2021 Report of the Section on *Marine Birds and Mammals*

The meeting of the Section on *Marine Birds and Mammals* (S-MBM; under the auspices of the BIO Committee) was held virtually on September 29, 2021) from 17:00–20:00 hours (PDT; UTC-7hrs) via Zoom, hosted by the PICES Secretariat. The meeting focused on the current activities of S-MBM and on preparations for next project associated with the S-MBM Terms of Reference.

Dr. Patrick O'Hara (Co-Chair, Canada) and Dr. Kaoru Hattori (Co-Chair, Japan) called the meeting to order and welcomed members and observers (*S-MBM Endnote 1*).   S-MBM members representing Canada, Japan, Korea and USA were present. S-MBM members from China and Russia did not attend.

AGENDA ITEM 1
Adoption of agenda

The agenda was reviewed and approved (*S-MBM Endnote 2*).

AGENDA ITEM 2
Membership changes

No membership changes.

AGENDA ITEM 3
Reports from participants

a) Dr. Andrew Trites and Dr. Tsutomu Tamura reported on previous S-MBM activities. They have completed data acquisition, analyses and model validations needed to finalize our report on "Food requirements of marine mammals in the North Pacific" to be tabled and presented at next year's Annual Meeting. In relation to this activity, Dr. Trites co-convened an ICES theme session titled "*Top predators, food webs, and ecosystem-based fisheries management*" (September 10, 2021; 28 presentations; >200 participants). The session concluded with a recommendation that ICES and PICES hold a joint workshop on Ecosystem Based Fisheries Management that brings together its wealth of scientists from their different expert groups (*S-MBM Endnote 3*).

b) Dr. Ken Morgan and Dr. O'Hara reported on their participation in the WG 47 (Ecology of Seamounts) business meeting (September 20, 2021) as representatives of S-MBM. A number of common interests have been identified between WG 47 and S-MBM in Terms of Reference and work/activity plans. S-MBM will continue to work closely with WG 47 as they progress through their work plan.

c) Dr. O'Hara reported that he submitted a session proposal for the Ocean Sciences Meeting (February 27–March 4, 2022) on "*Environmental indicators of plastic pollution in the North Pacific*" (Matthew Savoca as lead convenor with Chengjun Sun, Won Joon Shim, Patrick O'Hara).

d) Dr. Tamura provided a report on the 2021 International Whaling Commission Scientific Committee (IWC/SC) meeting, held virtually (*S-MBM Endnote 4*). Dr. Tamura continues as an observer representing PICES.

e) Participants reported past and future meetings related to S-MBM activities. Notable symposia include:
- World Seabird Conference will be held on October 4–8, 2021 virtually, with three sessions related to S-MBM activities: 1) Plastics (Dr. Yutaka Watanuki and Dr. Miran Kim as presenters), 2) Marine Heatwaves (Dr. William Sydeman and Dr. O'Hara), and 3) Boat disturbances on birds (Dr. O'Hara).
- Pacific Seabird Group Meeting will be held on February 23–25, 2022 virtually.
- Marine Mammal Conference has been postponed till August 2022.

f) W3 "*Anthropogenic stressors, mechanisms and potential impacts on Marine Birds and Mammals*" has been canceled for PICES-2021 due to few submissions, and resubmitted with revision as a workshop on "*Anthropogenic stressors, mechanisms and potential impacts on Marine Birds, Mammals, and Sea Turtles*" for PICES-2022 (*S-MBM Endnote 5*).

AGENDA ITEM 4
Discussions

a) *Review of Terms of Reference*

A resubmitted workshop proposal for PICES-2022 on "*Anthropogenic stressors, mechanisms and potential impacts on Marine Birds, Mammals, and Sea Turtles*" was modified to include more stressors, with a shift in emphasis from the East to West Pacific, and includes sea turtles as a receptor (*S-MBM Endnote 5*).

b) *S-MBM project on "Climate and Trophic Ecology of Marine Birds and Mammals"*

Members reviewed current work on the 2015–2020 S-MBM project on "Climate and Trophic Ecology of Marine Birds and Mammals" estimating food consumption using a new generation of bioenergetic models (an update of PICES Scientific Report 2000).
- a table has been prepared that updates Hunt *et al*. (2000) estimates for marine mammal consumption rates,
- COVID-19 has delayed progress on report;
- A scientific report will be submitted at PICES-2022 scheduled to be held in-person in Busan, Korea (hopefully).
- Short case-study reports on birds in Japan and Korea will be included.

c) *S-MBM new project on "Interaction between MBMs and other ecosystem components and stressors"*

Members discussed and agreed to ask for a postponement of the start of the S-MBM current Project Plan (2021–2025) one year due to COVID-related challenges. A revised of the plan is in progress, to be submitted for approval by Science Board at ISB-2022 (*S-MBM Endnote 6*).

d) *Review of S-MBM chairship*

S-MBM agreed to extend co-chair appointments until the next in-person PICES Annual Meeting to select replacements.

AGENDA ITEM 4
Others

S-MBM discussed the special SEAturtle project on turtle movement and was informed by the Secretariat of the latest status. On the SEAturtle page members noted the listed interactions did not include S-MBM. S-MBM requests that this special project also collaborate with us given the overlap with our upcoming 5-year plan.

S-MBM Endnote 1

S-MBM participation list

<u>Members</u>

Kaoru Hattori (Japan, Co-Chair)
Patrick D. O'Hara (Canada, Co-Chair)
Ken Morgan (Canada)
Andrew W. Trites (Canada)
Tsutomu Tamura (Japan)
Yutaka Watanuki (Japan)
Yong-Rock An (Korea)
Hyun Woo Kim (Korea)
Miran Kim (Korea)
Elliott L. Hazen (USA)

<u>Members unable to attend</u>

Canada: Douglas F. Bertram
China: Shuai Chen, Wei Lei, Xuelei Zhang, Liyuan Zhao
Russia: Alexander Boltnev, Vjatcheslav P. Shuntov,
     Andrey Vinnikov
USA: Rolf R. Ream, Willam Sydeman

<u>Observers</u>

Seok-Gwan Choi (Korea)
Vera L. Trainer (Science Board Chair)

S-MBM Endnote 2

S-MBM meeting agenda

17:00-20:00 September 29, 2021 (Pacific Time; UTC-07:00)

1. Call to order – Review Agenda (modify as needed)
2. Introductions - meeting participants, new members of PICES community; membership needs (if any); as EG report
3. Reports from participants
   a: Three main recent activities and their scientific achievements related to TOR; as EG report
      1) Completing estimation of food consumption
      2) Proposed 2021–2025 Activity Plan
      3) Others (if any; completed manuscript?)
   b: Report of IWC activities (T Tamura)
   c: International Symposium related to S-MBM activities:
      - World Seabird Conference/Pacific Seabird Group meeting
      - S-MBM participation at ICES
      - Others?
   d: W3 canceled for PICES 2021, and resubmitted as workshop for PICES-2022
   e: Other activities (if any)
4. Discussions
   a: S-MBM project
      ✓ Final products on 2015–2020 project "Climate and Trophic Ecology of Marine Birds and Mammals" (Lead by A Trites)
      ✓ A new focal project in 2021-2025 "Interaction between MBMs and other ecosystem components and stressors"
   b: Planning PICES 2022 Annual Meeting (Busan, Korea; September 23–October 2., 2022)
      ✓ Postpone and resubmit the workshop W3 to PICES-2022
      ✓ Additional proposals of Sessions/Workshops (if any)
   c: Review of S-MBM chairship
5. Others
   a: Additional information / other recommendations for SB (if any)

S-MBM Endnote 3

ICES Theme Session A report
on
"Top predators, food webs, and ecosystem-based fisheries management (EBFM)"

Conveners: Christopher Lynam (UK), Anita Gilles (Germany), Andrew Trites (PICES/Canada)

Session A received 28 presentations, including 14 from Early Career Scientists, that addressed 5 sub-topics:
1. **Foodweb modelling** to identify consumption requirements of top predators along with the production of fish prey (*e.g.*, multispecies functional response and dynamic energy budget models) [8 presentations];
2. **Spatio-temporal empirical studies** to identify overlap between predators and prey [8 presentations];
3. **Evidence of indirect interactions** between fisheries and top predators: specifically, competition for food sources or fisheries losses (discard/slippage/offal discharge) as a food source [4 presentations];
4. **Assessment approaches** that can deliver ecosystem advice including but not limited to the extension of multi-species fisheries models to include top predators, Bayesian network analyses and risk-based models [4 presentations];
5. **Management options** that enable productive fisheries and support conservation aims, including spatial and temporal management of fishing fleets through protected areas, seasonal closures, catch restraints and effort limits [4 presentations].

The majority of presentations fell under the first two sub-topics (predator–prey interactions), but each sub-topic was addressed with highly relevant and interesting material.

One additional presentation given by the PICES co-convener A. Trites explained the derivation of recently updated equations to estimate daily prey consumption by marine mammals as a function of their cost of living. These equations were used by T. Tamura who demonstrated that survey estimates of biomass, along with residence time, for a range of cetaceans can be used to determine the prey levels that current populations of marine mammals require in the North Pacific. For the Nordic and Barents Seas, M. Skern-Mauritzen compared marine mammal consumption to removals by fisheries, and emphasized the importance to integrate these complex mammal-fisheries interactions in EBFM. However, such levels of prey must be available to the predators both temporally and spatially, including in the vertical dimension as addressed by J. Fall's study of interactions between capelin and cod in the Barents Sea.

Predator species may also compete for access to habitat and prey resources as suggested by N. Goñi's investigation on the avoidance of albacore tuna by bluefin tuna in the Bay of Biscay, while A. Dolgov noted the persistent lack of large predatory fish in the Arctic Seas. For successful foraging, prey species must also be of the appropriate size for the predator as demonstrated by A. Receveur's study of interactions between pelagic prey and predatory tuna and shearwaters in the southwest Pacific — and by A. Mulas for deep-sea elasmobranch species inhabiting the Sardinian slope. Additionally, climate change might drive alterations in abundance and body size (M. Erauskin-Extramiana). Clearly effective foraging requires a greater biomass of prey in an ecosystem than solely that needed to meet energy demands of the predator, but it is also important to note that the size and energy content of prey differs between species (as demonstrated by C. Booth for harbour porpoise diet). Diet studies, such as from A. Preti on dolphins, are key to understand spatio-temporal shifts in predator distribution but also highlight the need for more information on prey distribution. In this respect new methods, such as DNA-barcoding techniques (Lucile Ranguin/Jean-Paul Robin) are key to overcoming some limitations from hard-part analysis.

There are a number of ways in which fisheries impact top predators. For example, I. García-Barón demonstrated that Great shearwater over the Armorican slope and southern off-shore waters are at risk of

bycatch by the Artisanal tuna fishing fleet. In addition, fisheries can lead to indirect impacts on predators as shown by the model study of O. Paradell, who found that diet of top predators can be altered when ecosystems are fished at high or low levels. Alternatively, N. Kulatska demonstrated that natural mortality on sprat in the Baltic Sea (*i.e.*, through predation by cod) was greater historically than mortality imposed by pelagic fisheries, but as the cod stock declined and consumption shifted towards smaller individuals this pattern reversed. J. Burgess documented an increased mortality rate of grey seals in years with higher sandeel landings potentially linked to indirect competition with fisheries for sandeels or concomitant with change in the environment. Thus, fisheries management can have unintended consequences such as that postulated by S. Quer in her study on the potential early implications of the landings obligation on Great skua diet since a decrease in the proportion of fish prey has been observed since 2015.

Fisheries and predators are able to coexist as demonstrated by P. Breen in her study of the common scoter and razor clam fishery in the Irish Sea. The qualitative modelling approach of L. Clavareau demonstrated clearly that depredating species can be tolerated by a fishery if fishers are more successful in capturing fish than depredating species are at removing their catch from fishing gear when stocks are sustainably managed.

Potential foodweb effects linked to commercial fishing were demonstrated by A. Fariñas-Bermejo whose study on top-predators in the Celtic Sea ecosystem found that a high abundance of the sprat stock was linked to the occurrence of fin whales, while humpback whales and minke whales were in higher abundance when herring dominated. Similarly, S. Surma demonstrated the Norwegian spring spawning herring were key in the diet of minke whales, harp seals and killer whales—and fisheries could have competed with top predators historically (1960-70s) when over half of herring production was harvested annually. Environmental variability and zooplankton productivity at the base of the foodweb is important also as demonstrated by the large-scale movements of baleen whales in the mid-Atlantic Ocean by S. Pérez-Jorge. Similarly, G. Pierce highlighted, in their study of persistent organic pollutants in small cetaceans in European waters, that human impact can arise through other activities. A fuller understanding of the impacts of contaminant and pathogen flow through marine foodwebs is required within EBFM.

From a foodweb perspective, areas of resilience can be identified from traits-based analyses as shown by L. Flensborg, which can inform spatial management to maintain ecosystem functioning. Marine Spatial Planning and management (MPAs) were considered key to the successful development of extensive wind farms offshore. One means to evaluate the trade-offs this poses for fisheries and conservation is to use spatial modelling through Ecopath with Ecosim (EwE) and the extension Ecospace as demonstrated by M. Püts.

M. Coll gave an overview of a programme of work addressing EBFM in the Mediterranean Sea. She addressed a significant body of work on the ecological and socio-economic consequences of the changes in small pelagic fish populations on fisheries, iconic predator species, and ecosystem-wide dynamics; and provided a robust means to evaluate future management options.

X. Corrales communicated the development of an EwE Ecospace model for the Bay of Biscay to inform Integrated Ecosystem Assessments enabling interactions between climate change and fishing strategies to be investigated. D. Chagaris similarly demonstrated that models of intermediate complexity, using the EwE framework, had been used successfully to deliver management advice for "Ecological reference points" for Atlantic menhaden.

J. Thayer's presentation "Implementing Ecosystem Considerations in California Current Fisheries" was particularly noteworthy as she demonstrated the wealth of studies required and the framework needed to integrate available information into management outcomes. In addition to identifying prey needs of predators
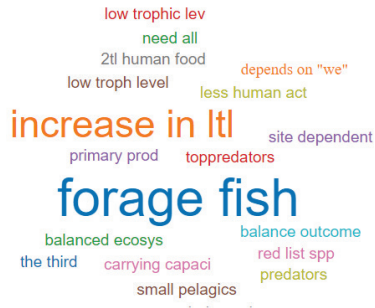
through empirical diet studies and meta-analyses, they also quantified needs through modelling to determine predator productivity thresholds of prey abundance. The key fishery – predator interactions were then documented in ecosystem assessments to highlight trade-offs between forage fishing and predators, and the spatial overlap between fishery and predator hotspots. Assessment approaches to deliver ecosystem advice used both quantitative predictions for fish stocks and qualitative forecasts for impacts on predators. In order to develop effective options EBFM, precautionary legislation was of upmost importance, and fishery management plans were needed that incorporated ecosystem considerations. As a result, spatial management (including MPAs) and harvest guidelines to avoid harm to predators have been possible.

Five polls were asked of the session attendees, and the responses provided useful information. Clearly a range of outcomes from EBFM was desired, but overall respondents considered that a healthy prey base of generally low trophic level forage fish for predators was key. Notably, the role of jellyfish in marine ecosystems was considered important to understand the prey distribution of top-predators [40 respondents]. In terms of integrative modelling approaches that are able to support effective ecosystem-based management actions, Ecopath with Ecosim and End-2-End models were considered the main options available currently. The best-known examples of EBFM (including top predators) in practice were considered to be enacted by the USA for the California Current Ecosystem and by Norway [25 respondents]. In response to the question, "Which parameters and processes are critical to test the impact of closed areas for highly migratory species?", the majority of 25 respondents considered movement in/out of MPAs the most important. However respondents mentioned that the spatio-temporal response of fishing fleets and their impact on spawning/ nursery habitat quality should be considered also.

Conclusions
The area of Ecosystem Based Fisheries Management was clearly of broad interest (with over 200 participants attending the session). However, the scientists working in this area are often working in silos relevant to their ecosystem component and/or key pressure. To improve ICES science and advice in this area, we as a community need to continue to connect people, not least biologists with ecologists, modellers and social scientists both within government institutes/agencies and wider academia. Currently, there is a broad range of working groups within ICES that touch on this area. To further the collective need and desire to improve ecosystem-based fisheries management, we recommend that ICES and PICES hold a workshop on EBFM that brings together its wealth of scientists from a range of Expert Groups.
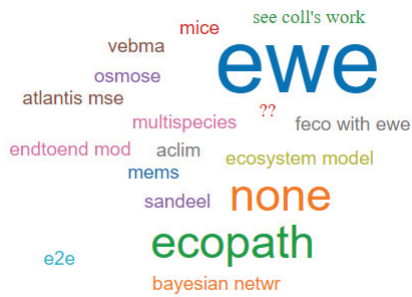
|	
What do we want most? Increase in all top predators or IUCN Red List species, plentiful forage fish for fisheries or for aquaculture feed, increase in low trophic level species as food for predators? [32 answers]	**Which are the key prey species for which more data is required to understand their biomass/distribution: gobies, gurnards, cephalopods, jellyfish, other? [40 answers]**

Which integrative modelling approaches are currently able to support effective ecosystem-based management actions (including human, stock and depredating species)? [25 answers]	**Where are great examples of EBFM incorporating top predators? [20 answers]**
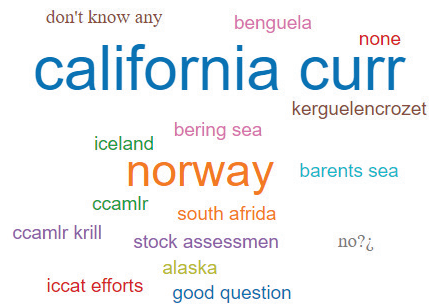
S-MBM Endnote 4
PICES Observer Report of the 68C session of the IWC Scientific Committee Meeting (SC68C)

Tsutomu Tamura

Institute of Cetacean Research, 4-5, Toyomi-cho, Chuo-ku, Tokyo 104-0055, Japan

Meeting place: Virtual Meetings

Meeting period: From April 27 to May 14, 2021

Chair: Dr. Robert Suydam (USA)

Participants:
214 national delegates, 270 Invited Participants (IP), 28 Observers, 18 intergovernmental organizations and 25 IWC Secretariat

Sub-committees and Working Groups:
- Sub-Committee
    1. Implementation Reviews and Simulation Trials (IST)
    2. In-depth Assessment (IA)
    3. Other Northern Hemisphere whale stocks (NH)
    4. Other Southern Hemisphere whale stocks (SH)
    5. Small Cetaceans (SM)
    6. Whale Watching (WW)
    7. Aboriginal Subsistence Whaling (ASW)
    8. Conservations Management Plans (CMP)
    9. Non-Deliberate Human-Induced Mortality of Cetaceans (HIM)
    10. Environmental Concerns (E)

- Working Groups
    1. Stock Definition/DNA Testing (SD/DNA)
    2. Ecosystem Modelling Approaches (EM)
    3. Abundance Estimates, Stock Status and International Cruises (ASI)

- *Ad hoc* Working Groups
    1. Photo-ID (PH)
    2. Sanctuaries (SAN)
    3. Databases and Related Issues (GDR)

The 68C session of the IWC Scientific Committee meeting (SC68C) was held from April 27 to May 14, 2021. As in 2020, it was held virtually due to the global pandemic of COVID-19. The Chair (R. Suydam), vice-Chair (A. Zerbini), Convenors of the Sub-Committees and Working Groups and the Secretariat cooperated to hold a series of 'virtual' pre-meetings and workshops prior to the Committee meeting.

Following the two days of initial Plenary, seven days were allocated to Sub-Committees and Working Groups meetings, and then three days were again allocated to the Plenary to discuss results and recommendations from the Sub-Committees and Working Groups as well as miscellaneous issues and

adopted Committee's report. At SC68C, three meetings of Sub-Committees and/or Working Groups were concurrently held in two sessions a day.

In relation to the North Pacific the following matters were discussed and examined.
▪ Sub-Committee on In-depth assessment (IA)
In-depth assessment of several whale species in the North Pacific were made including the examination of current stock size, recent population trends, carrying capacity and productivity.

1. *Comprehensive Assessment of North Pacific sei whales*: A multi-area age-structured population model has been developed by Dr. Punt (US). An intersessional correspondence group was established to review the data used and to oversee the further development of the population model. The work to date has proceeded on the basis of two working hypotheses regarding the population structure: (i) a single stock of sei whales distributed throughout the North Pacific; and (ii) five stocks, centered on five designated sub-areas. There has not been consensus on the relative plausibility of the two hypotheses at this stage. The committee agreed to re-establish the intersessional group to enable completion of the assessment by the Committee next year. The terms of references of this intersessional group are below.
   • *Check final model inputs and review results of the model fitting.*
   • *Produce a document detailing the input data and the main modelling results.*
   • *Produce a document summarizing the status of sei whales in each area of the North Pacific*
   • *Review any new genetic results or abundance estimates that become available.*

2. *In-depth assessment of western North Pacific common minke whales*: An intersessional workshop had been planned to further the in-depth assessment, but it had not been possible to hold it this year prior to the Committee meeting. The in-depth assessment is based on three primary stock structure (the J-stock, O-stock and P-stock) hypotheses. The Committee reiterated the need to conduct an in-depth assessment of western North Pacific common minke whales with a focus on bycatch levels and the status of J-stock. The committee agreed to re-establish the intersessional group and to reiterate its support for holding the workshop prior to SC68D.

3. *Comprehensive Assessment of North Pacific humpback whales*: The comprehensive Work towards a Comprehensive Assessment of North Pacific humpback whales began in 2016. An intersessional workshop was held in 2017. In 2018, a simplified age-aggregated assessment model and four potential stock structure hypotheses were proposed. However, there were questions about the connections among the proposed breeding and feeding areas. As a result, it was decided that the Comprehensive Assessment should be postponed until the completion of a large-scale photo-ID matching exercise. The committee agreed to continue the intersessional group and to reiterate its support for holding the workshop.

▪ Working Group on Abundance Estimates, Stock Status and International Cruises (ASI)
1. North Pacific Sighting Survey: The IWC-POWER (IWC-Pacific Ocean Whale and Ecosystem Research Program: https://iwc.int/power) is an international collaborative effort coordinated by the IWC and Japan. The project includes line transect sighting for estimating population abundance and biopsy skin-sampling and photo ID for stock structure on major large cetaceans. It has been conducted since 2010. The Committee reiterated to the Commission the great value of the data contributed by the IWC-POWER cruises which have covered many regions of the North Pacific Ocean not surveyed in recent years. The programme addressed important information gaps for several species, and has already contributed greatly to the ongoing assessment work of the

Committee. The Committee endorsed the 2021 POWER cruise planed in the western North Pacific from August to September with a back-up plan in the eastern North Pacific (Figure 1).
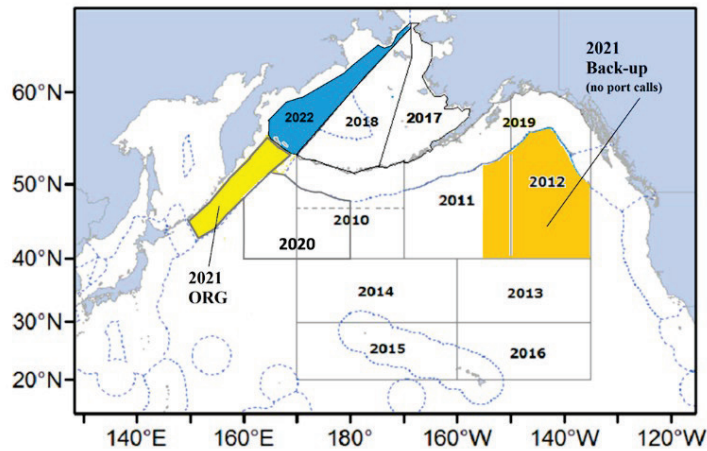

Figure 1. Survey strata for POWER-cruised in 2021 (Orange zone).

▪ Other matters

SC68C also covered other issues such as environmental concerns, small cetaceans, whale watching and by-catch in relevant Sub-Committees and Working Groups. The report of SC68C can be downloaded at the following link:

https://archive.iwc.int/pages/view.php?ref=19276&k=

It was the final year of the Chairmanship by Dr. R. Suydam (USA) , and the Vice-Chair (A. Zerbini, Brazil) took the place as the new Chairman. Dr. L. Porter (UK) was elected as the new Vice-Chair.

▪ Schedule and venue of the 68D session of the IWC Scientific Committee meeting (SC68D)
From April 26 to May 8, 2022 (Bled, Slovenia)
The information on SC68D can be downloaded at the following link:

https://iwc.int/sc68d-2022

S-MBM Endnote 5

Proposal for a Workshop on
"*Anthropogenic stressors, mechanisms and potential impacts on Marine Birds, Mammals,*
***and Sea Turtles*"**
resubmitted for PICES-2022

Duration: 1 day

Convenors: Yutaka Watanuki (Japan), Miran Kim (Korea), Patrick D. O'Hara (Canada)

Anthropogenic stressors, such as climate change, plastic pollution, discharged toxins, fishery interaction, noise pollution, ship-strike, aquaculture, disturbance, and offshore wind farms impact marine birds, mammals and sea turtles, affecting their distributions and abundances. These stressors can act directly or indirectly on marine birds and mammals, and can pose a considerable challenge for marine conservation. Understanding how stressors affect marine birds and mammals is an important step in estimating and mitigating against these threats.

The aim of this workshop is to improve our understanding of anthropogenic stressors, and how they affect marine birds and mammals throughout the North Pacific Ocean.   One of the main outcomes of the workshop will be the development of a Pathways of Effects style heuristic or conceptual model describing how stressors act on marine birds and mammals. Workshop participants will be invited to discuss a PICES region-by-region assessment of stressor importance, and how mechanisms of impact may differ among regions.

Potential Co-sponsoring organization: TBD

Potential Linkages within PICES:
1) MEQ/WG 42 – microplastics and other contaminants
2) FIS/WG 43 – indirect impacts on marine birds and mammals through forage fish
3) WG 44 – POEs and Climate Change input into Ecosystem Assessments of Northern Bering Sea – Chukchi Seas

S-MBM Endnote 6

S-MBM Activity Plan, 2021-2025
(draft)

The S-MBM proposes to address the next stage of Climate and Trophic Ecology of Marine Birds and Mammals over the next 5 years. This program has been chosen because birds and mammals can have top-down effects on marine ecosystems and because birds and mammals respond to multiple scales of variability in the environment and their prey-base. We are completing our update of the 2000 report (Hunt et al., 2000) on diets and food consumption of marine mammals with case studies from seabirds as well based on additional datasets and improved bioenergetic models. Combining this information with data on prey quantity, quality, composition and distribution will further allow us to understand and predict the impacts of prey on marine birds and mammals, as well. In particular, we plan on examining the influence of climate variability and change on trophic linkages and, consequently the distribution and abundance of marine birds and mammals in the North Pacific. In addition, our project will link directly with other PICES committees (*e.g*., BIO, FIS, POC, MEQ), provide improved data needed on energy flow for ecosystem models for PICES sub-regions and

broader LMEs, and will address the goals of FUTURE to forecast ecosystem status and understand how marine ecosystems in the North Pacific respond to climate change and human activities.

Our project is premised on the fact that marine birds and mammals (MBMs) are important top predators that respond directly to changes in and consume large amount of forage species. It also recognizes that MBMs can induce trophic cascades, and that they are susceptible to changes in marine food web structure and productivity as a result of both natural and anthropogenic impacts. MBMs overlap directly with anthropogenic stressors, such as climate change, plastic and other pollutants, increased shipping, and fishery interactions. Finally, many MBM are easily observed and highly mobile, and are considered sentinels of ecosystem status and health. As such, we believe the detailed analyses of MBMs we are proposing will contribute significantly to meeting the objectives of FUTURE 2.0.

The following describes 1) the rationale of our proposed project, and 2) describes potential activities or products to be accomplished by the S-MBM over these 5 years.

Our activity plan will focus on the "Interaction between MBMs and other ecosystem components and stressors." This will include important sub-themes such as:
- Documenting, understanding, and potentially forecasting changes in forage species and response of bird and mammal top predators to these changes. Forecasting seems like a difficult goal, but documenting bird and mammal predation might be more feasible?
- Marine birds and mammals as ecological indicators of changing marine ecosystems using metrics such as population vital rates, spatiotemporal distributions and abundances, diet composition, body condition and stress hormones.

Phases:
1. Identification and assessment of important stressors (anthropogenic and environmental) on MBMs, developing POE (Pathways of Effects) models, and estimating potential impacts from these stressors.
2. Use of MBMs as indicators of impacts regionally and among regions.
3. Comparative synthesis of information from phase 1 and 2 across the PICES region.

Upcoming possible workshop themes:
1. Anthropogenic stressors, mechanisms and potential impacts on MBMs (lead by M. Kim, P. O'Hara and Y. Watanuki)
2. Climate change (including Marine Heat Waves) associated changes in migration patterns/distribution of MBM (lead by W. Sydeman, K. Hattori and P. O'Hara)
3. Predicting changes in small pelagic prey fish and potential impacts on MBMs (lead by H.W. Kim and E. Hazen)
4. MBMs as indicators of impacts (lead by R. Ream and W. Sydeman)