


Vásquez et al., submitted

Eddies, drifters and circulation

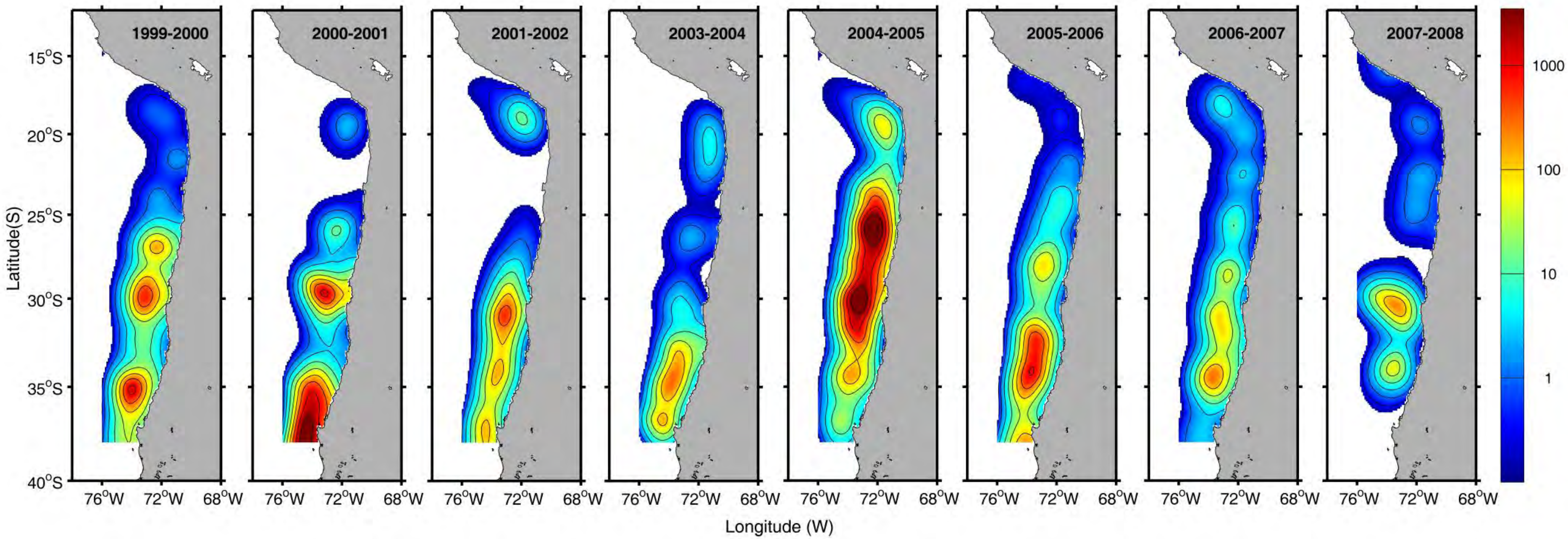


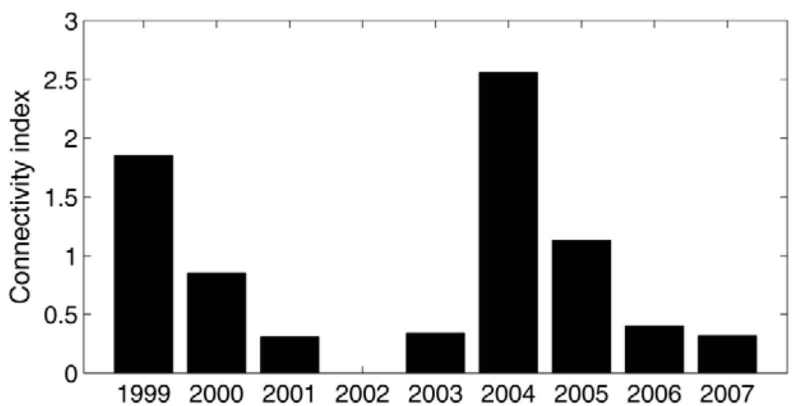


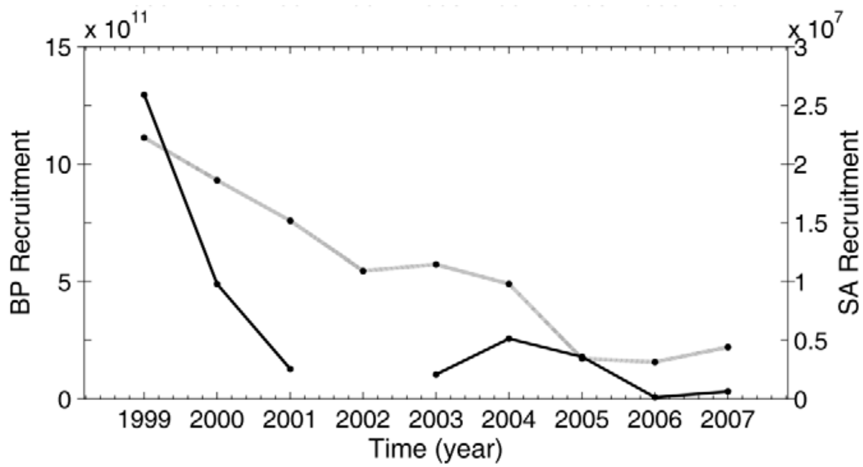


Vásquez et al., 2013

Spatial and temporal connectivity – Recruitment indices

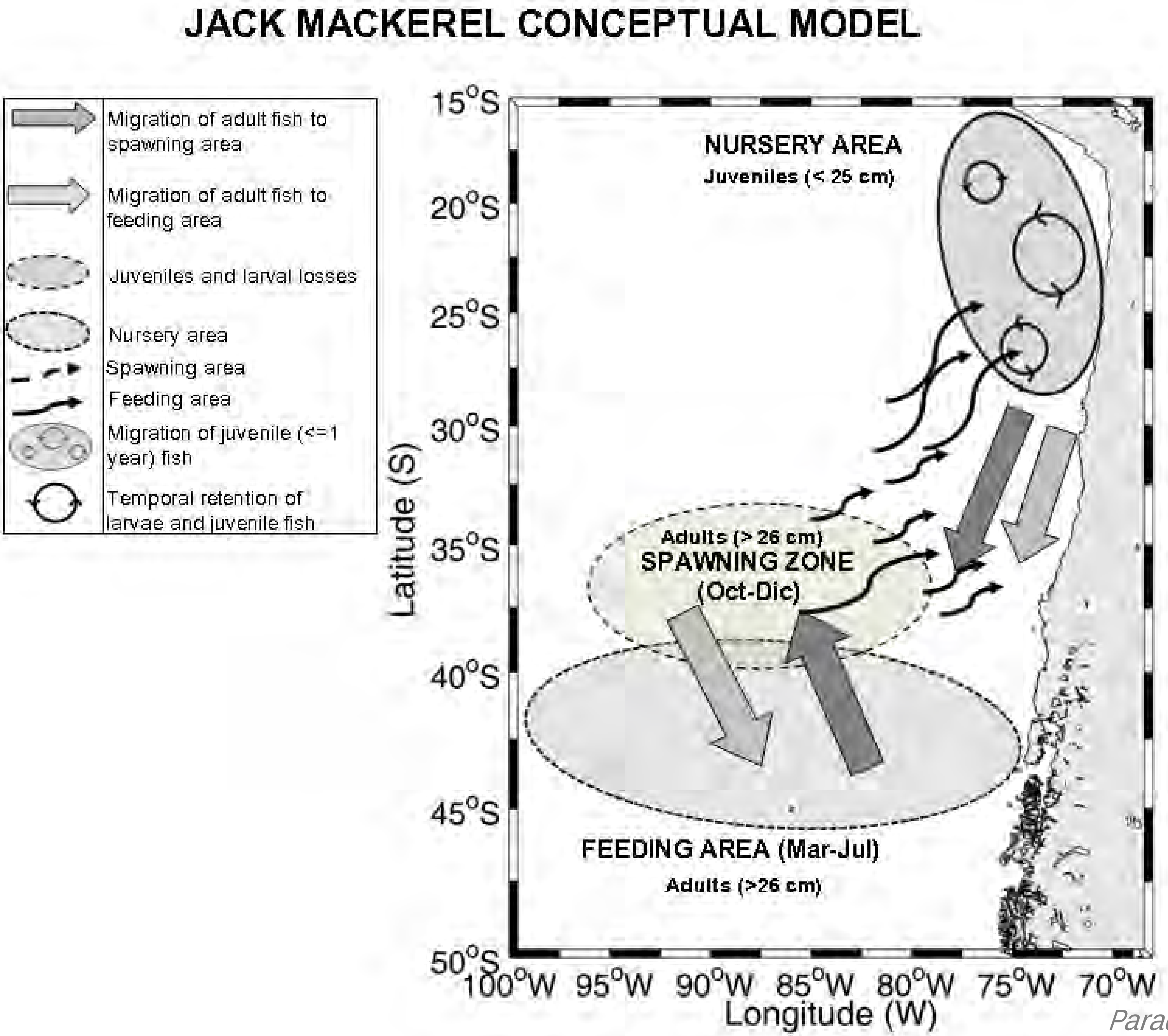






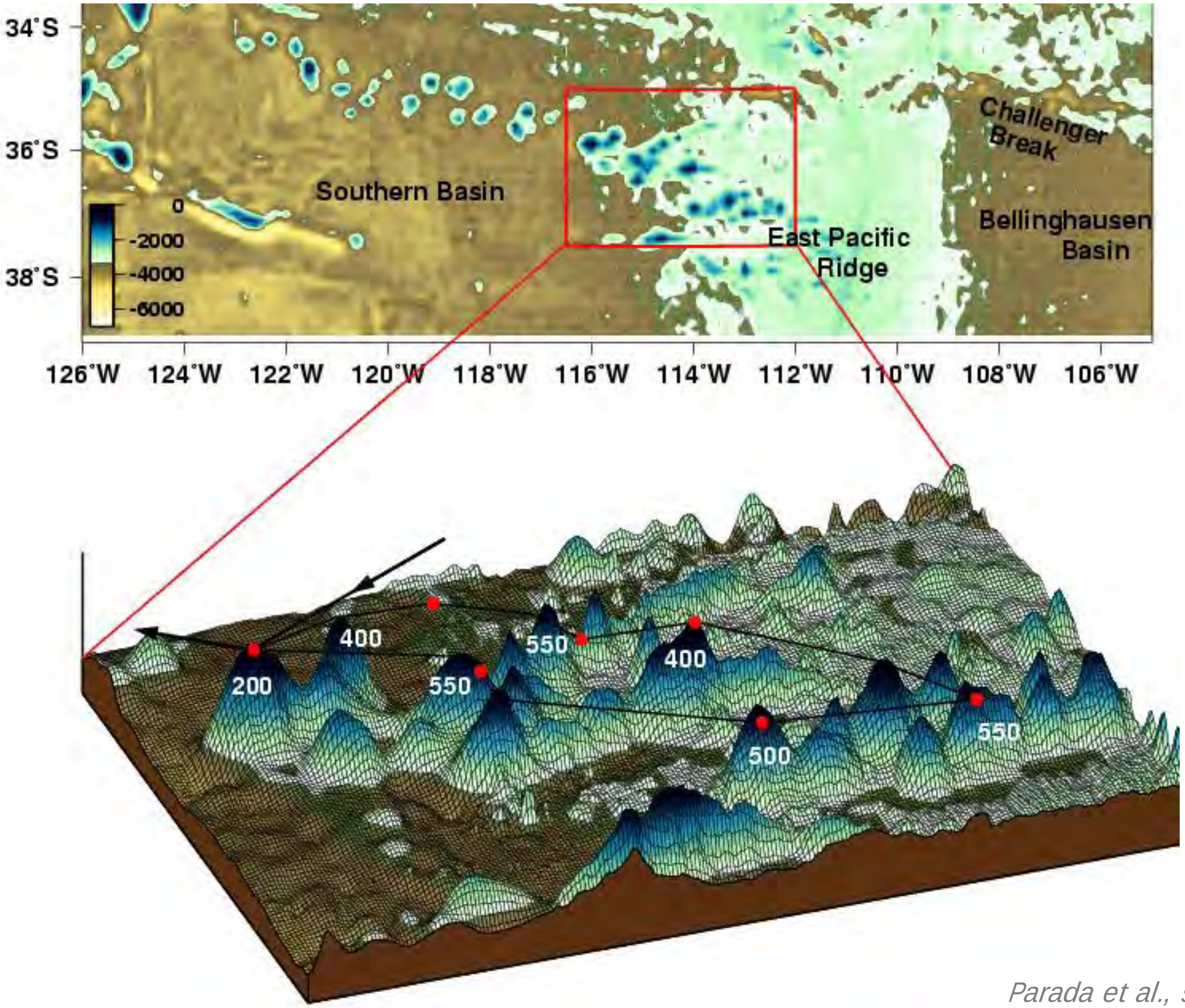
Vásquez et al., submitted

Jack Mackerel conceptual model



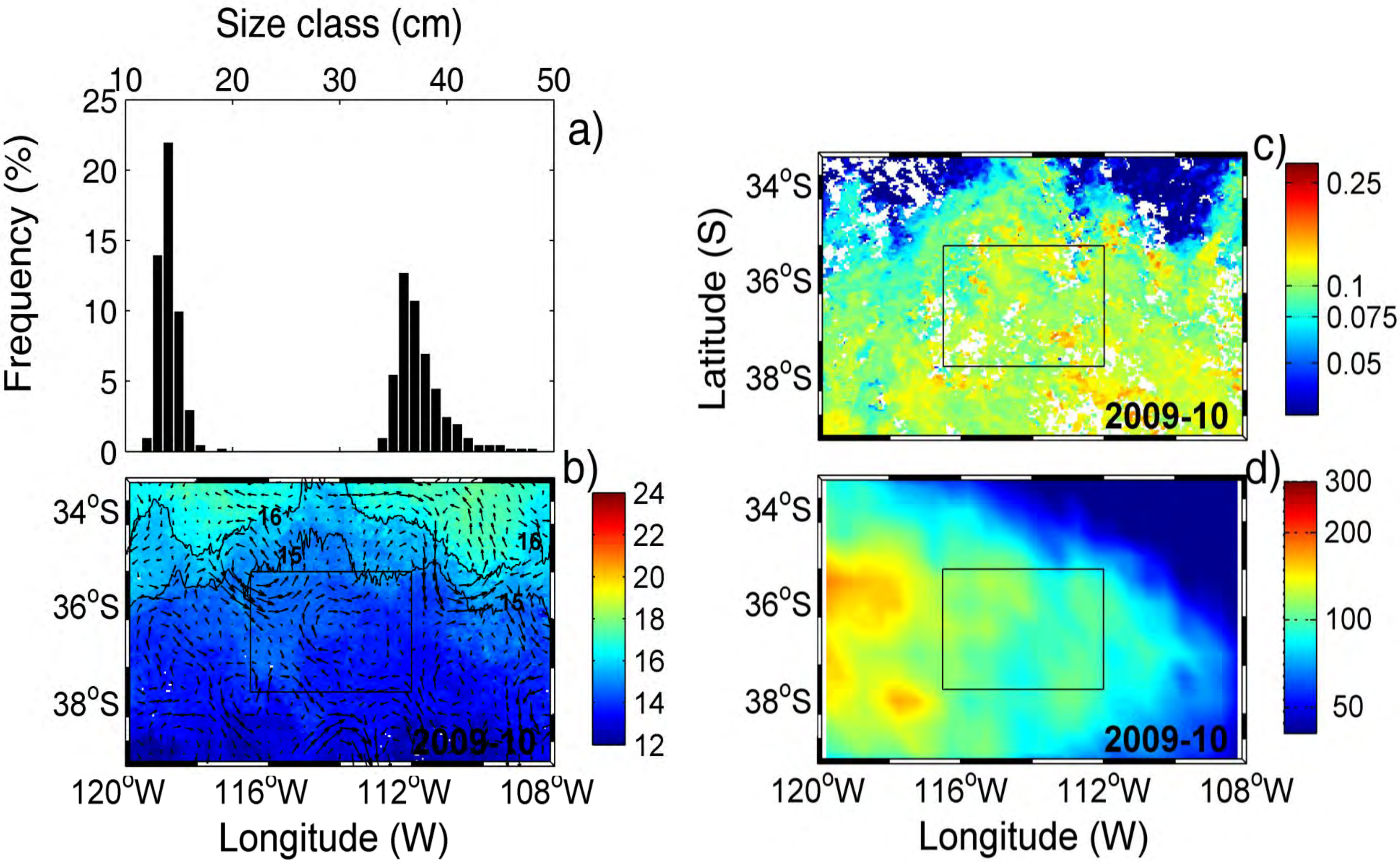
Parada et al., submitted

Challenger break: seamount region



Parada et al., submitted

Spawning habitat in the Seamount region



Parada et al., submitted

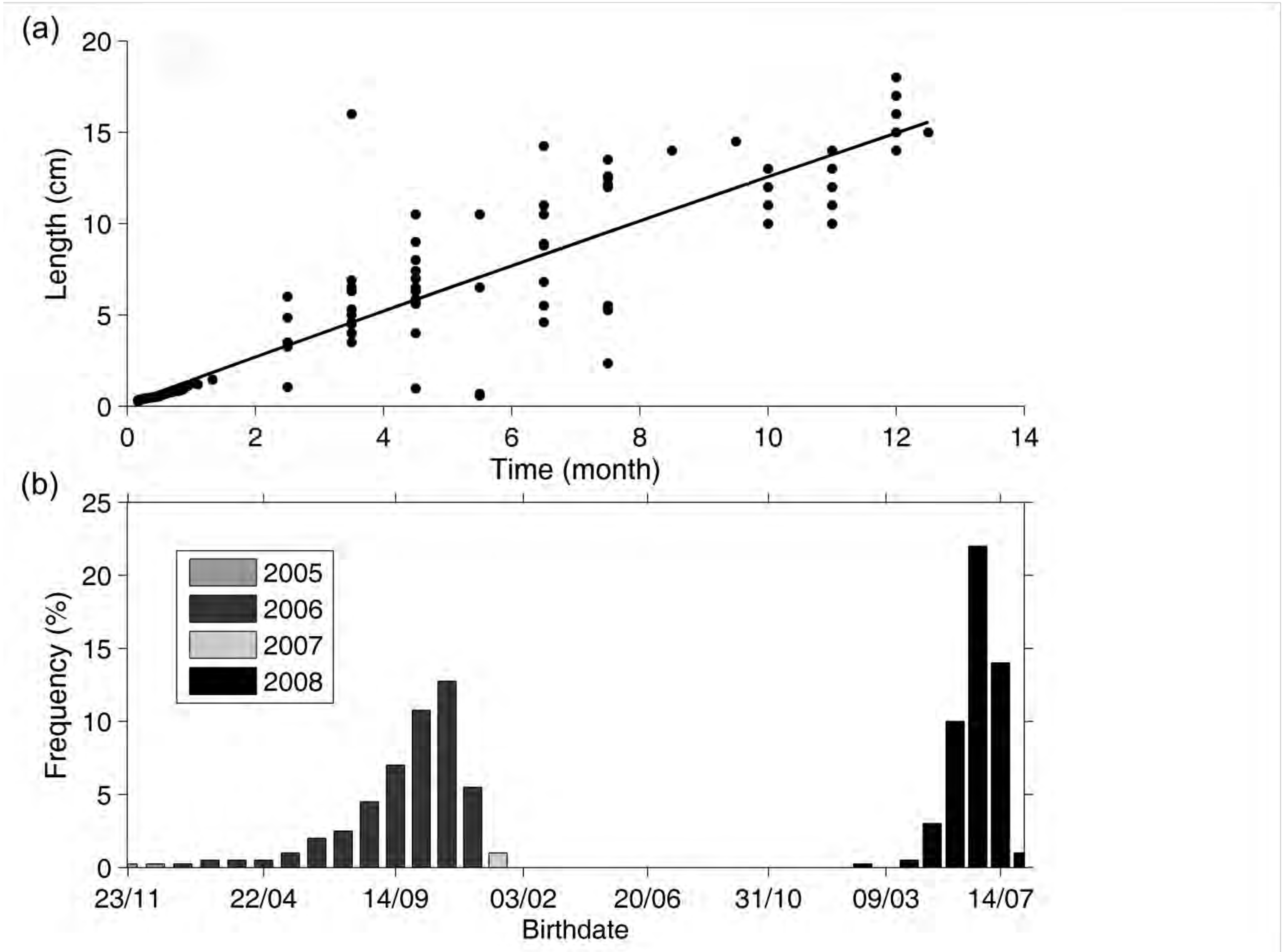
Juvenile collected since 1980's in seamount region

Table 2. Compilation of jack mackerel juveniles data collected by Industrial fishing Russian fleets and Oceanographic cruises in the southeast Pacific Region associated to seamounts region.

Cruise	Dates	Region prospected	Minimum and Maximum size of juvenile jack mackerel sampled (cm)	Size of aggregations	References
Fisheries Oceanography Research cruises organized by VNIRO and AtlantNIRO, Ex Sovietic Union.	January 1980	40°41'20"S-111°30'W	4-6 cm	Biological samples	Logbook of fishing set of research fishing boats VNIRO y AtlantNIRO (Com. pers. A. Gretchina)
	January 1980	38°40'S-109°50'W	5-9 cm		
	January 1982	36°40'S-106°40'W	6-7 cm		
	February 1985	39°42'S-125°46'W	9.2-10.2 cm		
	February 1987	36°17'S-116°00'W	8-13 cm		
	March 1987	35°07'S-105°03'W	8-13 cm		
	May 1987	41°45'S-111°52'W	16-22 cm		
	May 1987	41°12'S-112°17'W	18-25 cm		
	March 1988	38°57'S-112°41'W	6.5 cm		
	February 1988	34°59'S-108°27'W	5-13 cm		
Industrial boat Margiris Theodora	1 September 2008	southeast Pacific 34°15'S / 102°04'W	12-20 cm and 33-35 cm	Commercial aggregations	Com.pers. Anikeev V.
BIC Atlantida conducted by AtlantNIRO	18 – 22 October 2009	southeast Pacific 34°-36°S/109°-112°W	12-19 cm and 34-45 mm	Commercial aggregation	Cruise report of research activities of BIC Atlantida, AtlantNIRO (Anikev et al., 2010)
Russian Industrial opportunity ships	May-June 2010	40°-44°S/98°-104°W	20-25 cm	Commercial aggregation	Com.pers. Anikeev V.

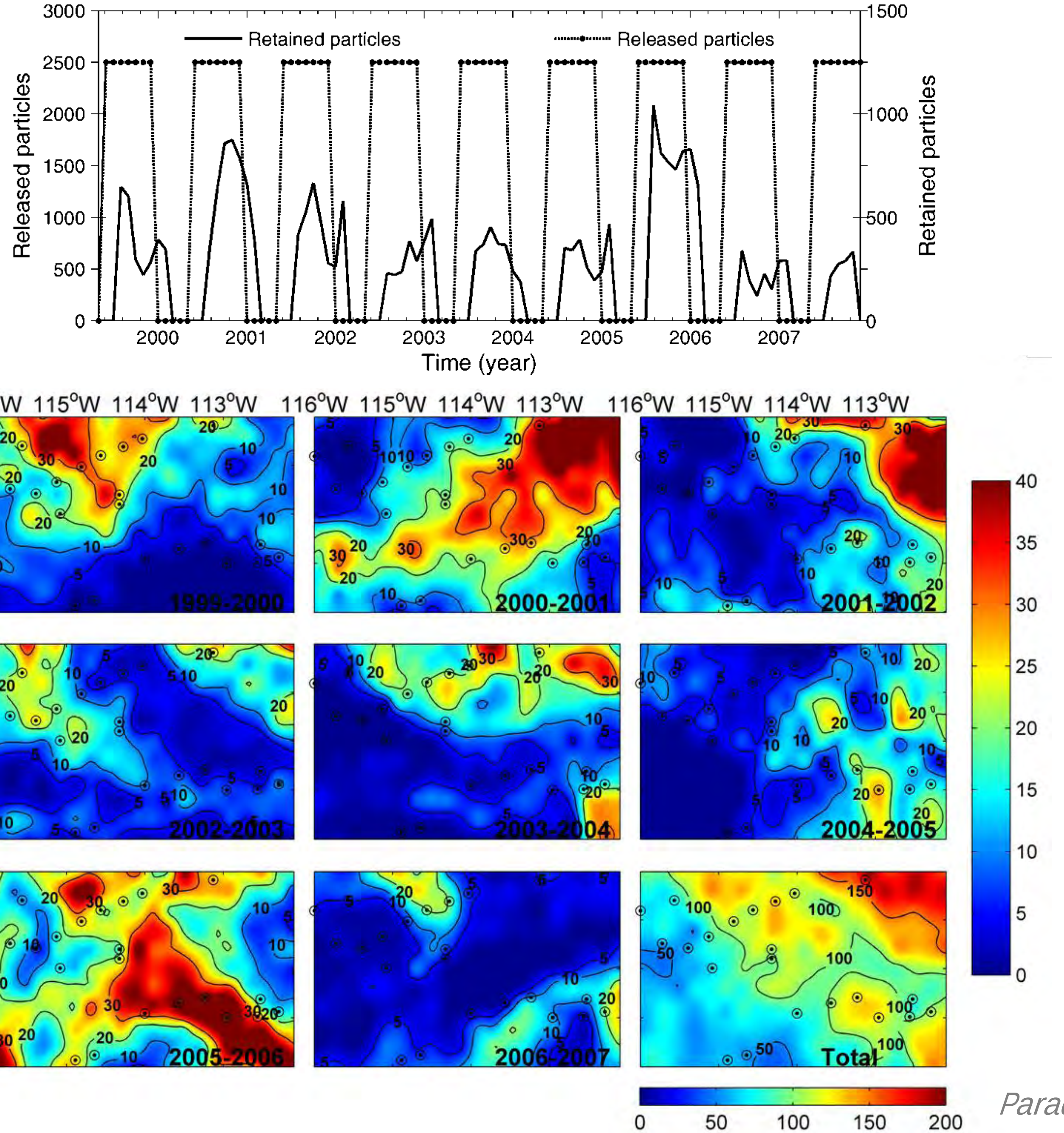
Parada et al., submitted

Age-length function and birthdate retrocalculation



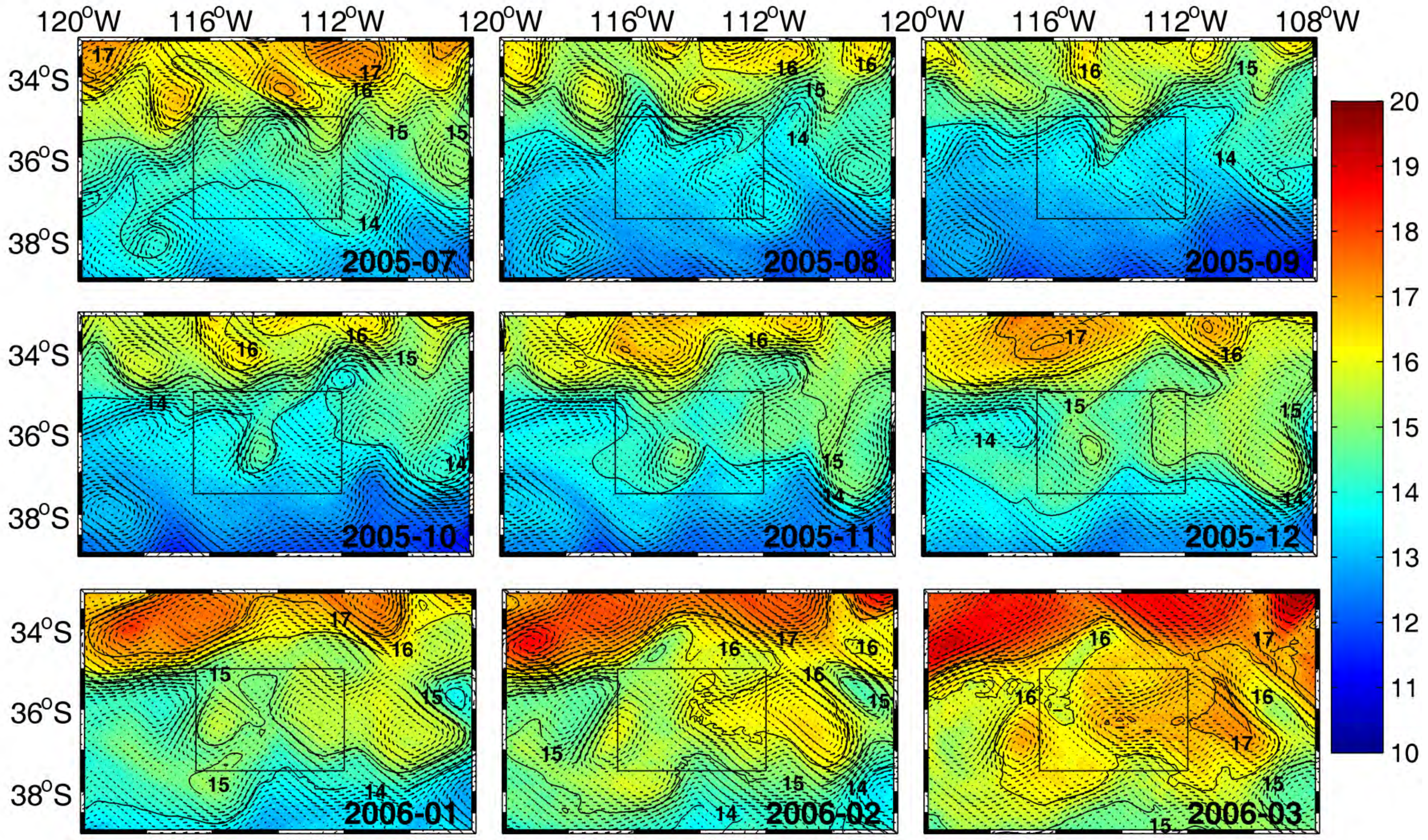
Parada et al., submitted

Simulated Temporal and Spatial Retention



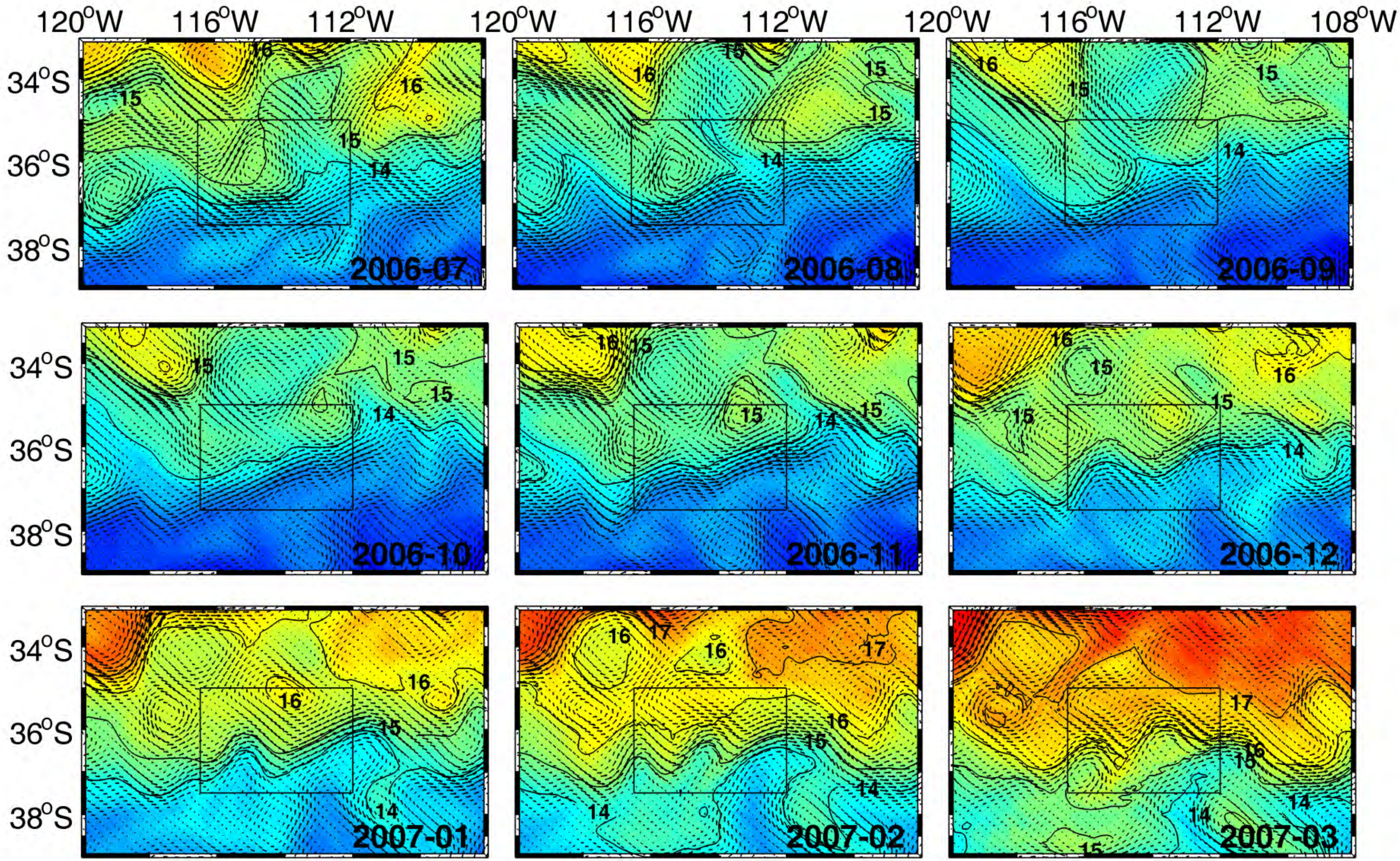
Parada et al., submitted

Mesoscale Eddies in a good Retention Year



Parada et al., submitted

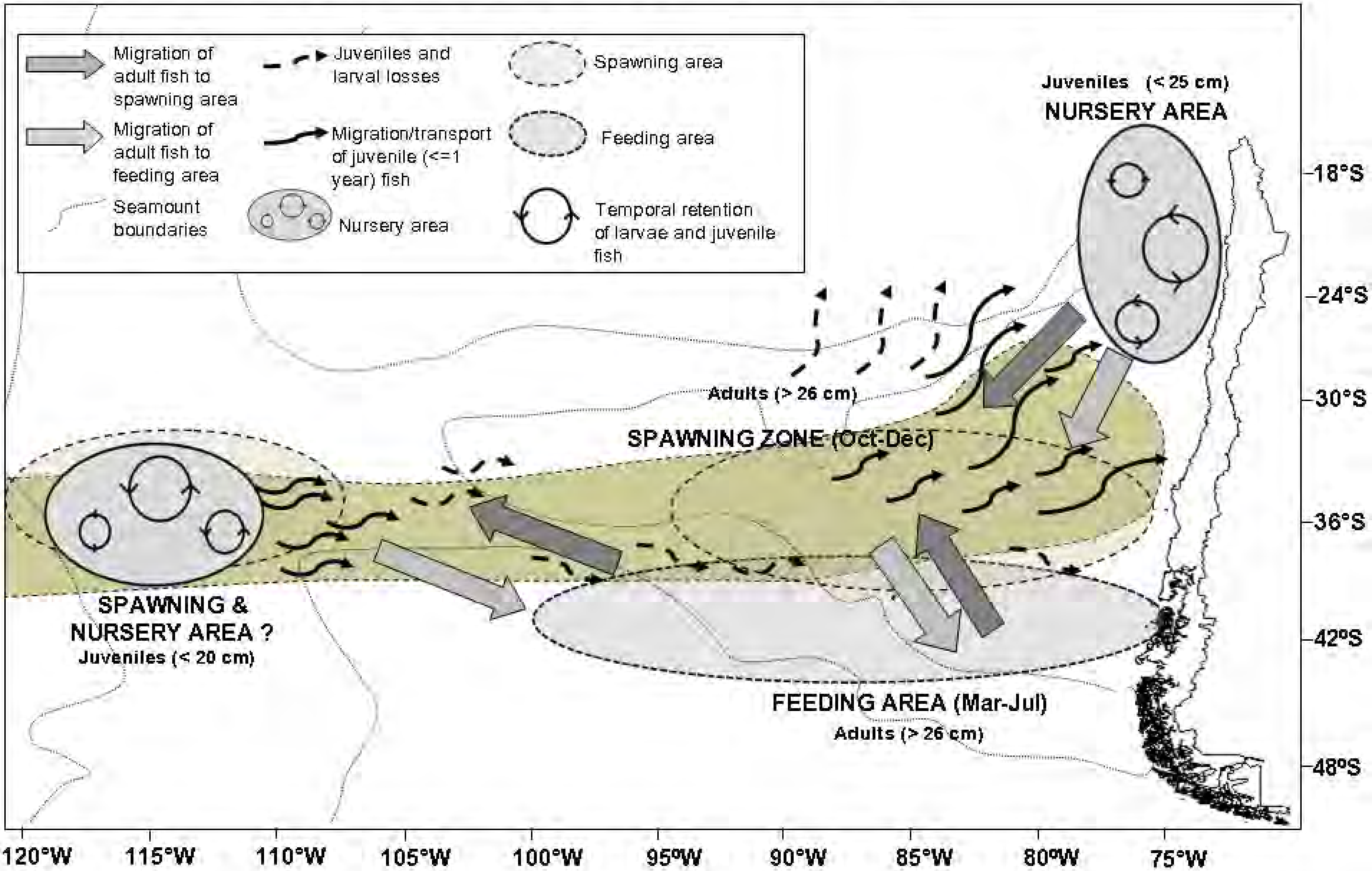
Mesoscale Eddies in a Bad retention Year



Parada et al., submitted

Parada et al., submitted

JACK MACKEREL CONCEPTUAL MODEL OFF CHILE



Summary

- Jack mackerel oceanic spawning region is connected to nursery ground in the north of Chile (>30°S)

- Recruitment indices from IBM simulation are in good agreement with stock assessment estimates

- There are spawning/nursery regions in seamount region that might be important for the population

- The role of stationary eddies (on retention) in the seamount challenger break region

- Expand the conceptual model of Jack Mackerel in the South Pacific

Future and Challenges

- Explore whether modeled eddies and its scales are realistic (physics involved)

- Explore how productive those eddies are?

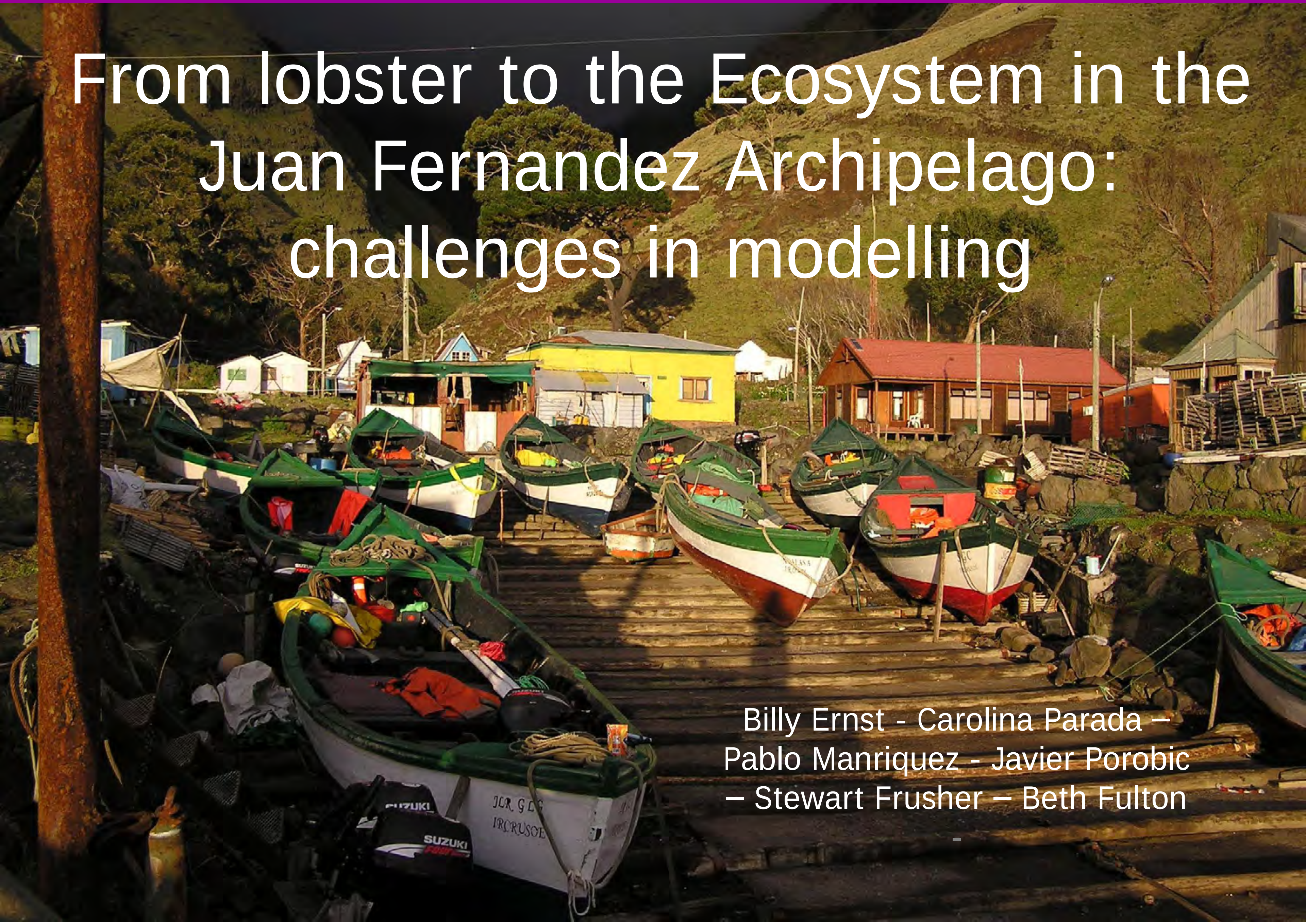
- Explore whether biophysical indices can be informative and input in single/multi species population dynamic model (increase predictability?)

- Refine further mortality sources (and data collected) to improve our ability to model population dynamic variability

Acknowledgement

- FATE
- North Pacific Research Board
- Conicyt

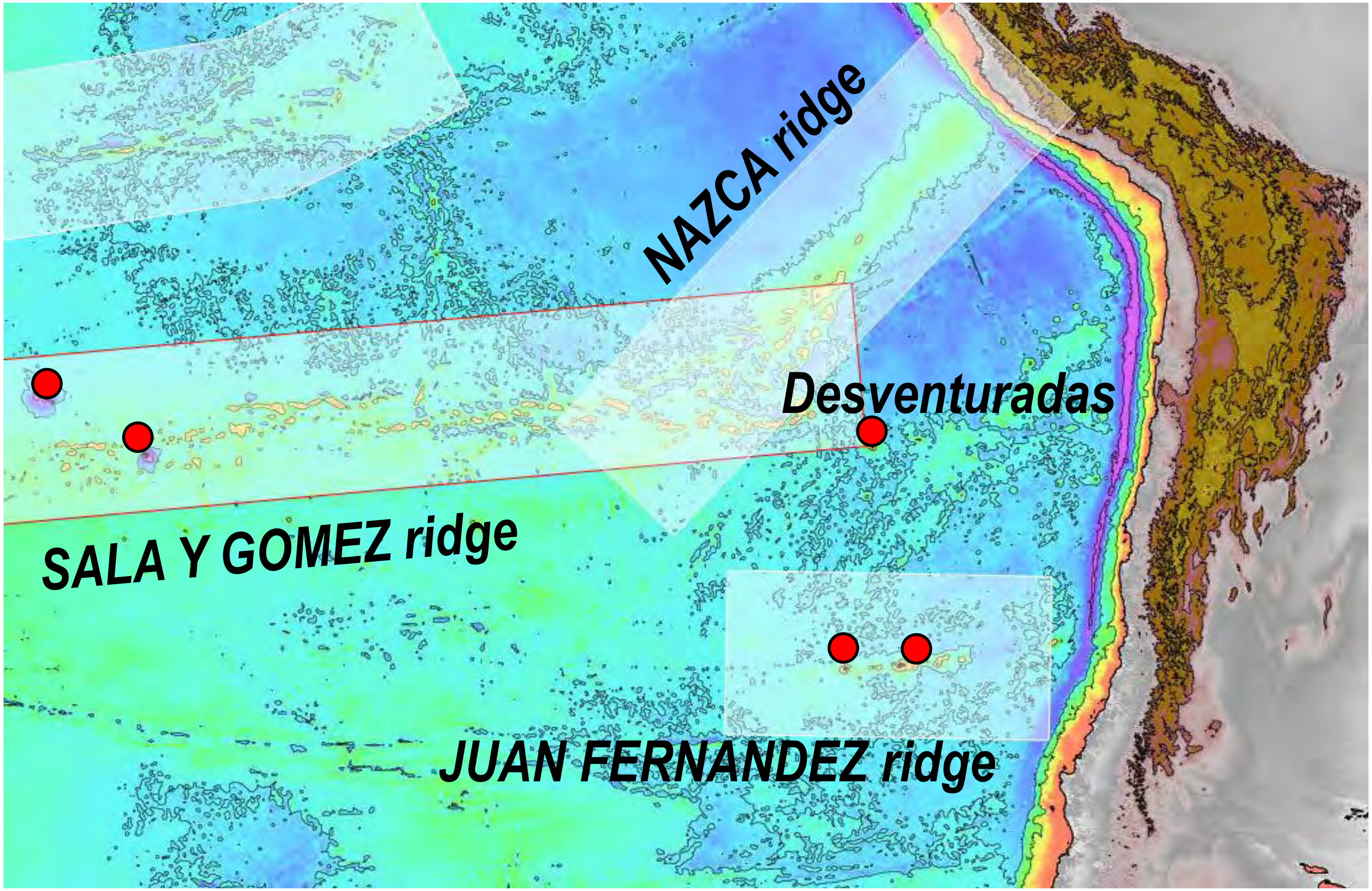
- Franz Mueter
- Jaison Waite
- Myriam Doyle
- Sebastian Vasquez
- Alexandre Gretchina



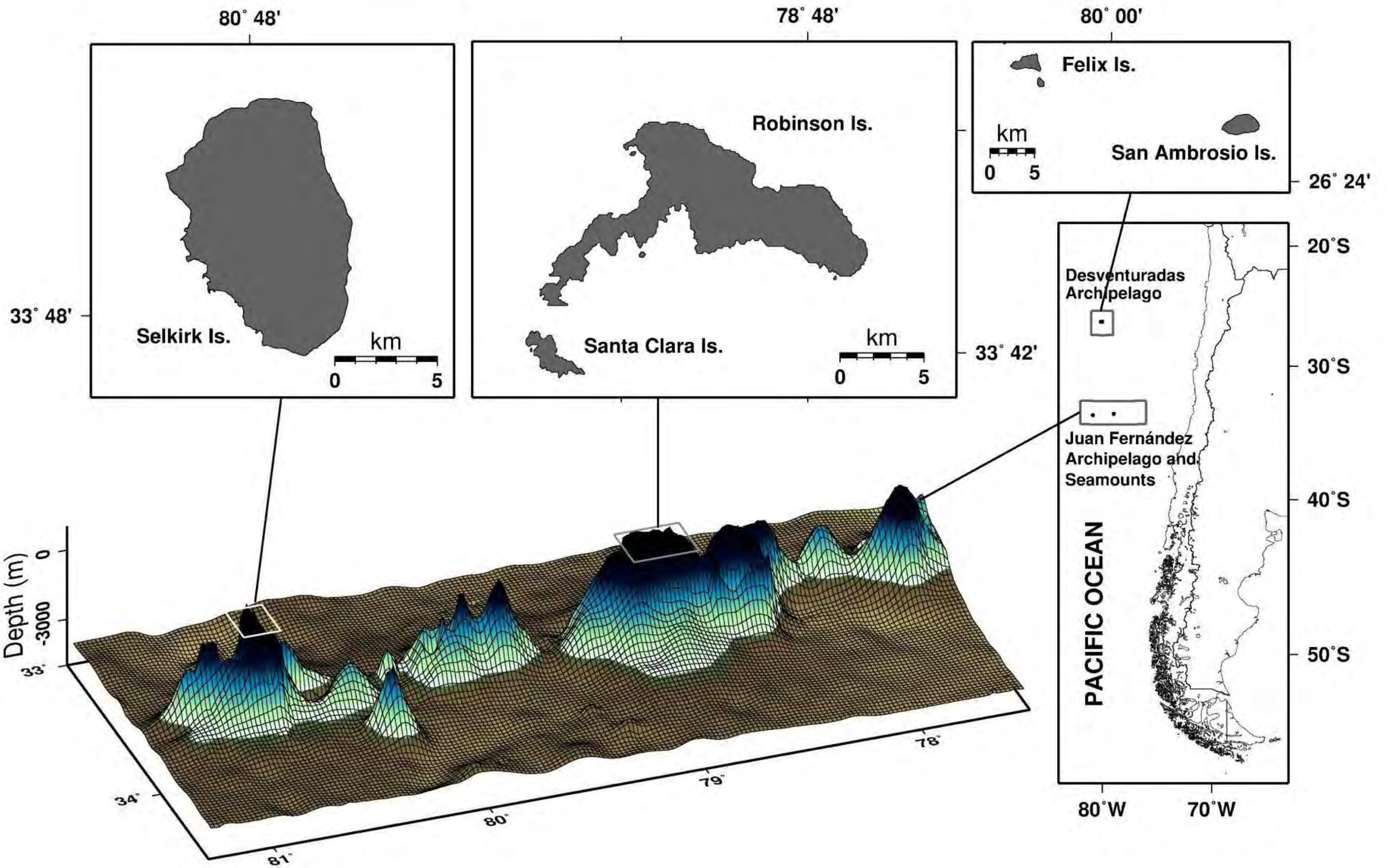
From lobster to the Ecosystem in the Juan Fernandez Archipelago: challenges in modelling

Billy Ernst - Carolina Parada – Pablo Manriquez - Javier Porobic – Stewart Frusher – Beth Fulton

Oceanic islands



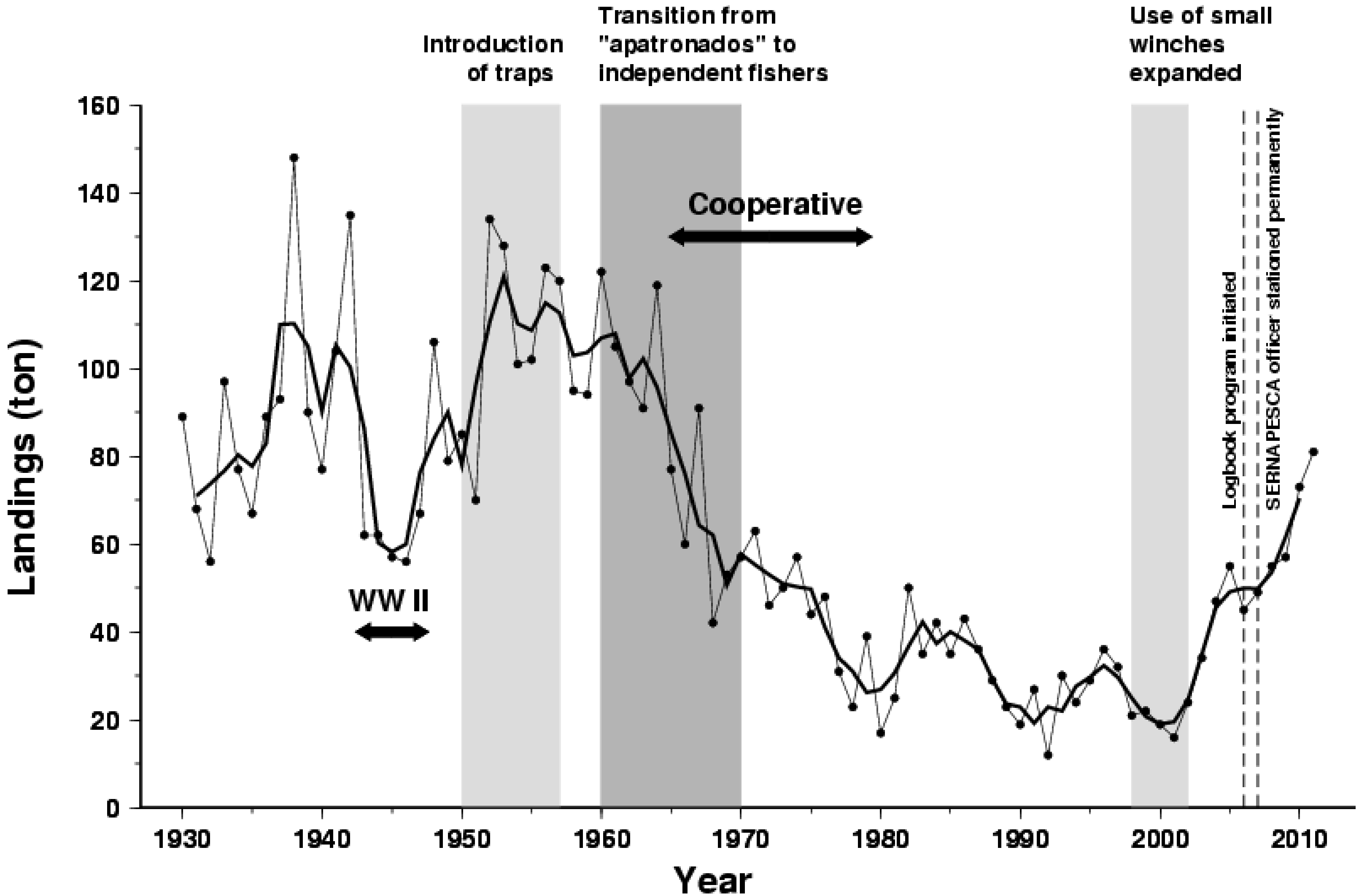
Juan Fernandez Ridge



Fisheries in Juan Fernandez Archipelago

- Started in 1883
- Modern fishery took shape after 1914
- Has remained an artisanal activity
- Lobster fishery is the mainstay of the archipelago community
- The lobster fishery through several associated bait fishery has an impact on the pelagic, demersal and benthic communities.

Landings

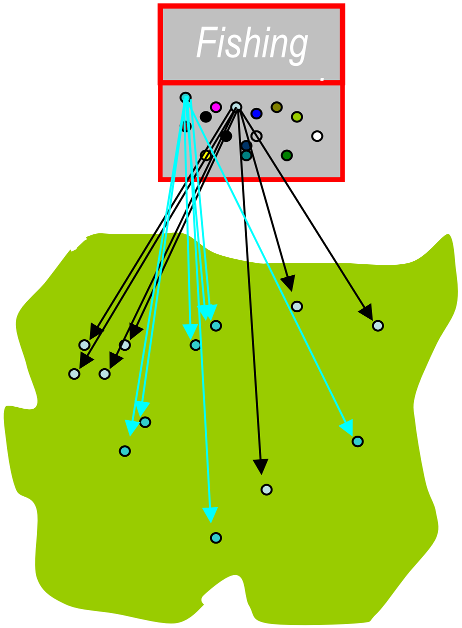


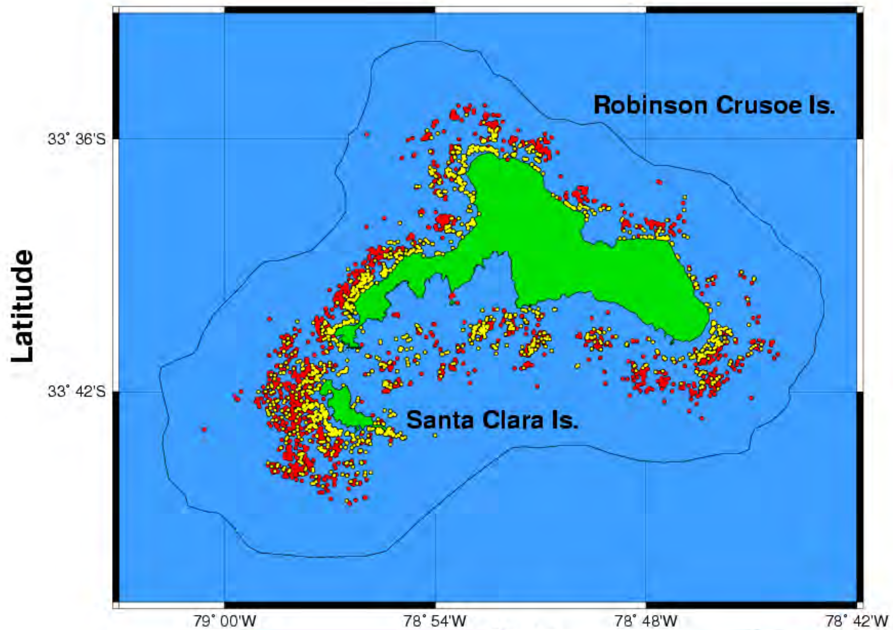
Introduction of traps
Transition from "apatronados" to independent fishers
Use of small winches expanded
Cooperative
WW II
Logbook program initiated
SERNAPESCA officer stationed permanently
Landings (ton)
Year
0
20
40
60
80
100
120
140
160
1930
1940
1950
1960
1970
1980
1990
2000
2010

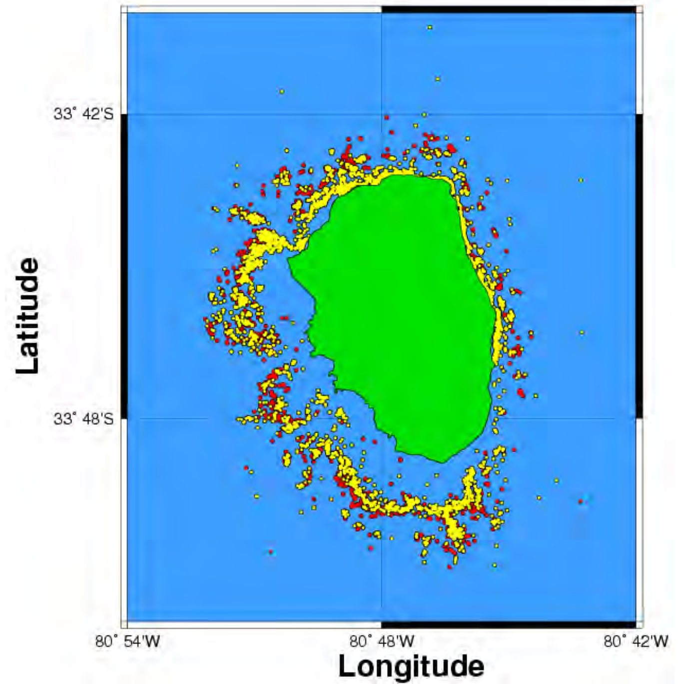
Management

- Formal regulations (SSS type fishery)
- Informal (Sea tenure system of individual discrete fishing spots)
  - We developed several surveys, interviews and field measurements to describe this system.

Juan Fernandez Lobster





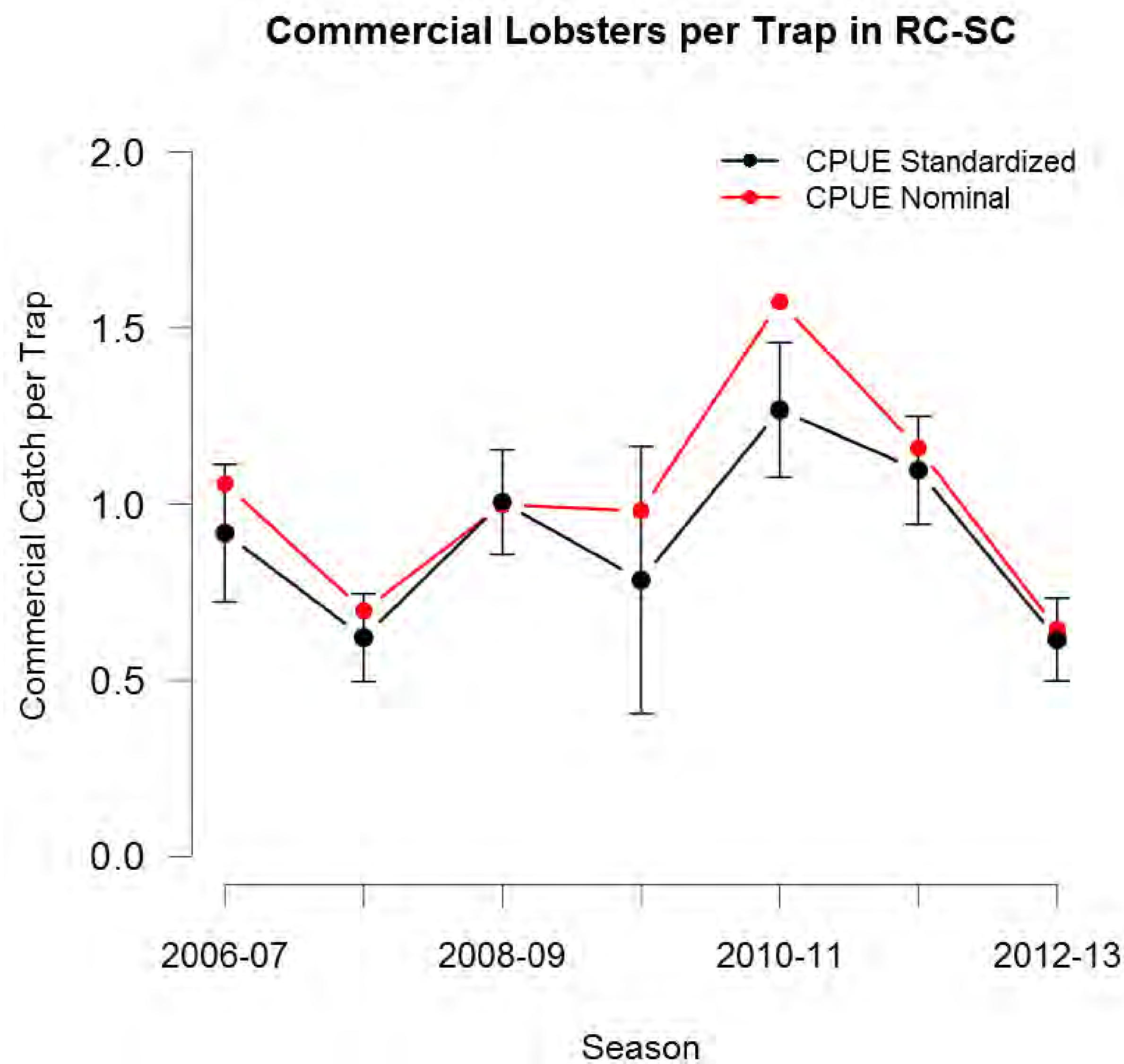


- Access to resources is controlled by historical rights of INDIVIDUAL DISCRETE FISHING SPOTS
- The role of the community is to endorse this system

The «log book program»

- In the past not enough data was collected
- Common problem in S-fisheries
- Development of a cost-effective logbook program:
  - Use local manpower
  - Barefoot ecologist type of approach
  - No hyperstability of indicators
  - Known spatial coverage of participants
  - This has evolved into a cost-effective government financed monitoring program

CPUE


Commercial Lobsters per Trap in RC-SC
CPUE Standardized
CPUE Nominal
Commercial Catch per Trap
2.0
1.5
1.0
0.5
0.0
2006-07
2008-09
2010-11
2012-13
Season

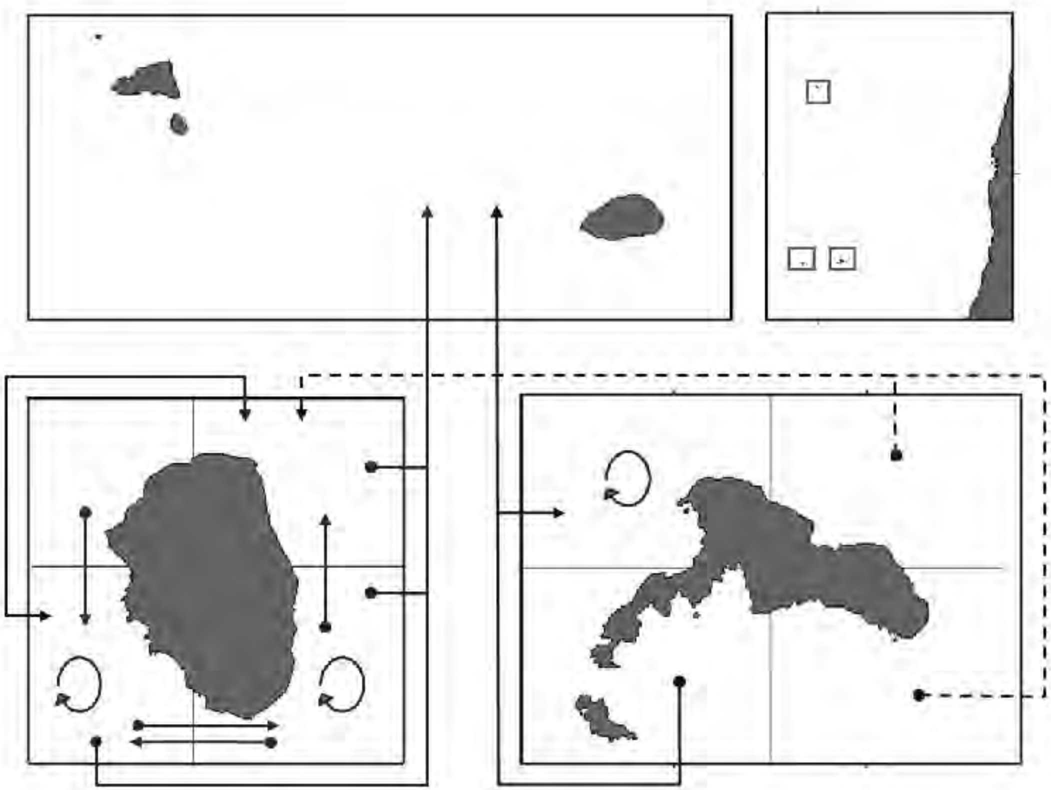
Sustainability of the island System

- Lobster fishery has operated sustainably for 120 years
- New challanges are associated to increase in fishing effort and other fishing activities that might impact the ecosystem
- Given the configurations of the islands there is a need for understanding connectivity
- Effect of environment at different temporal scales (low and high frequency)

Oceanographic models

- Low resolution OFES model for the Eastern South Pacific.
- High resolution ROMs model for the Juan Fernández ridge
- Effect of mesoscale gyres and EMI on chlorophyll-a distribution around the islands
- Intrathermocline eddies fertilizing the Juan Fernández ridge.

Connectivity of *Jasus frontalis* Subpopulations



Overview:

- High level of genetic connectivity

  Porobić et al., 2013

- Significant migration flows among subpopulations (Biophysical Model)

  Porobić et al., 2012

- Pelagic stage up to 12 months

  Arana, 1987

- Connectivity highly influenced by oceanographic processes.

  Porobić et al., 2012

Ecosystem-based management

- Under the light of recent advances in understanding the physical environment and the interaction with biological systems

- Small and vulnerable ecosystem
- Interplay of different fisheries (e.g. lobster and all bait fisheries)

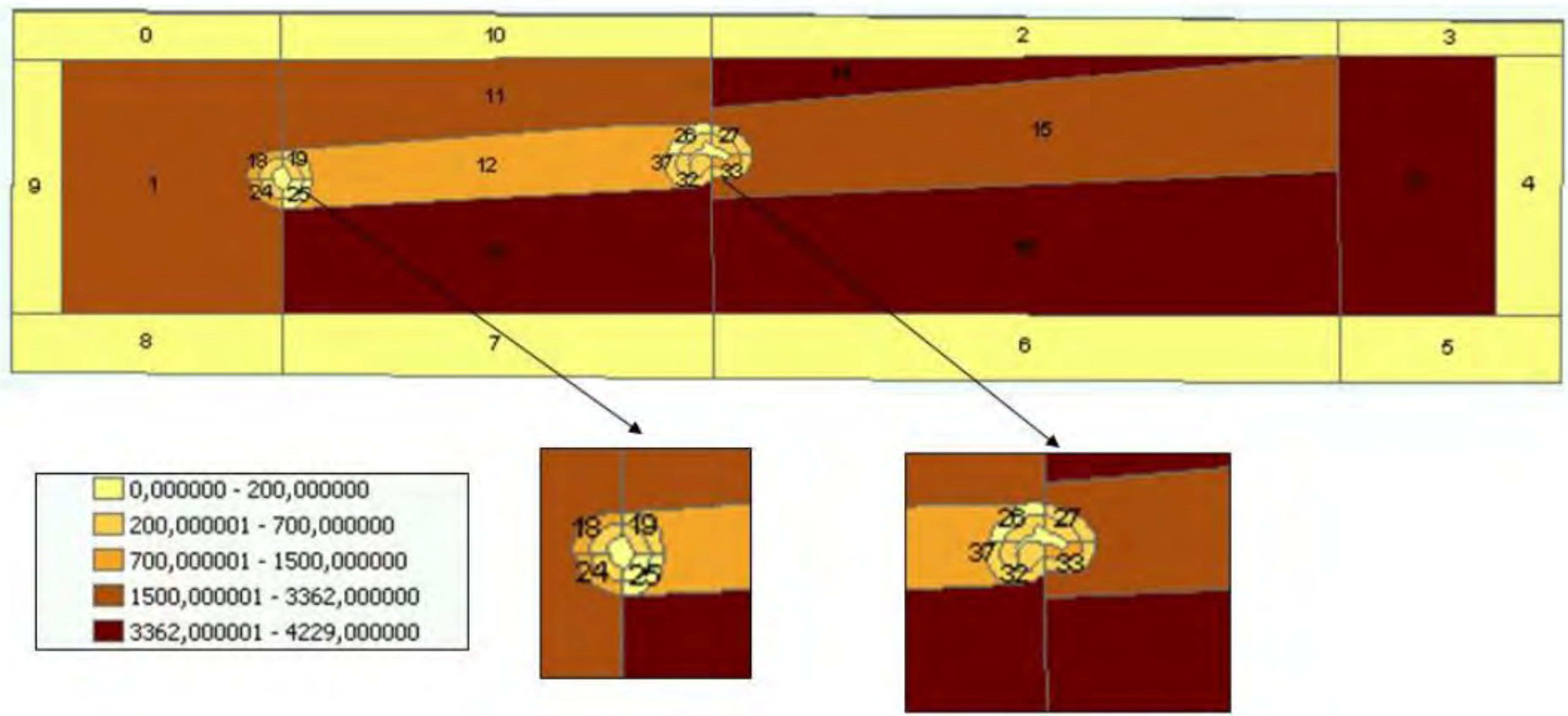
- Ecosystem approach to study sustainability of Juan Fernández resources

- Develop a comprehensive research program for the Juan Fernández ecosystem → Using ATLANTIS framework

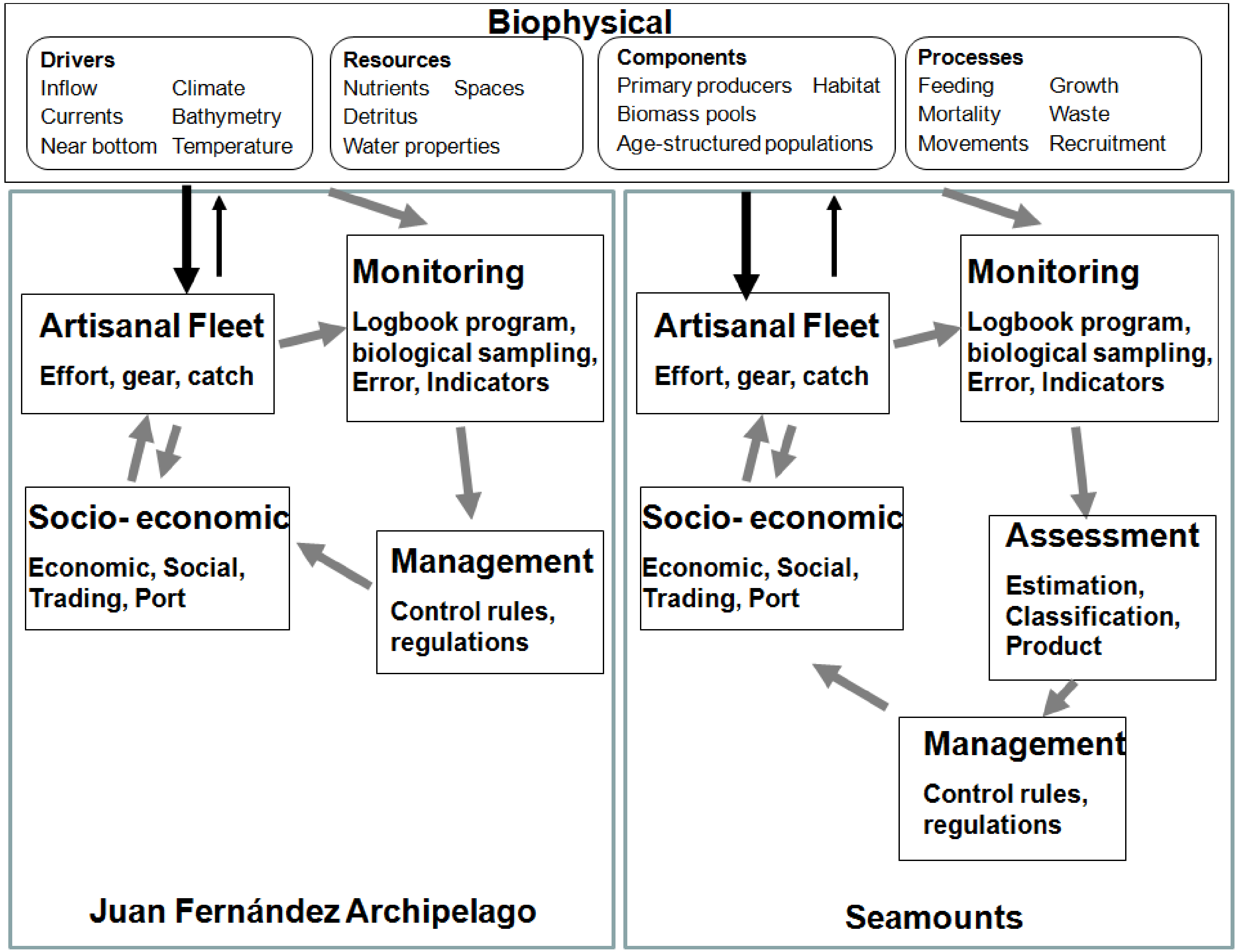
Spatial Domain of Ecosystem model

- The biophysical submodel of ATLANTIS is a 3D deterministic model, conformed by a system of irregular polygons whose size is characterized by the scale of the process at each location.

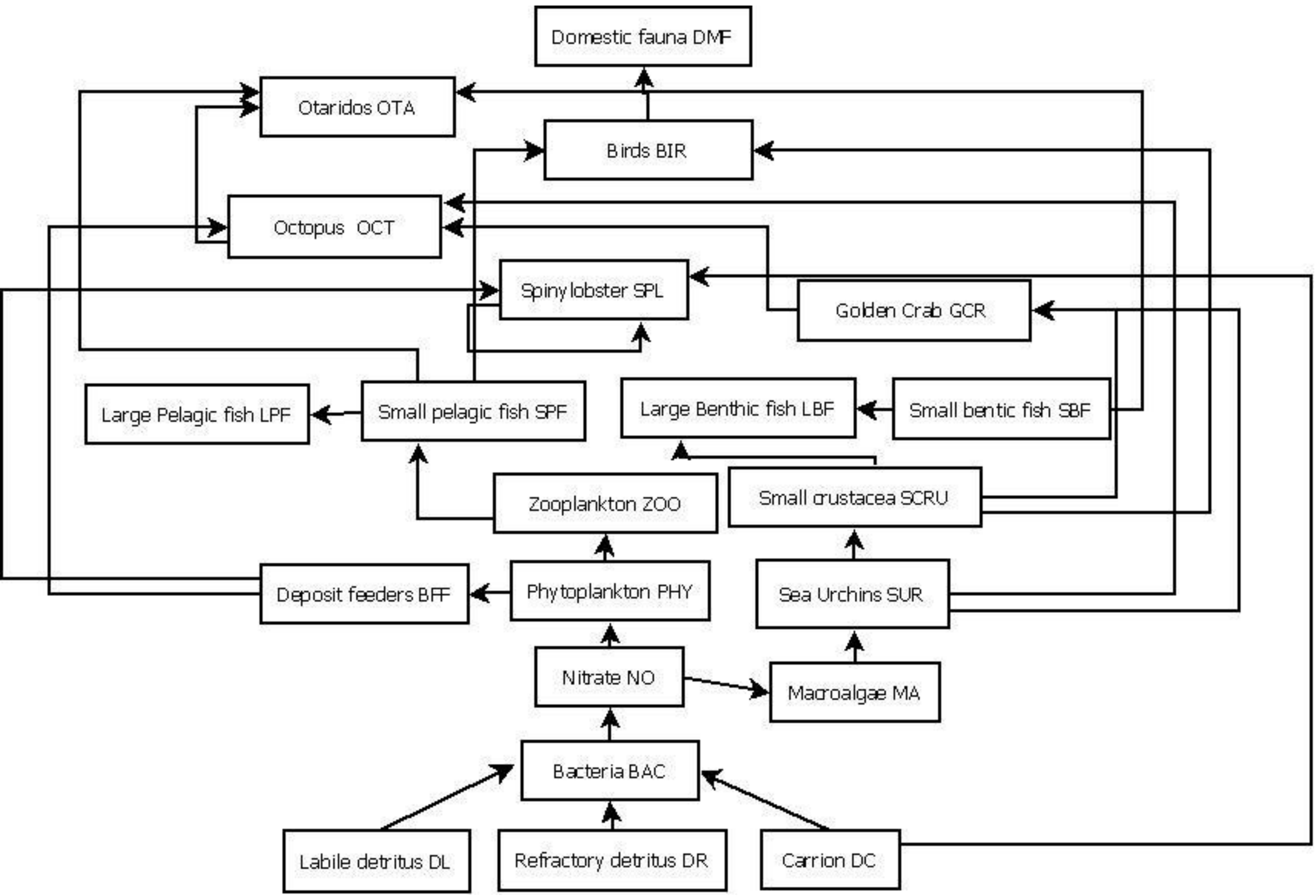
- The horizontally generated polygons have a bathymetric representation associated to vertical layers, which go from 3 to 6 depending on the polygon bathymetry and species habitat definition.



Atlantis Framework



Functional Groups



Outcomes and challenges

- Assess the impact of various management actions, with spatial considerations
  - MPA performance
  - Input and output controls
- Impact of the development of new fisheries on the lobster complex and JF ecosystem
- Assess the productivity of different JF ecosystem
- Identify research gaps associated to ecosystem modelling

Acknowledgement

- All syndicates from the islands (STIPA, SPIIAS)
- Chilean Undersecretariat of Fisheries
- SERNAPESCA
- CREO Scholarship
- And many other people that collaborated

Future and Challenges

- Explore whether modeled submesoscale eddies and its scales are realistic (physics involved)
- Explore how productive those eddies are?
- Explore whether biophysical indices match recruitment variability of target species
- Explore whether biophysical indices can be informative and input in single/multiple population dynamic model (reduce uncertainty – increase predictability)
- Refine further mortality sources (and data collected) to improve our population dynamic variability
- Disciminate the effect of environmental variables