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 BIO Committee) was held from 09:00–18:00 hours on November 4, 2016 in San Diego, USA. The business meeting focused on the current activities of S-MBM, and on preparations for activities associated with the S-MBM project.

AGENDA ITEM 1
Welcome

Dr. Rolf Ream, Co-Chair of S-MBM, 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. Dr. Yong-Rock An was welcomed as a new member of S-MBM, representing Korea. S-MBM members from China and Russia did not attend.

AGENDA ITEM 2
Adoption of agenda

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

AGENDA ITEM 3
Reports

a) Dr. Andrew Trites summarized the outcome of W6: BIO Workshop entitled, "*Consumption of North Pacific forage species by marine birds and mammals*" (***S-MBM Endnote 3***). The 1-day workshop was held on November 3, 2016 and involved 16 presentations, facilitated discussions, and was attended by 23 people from Canada, Japan, USA, and Norway. Recommendations were made for planning future activities and products to meet the objectives of the S-MBM project, "Climate and Trophic Ecology of Marine Birds and Mammals".

b) Dr. Patrick O'Hara introduced S5: BIO/MONITOR/MEQ Topic Session entitled, "*Understanding our changing oceans through species distributions and habitat models based on remotely sensed data*". The goal of this 1-day session, to be held November 8, 2016, is to identify and understand the processes driving distributions of marine organisms. The session includes 16 oral presentations (and 1 selected for a plenary presentation) and 3 poster presentations covering a range of taxa and trophic levels, from plankton to fish/squid to top predators. A brief report summarizing the presentations and conclusions was prepared by the co-convenors following the session and added to this report (***S-MBM Endnote 4***).

c) Dr. Elliott Hazen introduced S6: POC/MEQ/MONITOR/BIO Topic Session entitled, "*What factors make or break trophic linkages?*" The goal of this 1-day session, also to be held on November 8, 2016, is to understand how ecosystem linkages and species distribution are influenced by ocean features and how these linkages translate through the food web. The session includes 16 oral presentations and 12 poster presentations that cover a range of topics, from physics to top predators, across multiple PICES disciplines. A brief report summarizing the presentations and conclusions was prepared by the co-convenors following the session and added to this report (***S-MBM Endnote 5***).

d) Dr. Tsutomu Tamura provided his report on the 2016 International Whaling Commission Scientific Committee (IWC/SC) meeting in Bled, Slovenia (***S-MBM Endnote 6***). Species/stock assessments are

ongoing and involve sighting surveys planned for 2017 in the North Pacific. The IWC POWER cruise will be conducted in the Bering Sea during 2017, and Russia will continue a systematic sighting survey in the northern Sea of Okhotsk. Dr. Oleg Katugin provided additional details on the 3-year joint sighting surveys in the Sea of Okhotsk. A review of the Japanese Whale Research Program under Special Permit in the western North Pacific (JARPNII) was completed, and Japan has drafted a new research plan for review by IWC/SC. Due to earlier requests for S-MBM to comment on the research plan, S-MBM discussed its possible role in these types of reviews and determined it was not appropriate.

e) Dr. William Sydeman reported on upcoming and planned international symposia related to S-MBM activities. Notable symposia include:
   - International Small Pelagics Symposium, "*Drivers of dynamics of small pelagic fish resources*", co-sponsored by PICES and ICES, to be held in Victoria, Canada, from March 6–11, 2017;
   - ESSAS Open Science Meeting on Subarctic and Arctic Science, to be held in Tromso, Norway, from June 11–15, 2017;
   - 4th International Symposium on "*The effects of climate change on the world's oceans*" to be held in Washington DC, USA, during June 2018.

f) S-MBM discussed link with other expert groups during the Annual Meeting. One group of particular interest is the SG-CERP (*Common Ecosystem Reference Points across PICES Member Countries*). SG-CERP is proposing the establishment of a Working Group on *Common Ecosystem Reference Points across PICES Member Countries*. Dr. Elliott Hazen summarized the objectives of this group, and the potential connections to S-MBM (*e.g.*, indicators of stressors needed for reference points, thresholds for temperature and changes in productivity). S-MBM discussed possible involvement in the WG if it is approved, and Dr. Trites voiced his interest.

AGENDA ITEM 4
Discussions

a) Review of Terms of Reference

S-MBM reviewed its Terms of Reference, and a suggestion was made to drop the word "demographic" from TOR #3 (***S-MBM Endnote 7***). After some discussion S-MBM members unanimously voted to approve the change.

b) Change of Co-Chair

Dr. Ream will step down as Co-Chair of S-MBM after the Annual Meeting. Dr. O'Hara was nominated and unanimously approved by S-MBM members to replace Dr. Ream, and he accepted the position of Co-Chair.

c) Review of Topic Session/Workshop proposals

S-MBM discussed and refined a proposed Topic Session on "Seasonal and climatic influences on prey consumption by marine birds, mammals, and predatory fishes" for PICES-2017 (***S-MBM Endnote 8***). In order to facilitate inclusion of predatory fishes in the session, S-MBM will contact Dr. Michael Seki (USA) to inquire if he has interest in co-convening the session.

AGENDA ITEM 5
S-MBM project on "Climate and Trophic Ecology of Marine Birds and Mammals"

Review and discussion of S-MBM's climate and trophic ecology project (described in its Activity Plan for 2015–2019 and approved by BIO at PICES-2014) was largely covered during discussions at the workshop W6 (see Agenda Item 3). Outcomes and recommendations from those workshop discussions were

summarized, and S-MBM then focused on completing its plans for activities at PICES-2017. S-MBM also discussed current and possible additions to its membership, in order to facilitate successful completion of the S-MBM project. The U.S. members would like to add Drs. Robert Suryan and Jaime Jahncke to S-MBM, and members from other countries were asked to review and update their membership in the Section.

S-MBM Endnote 1

S-MBM participation list

Members

Yong-Rock An (Korea)
Elliott Hazen (USA)
Patrick O'Hara (Canada)
Rolf Ream (USA, Co-Chair)
William Sydeman (USA)
Tsutomu Tamura (Japan)
Andrew Trites (Canada)
Yutaka Watanuki (Japan)

Observers

Motohiro Ito (Japan)
Jaime Jahncke (USA)
Oleg N. Katugin (Russia, FUTURE SSC)
Bungo Nishizawa (Japan)
Hiroaki Saito (Japan, FUTURE SSC)
Robert Suryan (USA)
Julie Thayer (USA)
Peter Warzybok (USA)

Members unable to attend

Canada: Douglas Bertram, Ken Morgan
China: Shuai Chen, Enyuan Fan, Wei Lei, Chao Song, Xuelei Zhang, Can Zhou
Japan: Kaoru Hattori
Korea: Hyun Woo Kim, Kyum Joon Park, Hawsun Sohn
Russia: Alexander I. Boltnev, Vjatcheslav P. Shuntov, Andrey Vinnikov

S-MBM Endnote 2

S-MBM meeting agenda

1. Call to order – meeting participants, new members of PICES community
2. Review agenda (modify as needed)
3. Country Reports from participants
   a) Report of W6 on "MBM-forage" (Trites)
   b) Introduction of S5 on "Changing Oceans" (O'Hara)
   c) Introduction of S6 on "Trophic Links" (Hazen)
   d) International Symposium related to S-MBM activities
   c) Link with other groups during this meeting
   d) Report of IWC activities (Tamura).
4. Discussions
   a) Review S-MBM Terms of Reference
   b) Change of Co-Chair (R. Ream to P. O'Hara)
   c) Review 2017 Topic Session proposal ideas
5. 2015–2019 S-MBM project
   Title: Climate and Trophic Ecology of Marine Birds and Mammals
   Leader: Andrew Trites (Canada)
   Co-leaders: Yutaka Watanuki (Japan), William Sydeman (USA), Elliott Hazen (USA)
   Long term strategic plan; link with FUTURE, other committees, potential workshop, Session

S-MBM Endnote 3

W6 Workshop Report

Consumption of North Pacific forage species by marine birds and mammals

November 3, 2016

Determining how much food marine birds and mammals consume requires knowing what they eat (the species and relative proportions consumed), the energetic densities of prey ingested (from calorimetry or proximate composition analyses), and how much they need to eat (using bioenergetic models). It also requires knowing the size and age structure of the predator population (to determine total consumption), as well as where they feed (to determine the spatial distribution of prey biomass extracted by the birds and mammals). Combining these pieces of information yields the biomass of benthic invertebrates, zooplankton, squid, fish, consumed by different species and populations of seabirds and marine mammals.

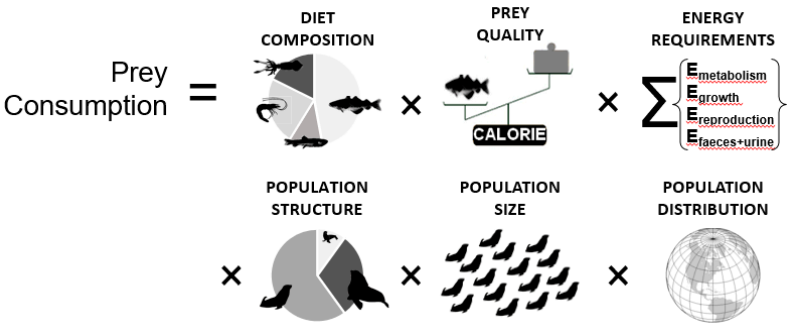
Hunt *et al*. (2000) estimated prey consumption for 135 species of seabirds and 47 species of marine mammals. Our workshop (Appendix 1) was designed to assess whether the Section on *Marine Birds and Mammals Section* (S-MBM) should update the Hunt *et al*. report. The workshop therefore 1) reviewed the state of the art in methods used to estimate prey consumption (through case study presentations), and 2) assessed the availability of new data from the past two decades that could be used to update the previous report.

The workshop was divided into two sessions (Appendix 1). The morning session focused on case studies that 1) calculated food consumption for individual species of birds and mammals, or 2) reviewed some of the methodological considerations that the S-MBM needs to consider when answering the question, "How much do marine birds and mammals consume in the North Pacific?" The afternoon session was led by S-MBM members and invited speaker Dr. Julie Thayer, who made short presentations, and facilitated discussions and small group activities about the availability of data and methodological considerations. Topics covered included:

- Methodological considerations for estimating food consumption,
- Dietary data: What is available, and how should it be compiled and standardized?
- Population abundances and distribution: When and where are data available?
- Seasonality and decadal changes: What time(s) of year and what year(s) or decade(s) should be targeted?
- What is the desired spatial resolution for data to estimate consumption?
- Recommendation of workshop participants on how the S-MBM should proceed to answer the question, "How much do marine birds and mammals consume in the North Pacific?"

Methodological considerations for estimating food consumption

Determing amounts of prey consumed require data (diet composition, caloric density of prey, and population size age structure and distribution) and bioenergetic models that calculate energy requirements (Trites and Spitz, 2017). The product of these 6 pieces of information yields total prey consumed for each species of marine bird and mammal:



Obstacles to bioenergetic consumption models of marine predators in general include the lack of synthesis of existing predator data, data gaps, no standardized approach to calculating predator diet composition, the problem of means not accurately representing how predators respond to prey availability, and spatio-temporal and ontogenetic differences among predators and prey.

Analyses of a predator diet database of seabirds, marine mammals, bony and cartilaginous fishes, and giant squid ranging from Baja California, Mexico, to Vancouver, Canada (J. Thayer, morning session) shows that predatory fishes tend to consume far more than seabirds and marine mammals. Fish consumption should thus be considered in concert with marine bird and mammal consumption. It is important to evaluate not only overall consumption of whole predator communities, but also relative consumption between predators, as well as more detailed modeling of data-rich species on annual levels to determine more specific consumption amounts related to changing conditions.

Bioenergetic consumption models need to be put into perspective to evaluate their predictions. One means is to compare their predictions with those of prey threshold models for predators Discrepancies that may occur between the two sets of model predictions may reflect the schooling and patchy distribution of forage fish (*i.e*., minimum abundances for schools to form, for predators to encounter schools, for predators to be successful at capture).

Other issues that need attention are data gaps in winter, further investigation of adult vs. immature predator diets, and changes in predator-prey relationships such as prey-switching or more fundamental changes in these relationships through time. This generally applied to all PICES sub-regions.

BIRDS: Seabirds in particular have some of the best diet and population trend information of all marine predators. Good abundance data for migratory birds, however, is still largely lacking due to difficulties in assessment, although they comprise some of the highest biomasses and therefore may have highest impact on consumption models. Seabirds may be more tightly coupled to prey resources (spatial restrictions during breeding, prey size limitations, *etc*.), so more sensitive to changes than often more mobile fishes and marine mammals.

MAMMALS: Considerable attention has been paid to obtaining accurate estimates of diet and population abundance of marine mammals, but comparatively little consideration has been given to whether estimates of daily food requirements from the "energy requirement" (bioenergetics) models are reliable. Hunt *et al*. (2000) estimated energy requirements of birds and mammals using simple equations that scaled energy requirements as a function of body mass. Detailed bioenergetic models that account for production (growth, stored energy, reproduction), maintenance (basal metabolism, activity, digestion, thermoregulation), and energy lost (feces, urine) were not available when the Hunt *et al*. report was prepared—but are now available for some species.

Comparing the predictions from the mass-scaled relationships with a few single species bioenergetic models indicates major discrepancies for some species (Trites, morning session presentation). This indicates that energy needs do not necessarily scale with body mass and that the simple models used to determine daily requirements are ineffective for some species of marine mammals. These discrepancies might possibly be used to determine precautionary confidence limit for species that require use of body-mass functions to predict their energy requirements. Further analysis is needed to understand the source of the discrepancies so that the generalized equations can be applied with confidence. In the meanwhile, it is recommended that detailed (species-specific) bioenergetic models be used when available, and generalized energetic models that predict requirements as a function of body-mass be used with caution for species with no detailed models.

The equations available to estimate energy requirements provide annual or average daily values. However, marine mammal requirements are not constant throughout the year. Most large cetaceans feed heavily in the summer and fall to store energy while fasting during winter and spring. Similarly, most pinnipeds have strong seasonal increases and decreases in energy requirements. Attention therefore needs to be given to appropriately partition the energy requirements of mammals by time of year, and not assume constant requirements throughout the year. In general mammals consume far more during summer than during winter.

Dietary data: What is available, and how should it be compiled and standardized?

BIRDS: There are many approaches for investigating seabird diets. These include direct observations of bill-loads, stomach contents, and regurgitations, or inferential descriptions of diets from stable isotope analysis of tissues having different turn-over rates, and fatty-acid profiles of the stomach oil and subcutaneous fat. Prey DNA may also be extracted from scats. Each technique has its advantages and disadvantages, which must be kept in mind when using diet data derived from them to estimate prey consumption. For example, the common technique of analyzing stomach contents of parents at colonies may underestimate the importance in the diet of seabirds of meso-pelagic fish caught far from land.

Summarizing prey composition requires standardizing information from various techniques. Bill-loads and stomach contents of adults is the best quality data and most relevant to estimating prey consumption during the breeding season. Stable isotope analysis, fatty acid analysis and DNA analysis are limited or not directly applicable to determining amounts consumed. Interannual and regional dietary changes can be carried out when and where constant methods (bill-loads or stomach contents) have been used.

Bird diet data (bill-loads and adult stomach contents) are limited in the western North Pacific. There are some chick diet data from the Sea of Okhotsk, and good time-series data on chick diet on the Japan side of the Sea of Japan. In the NW Pacific off of Japan, there are some chick diet data. Overall, there is very little adult boreal summer diet information available, and no information at all for winter diet.

In the eastern North Pacific, diet composition is usually derived from data collected from birds when attending at colonies. Some data are available from birds shot at sea in the 1970s, but not more recently. Only colony-based studies can provide information on both abundance and diet, but often fails to provide sufficient information on spatial area of foraging during the breeding season. In Canada, diet data are only available for breeding birds.

MAMMALS: Dietary data are available for many species of marine mammals, but the quality and amount of data vary by species. In general, the highest quality diet data are for pinniped species that breed on land, and the lowest quality diet data are for cetaceans that live in the open ocean. As with seabirds, diets have been described from stomach contents, direct observations of animals as they actively feed, and from identification of prey remains in scat samples (hard parts identification, and DNA analysis of the soft matrix). These methods are considered to yield the most reliable descriptions of diet. Other techniques to categorize diets include fatty acid analysis of blubber, and stable isotope analysis of skin, hair and whiskers.

Diet data tends to be presented in high resolution (i.e., by species consumed), but will likely need to be summarized by groups or categories of prey types) to simplify analyses and make results easier to understand and compare between species and regions. The 8 prey categories used in Hunt *et al*. (2000) are reasonable, but consideration should be given to splitting some of the 8 categories (such as fish) into finer groups that meet specific needs and interests of other people (*e.g*., keeping commercially or culturally important fish such as salmon and walleye pollock as separate categories).
Estimates of amounts of prey consumed will reflect total biomass consumed, but do not reflect numbers of individuals consumed. Consideration should be given to distinguishing between size classes of prey consumed, such as whether they are juvenile or adult fish. This additional dietary information will help address questions relative to competition with fisheries, or impacts of marine mammal predation on fish stocks.

The other important piece of information needed to estimate prey consumption is the caloric density of prey species. A database of caloric densities of prey species consumed by marine mammals needs to be compiled—and should contain values for both juvenile and adult prey species.

Population abundances and distribution. When and where are data available?

BIRDS: Abundance and distribution data in western North Pacific are limited. There is good historic data on at-sea abundance from boat surveys from the Sea of Okhotsk, but the availability of recent at-sea data is uncertain. There are some data on the colony size in the Sea of Okhotsk and Russian Pacific. On the Japan side of the Sea of Japan, there are some at-sea survey data, while in the East/Japan Sea off the Korean peninsula, there is some at-sea survey data. In the NW Pacific off of Japan, there are some at-sea survey data. Unfortunately, there are no abundance data available for winter. Colony size of seabirds around Japan is contained in the seabird colony data base maintained by the Environmental Agency, Japan.

In the eastern North Pacific, bird abundances can be estimated based on data from breeding colonies, at-sea surveys, coastal surveys, and movement or tracking. Only colony-based studies can provide information on both abundance and diet, but often fail to provide sufficient information on spatial area of foraging during the breeding season and the numbers of non-breeding individuals in the population. However, movement data are increasingly becoming available to link colony abundance and diet data with specific foraging areas. Another challenge is that colony data are unavailable for non-breeding seabirds. Efforts are underway to assess diet opportunistically from gastrointestinal tracts sampled from beach-cast and/or fishery bycaught seabirds (Laurie Wilson, Canadian Wildlife Service, pers. comm. in collaboration with Scott Pearson – Washington Department of Fish and Wildlife). At-sea and coastal survey data and movement data can be used to estimate at-sea abundance for both breeding and non-breeding birds that use the area during the boreal summer, and for estimating abundances during the boreal winter. Movement data can also be used to link colony data for austral breeding bird colonies with Regions of Interest in North Pacific. The disparities among data types highlights the need to integrate across data types to achieve stronger synthetic analyses.

The regions of interest (see Fig. 1) used in Hunt *et al*. (2000) are not very useful for the Canadian Pacific Region. Abundances estimated from at-sea surveys in Canada would have to be more model-based (*i.e*., use of covariates to reduce variability and increase precision of estimates to be useful) than abundance estimates from the California Current system where surveys are more systematic. Permanent plots on colonies are designed to estimate population trend rates, which could be used to update colony survey work done in 1991. Overall, boreal winter data are very poor in Canada (no colony data, low at-sea survey data availability). In addition, abundance data are not readily available (and would need some work to acquire). However, movement data may reveal that some proportion of local breeding populations remain during the non-breeding season.

MAMMALS: One of the more valuable sources for abundance data in the eastern North Pacific are the Marine Mammal Stock Assessment Reports (compiled for both Alaska and the U.S. Pacific regions) produced by the U.S. National Marine Fisheries Service. These reports provide data at a stock level (which often reflect regional distributions) and are updated regularly for many species. The quality of the assessments in these reports varies considerably among species, however, and is generally poorer for cetaceans (or missing entirely). Marine mammal abundance estimates have historically been reported by governmental agencies from other countries, as well (Russia, in particular), but it is not clear whether these assessments are still being completed, or where they are reported. Additional data sources, perhaps with better temporal resolution and longer time series, can be obtained from focused studies targeting specific marine mammal populations or habitats (*e.g*., surveys of ice seals); these types of studies are often conducted by universities, NGOs, and/or intergovernmental collaborations.

Abundance estimates at the stock level would provide the best data to assess how much prey the different species of marine mammals consume, and from where. However, there are still many stocks (and species) of marine mammals for which abundance estimates do not exist. These data gaps may be particularly problematic for attempts at ecosystem (energetics) modeling. Depending on the questions being asked, key factors to consider in applying abundance and distribution data to prey consumption estimates generally relate to the fact that data sets are highly variable among species and/or stocks. These factors include: the number or frequency of abundance estimates over time, the geographic range encompassing the estimates (multiple Large Marine Ecosystems vs a single bay, or unknown range), seasonal changes in distributions (long migrations vs none or unknown), and changes in distributions that relate to age structure or sex of the individuals.

Seasonality. What time(s) of year to target?

Prey consumption varies with seasonality in marine bird and mammal community structure, as well as with environmental variability on multiple temporal scales in the North Pacific. The abundance of marine birds and mammals is greatest during the boreal spring and summer when resident species are breeding, and migrants from breeding areas in the southern hemisphere, tropics, and subtropics move into the North Pacific to forage. For example, populations of baleen whales, such as humpback whales calve in southern regions, such as Hawaii or Mexico, before moving into Alaskan waters to feed in summertime (*e.g*., Calambokidis *et al*., 2001). Millions of southern hemisphere seabirds (e.g. shearwaters) also migrate to the North Pacific in the austral winter to forage (Shaffer *et al* ., 2006). This seasonal influx of birds and mammals into the temperate and subarctic regions of the North Pacific may increase overall abundance and prey consumption estimates by at least an order of magnitude. Fortunately, most of the dietary and population data needed are available during the boreal spring and summer, which means that this is the time of year when the most robust estimates of prey consumption are best calculated.

It is well known that most of the mysticetes and many sea bird species migrate to the high latitude regions in summer to feed and return to the low latitude regions in winter to breed. Other species, such as the northern fur seal, breed during the summer months on islands concentrated at higher latitudes, and migrate to lower latitude regions in the winter. It is important to understand seasonal migration, seasonal change of abundance, and seasonal changes in diet to produce robust estimates of food consumption.

For cetaceans in the western North Pacific, sighting surveys have captured some seasonal changes in distributions (*e.g*., the Japanese Whale Research Program in the western North Pacific – JARPN, JARPNII – and Japan dedicated sighting surveys). These have mainly used line-transect sampling theory, which is usually adopted by the Scientific Committee of International Whaling Commission (IWC/SC) to estimate abundance. In the central and eastern North Pacific, the systematic line transect sighting survey cruise of the IWC-Pacific Ocean Whale and Ecosystem Research (IWC-POWER) has been conducted in summer since 2010. Since last year, in the Okhotsk Sea, Japan-Russian joint sighting survey has been conducted. In the western North Pacific, data on the feeding habits of baleen whale species have been obtained by JARPN and JARPNII. However, most of the surveys have been in the summer season (May to September), resulting in little information on abundance, distribution and diets for other parts of the year.

For pinnipeds, representative studies of Steller sea lions have occurred in the eastern North Pacific and have shown dietary shifts between gadid- and forage-fish-dominated diets. Other species are also known to have experienced changes in abundance over time, and there are a number of diet data showing seasonal changes in diets. Unfortunately, seasonal diet data are only available for a few species of mammals; diet data limited to summer months only is more typical, and favors restricting calculations of prey consumption to summer months.

For cetaceans, in the western North Pacific, JARPN and JARPNII conducted comprehensive research on the western North Pacific ecosystem including cetacean, prey species and the environment during 1994–2016. The drastic yearly changes were observed in the prey species of sei whales, shifting from Japanese anchovy during 2002–2012 to mackerels and Japanese sardine after 2013. In the coastal waters off Kushiro, yearly changes in the prey species of common minke whale, also were observed. It shifted from Japanese anchovy and Pacific saury in the period 2002–2011 to Japanese sardine and mackerel after 2012.

Decadal changes. What year(s) or decade(s) to target?

In addition to seasonal effects, prey consumption also varies with North Pacific climate variability on interannual to interdecadal scales. Globally, the most well-known form of climate variability is the El Niño-Southern Oscillation (McPhaden *et al*., 2006). Recently, strong El Niño events with clear impacts on North Pacific ecosystems occurred in 1982–1983 (Schreiber and Schreiber, 1984), 1992–1995 (Trenberth and Hoar, 1996), and 1997–1998 (McPhaeden, 1999). Changes in primary and secondary productivity in these years

altered North Pacific food webs and caused shifts in marine bird and mammal diet composition. Estimates of prey consumption will therefore vary considerably when considering El Niño versus non El Niño years. The frequency and intensity of El Niño events may change with climate change (IPCC, 2014), though this is uncertain.

On longer time scales, environmental variability in the North Pacific is characterized by changes in the Pacific Decadal Oscillation (PDO) (Mantua *et al*., 1997) and North Pacific Gyre Oscillation (NPGO) (Di Lorenzo *et al.*, 2008) as well as other broad scale factors. Warm and cool "phases" or regimes of the PDO/NPGO may last for many years to decades, and cause major reorganizations of the prey base of marine birds and mammals (Anderson and Piatt, 1999), with concomitant shifts in diet composition (Sinclair *et al*., 2008; Sydeman *et al*., 2001; Tamura and Fujise 2002; Trites *et al*., 2007). Thus, in addition to high frequency climate variability exemplified by seasonality, quantifying prey consumption relative to low-frequency climate variability (*i.e*., El Niño) is an important consideration.

There are indications that decadal changes linked to oceanic regime shifts occurred in the abundance and diets of some species of pinnipeds and baleen whales in the North Pacific. Thus, estimates of food consumption likely correspond to particular phases of the regime shift, which may be different in the future than during the period that data are available.

Desired spatial resolution for data to estimate consumption

Hunt *et al*. (2000) compiled estimates of abundance and diets for the following 14 sub-regions of the North Pacific (Fig. 1). These sub-regions are still appropriate for broad-based calculations, but consideration needs to be given to finer spatial divisions within the larger subregions.

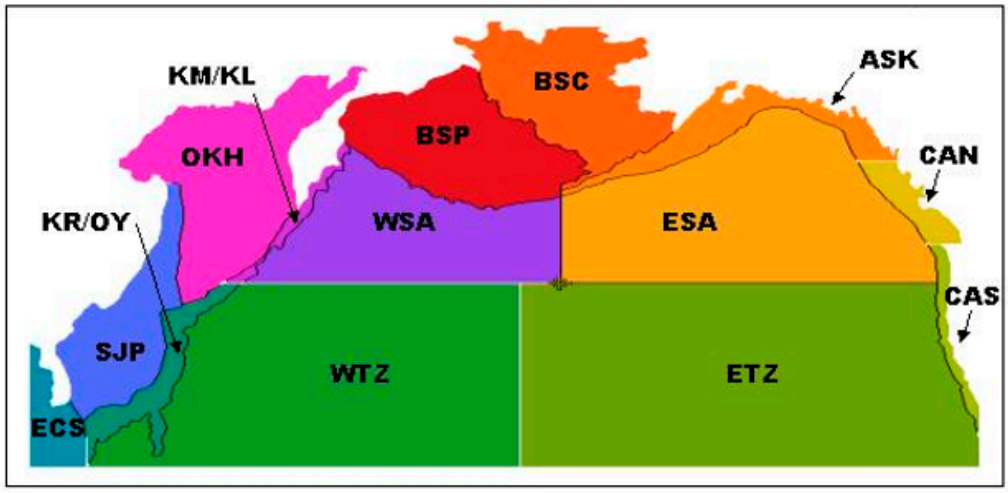


Fig. 1. Sub-regions in the PICES region (north of 30°N and including the marginal seas) of the North Pacific Ocean. ASK - Gulf of Alaska Continental Shelf; BSC - Bering Sea Continental Shelf; BSP - Bering Sea Pelagic; CAN - California Current North; CAS - California Current South; ECS - East China Sea; ESA - Eastern Subarctic; ETZ - Eastern Tropical Zone; KM/KL - Kurile Islands Region; KR/OY - Kuroshio/Oyashio Region; OKH - Sea of Okhotsk; SJP - Sea of Japan; WSA - Western Subarctic; WTZ - Western Tropical Zone.

Understanding and predicting the responses of wide-ranging marine predators such as cetaceans, seabirds, sharks, turtles, pinnipeds and large migratory fish to dynamic oceanographic conditions requires habitat-based models that can sufficiently capture their environmental preferences. Marine ecosystems are inherently dynamic, and animal–environment interactions are known to occur over multiple, nested spatial and temporal scales. The spatial resolution and temporal averaging of environmental data layers are therefore key

considerations in modelling habitat selection or spatial patterns in trophic ecology. There is much debate over the utility of environmental data contemporaneous to animal presence or movement (*e.g.*, daily, weekly), versus synoptic products (monthly, seasonal, climatological) as finer scale data often include greater gaps while broad scale data can lead to scale mismatches among ecological processes.

Temporally-averaged data fields of coarse spatial resolution are often used to contextualize movement, sightings, or trophic analyses for wide-ranging marine predators (Arrizabalaga *et al*., 2015;, Kaschner *et al*., 2006; Louzao *et al*., 2011; Mannocci *et al*., 2014). While climatological fields can provide a cloud-free, synoptic measure of the environment of particular utility for modelling broad-scale movements of migratory animals, there is a clear mismatch in spatial and temporal scale between climatological data fields and the scales at which animals often interact with the environment.

Fitting models on the finest scale environmental data, and then averaging model predictions into seasonal or climatological projections is preferred to using coarser data as model inputs (Scales *et al*., 2016). Where seasonal, annual or climatological GCM (Global Climate Model) products are all that is available, statistical downscaling may provide better accuracy in ecological models (Araújo *et al*., 2005). Moreover, there is a clear need to better understand the mechanistic linkages between the behavior of marine predators and dynamic biophysical conditions in pelagic systems, and how these linkages scale through space and time.

Recommendation of workshop participants on how the S-MBM should proceed to answer the question, "How much do marine birds and mammals consume in the North Pacific?"

Workshop participants recognized that determining "How much marine birds and mammals consume" is a basic fundamental question that is relatively straight-forward to answer in terms of methodologies, but near impossible to accurately answer due to data limitations. However, workshop participants also identified a number of other research questions that can be addressed on smaller scales, or for fewer species, using available data on diets and population numbers. They include:

- How much prey do marine birds and mammals need to support populations of different sizes and different growth rates?
- What are the implications for marine birds and mammals given the changes forecast to occur in the North Pacific in 20 years?
- What are the relative importance of different prey species to marine birds and mammals?
- What is the relationship between diets and populations trends and abundance?
- What is the relative importance of different marine birds and mammals in terms of the amount of energy they extract from the North Pacific?
- Are marine mammals and seabirds competing with fisheries, or are fisheries being out-competed by birds and mammals?
- What is the depth distribution over which marine birds and mammals feed?
- What is the relative distribution and densities of shelf feeders, shelf-break feeders, and open ocean feeders?
- What would a 5-fold increase in marine mammal abundance do to the flow of energy in the North Pacific?
- What consequence is the disappearance of ice likely to have on the population dynamics of marine birds and mammals in the North Pacific?
- What are the drivers of population increase or decrease?
- How do seabirds compete with fisheries?
- How does climate change link with interannual variation in prey consumption?
- How do the extreme climate conditions in recent years affect the population, diet and prey consumption of marine birds and mammals?

MAMMALS: Workshop participants recommended that the Hunt *et al*. (2000) report be updated with data collected over the past 2 decades to answer the over-arching question, "How much do marine mammals consume". The general approach proposed was to treat the Hunt et al. report as a living document, and have S-MBM members check and update tabulated data for species that they are familiar with over the next 12 months. S-MBM members will also assist in finding experts to verify and update tabulated data for species and areas where they cannot directly access the quality of needed information. This effort will be coordinated by Andrew Trites (Canada), with the intention of presenting and reviewing the tabulated findings at the next annual PICES meeting.

The workshop participants also recommended undertaking detailed analyses of the energy requirements and consumption of 3-4 species of marine mammals that have wide distributions and relatively good data that span decades to answer some of the other 10 questions listed above. The species identified as being the best candidates include sei whales (to be led by Hiroko Sasaki – Japan), gray whales (Seina Agabyani – Canada) and Steller sea lions (Andrew Trites – Canada). Other species with fair to good data that could be addressed in future years include common minke whales, Bryde's whale, Pacific white-sided dolphins, blue whales, northern fur seals, and harbor seals. The workshop participants recommended proceeding with the top 3 identified species, and that results be presented in Russia in 2017.

BIRDS: Workshop participants felt that it would be useful to update Hunt et al. (2000), but were less inclined to do so at this time. They felt it will require considerable effort to accomplish. They are, however, interested in focusing on selected species in selected regions, and propose to target regions and species that have long time series data of population counts (mainly colony counts) and diets (mainly chick diets). Candidate regions and species identified include:

1. Northern Japan: Rhinoceros Auklets, Japanese Cormorants, Black-tailed Gulls, Streaked Shearwaters: Teuri Island (~40 years), Mikura and Awashima (<10 years) Yutaka Watanuki (Japan)
2. Bering Sea: Shearwaters (at sea survey), Common and thick-billed Murres, Red-and Black-legged Kittiwakes, Tufted and Horned Puffins, Rhinoceros Auklets, Cormorants, Gulls, Cassins Auklets, Least Auklets, Crested Auklets: Pribilof Island, Middleton Island (>40 years) Robert Suryan (USA)
3. British Columbia : Rhinoceros Auklets, Cassin's Auklets, Puffins: Triangle Island, Frederick Island (25 years) Patrick O'Hara (Canada)
4. California Current: Rhinoceros Auklets, Common Murres, Cassin's Auklets, Gulls, Cormorants: Farallon I, AnoNoevo William Sydeman, Julia Thayer (USA)

Funding and products

S-MBM expects our concerted effort to address inter-related questions concerning food requirements of marine birds and mammals will result in a number peer reviewed publications. In addition, we anticipate updating the Hunt *et al*. (2000) PICES Scientific Report, but only for marine mammals at this time. Further consideration will be given about updating the seabird portion of the PICES report.

We will meet next year at the PICES Annual Meeting to review our progress, and expect to request a dedicated session to present some of the findings. We may also apply to BIO/Science Board to hold an inter-sessional meeting or to NCEAS (National Center for Ecological Analysis and Synthesis: https://www.nceas.ucsb.edu/).

We expect that most of the detailed modelling studies will be carried out by graduate students and young scientists employed by government agencies. Some funding has been requested to support the mammal studies (Andrew Trites – NSERC funding). Lack of funds to support dedicated analyses is seen as the biggest impediment to completing the tasks we have set ourselves. Advice and support from PICES would be gratefully received.

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Appendix 1: W6 Workshop agenda

Consumption of North Pacific forage species by marine birds and mammals

Thursday, November 03, 2016	
Overview	Determining how much food seabirds and marine mammals consume requires knowing what they eat (the species and relative proportions consumed), the energetic densities of the ingested prey (from calorimetry or proximate composition analyses), and how much they need to eat (using bioenergetic models). It also requires knowing the size and age structure of the population (to determine total consumption), as well as where they feed (to determine the spatial distribution of prey biomass extracted by marine mammals). Combining these pieces of information yields the biomass of benthic invertebrates, zooplankton, squid, fish, birds and mammals consumed by different species and populations of seabirds and marine mammals. Workshop participants will help to identify available data and will assist in framing how prey consumption in the N Pacific should be calculated in terms of spatial resolution, seasonality, decadal changes, and distributional data. This will be achieved through presentations, facilitated discussions, and small group activities.

Morning Session – Case studies	
9:00 am to 9:10 am	**Andrew Trites & Yutaka Watanuki**—*Introduction by Session Convenors*
9:10 am to 9:30 am	**Pete Warzybok** — *Consumption of forage fishes by marine birds in the Gulf of the Farallones, California*
9:30 am to 9:50 am	**Yutaka Watanuki** — *Consumption of salmon fingerlings by Rhinoceros Auklets breeding in Hokkaido, Japan*
9:50 am to 10:10 am	**Motohiro Ito** —*The records of Chum salmon fingerling predation by avian predators at the coastal area of Otsuchi, Japan*
10:10 am to 10:30 am	**Yu Kanaji** — *Spatio-temporal variations in the stable carbon and nitrogen isotopic compositions of Delphinidae species in the western North Pacific*
10:30 am to 11:00 am	Break
11:00 am to 11:30 am	**Julie Thayer** [invited speaker]— *Predator consumption of forage species in the California Current*
11:30 am to 11:50 am	**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 am to 12:10 pm	**Andrew 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 pm to 12:30 pm	**George Hunt** — *Prey consumption by marine birds in the eastern Bering Sea: Variability over time*
12:30 pm to 1:45 pm	Lunch

Afternoon Session – How will we estimate food consumption?	
1:45 pm to 2:00 pm	**Andrew Trites & Yutaka Watanuki** — *Goals & facilitated discussions*
2:00 pm to 2:15 pm	**Julie Thayer** — *How to estimate food consumption for marine birds*
2:15 pm to 2:30 pm	**Andrew Trites** — *How to estimate food consumption for marine mammals*
2:30 pm to 2:45 pm	**Yutaka Watanuki** — *Marine bird dietary data : What is available, how should it be compiled, and what methodological issues need consideration?*
2:45 pm to 3:00 pm	**Andrew Trites** — *Marine mammal dietary data : What is available, how should it be compiled, and what methodological issues need consideration?*
3:00 pm to 3:15 pm	**Pat O'Hara** — *Marine bird population abundances and distributions : When and where are data available?*
3:15 pm to 3:30 pm	**Rolf Ream** — *Marine mammal population abundances and distributions : When and where are data available?*
3:30 pm to 3:45 pm	**Bill Sydeman** — *Marine bird seasonality and decadal changes : What time(s) of year and what year(s) or decade(s) to target?*
3:45 pm to 4:00 pm	**Tsutomu Tamura** — *Marine mammal seasonality and decadal changes : What time(s) of year and what year(s) or decade(s) to target?*
4:00 pm to 4:20 pm	Break
4:20 pm to 4:35 pm	**Elliot Hazen** — *Desired spatial resolution for bird and mammal data to estimate consumption*
4:35 pm to 5:15 pm	**Breakout Group Discussions** — Two groups (birds & mammals) identify data sources, people to contact, and potential funding to support initiative.
5:15 pm to 5:30 pm	**Breakout Group Reports**
5:30 pm to 6:00 pm	**Workshop Participant Consensus** — *How should we proceed with estimating food consumption by marine birds and mammals in the North Pacific?*

Appendix 2: Workshop participants

Andrew Trites (Co-convenor)	University of British Columbia	Canada
Yutaka Watanuki (Co-convenor)	Hokkaido University	Japan
Patrick O'Hara	Canadian Wildlife Service	Canada
Zhongxn Wu	Guangdong Ocean University	China
Motohiro Ito	University of Tokyo	Japan
Yu Kanaji	National Research Institute of Far Seas Fisheries	Japan
Bungo Nishizawa	National Research Institute of Far Seas Fisheries	Japan
Hiroaki Saito	FUTURE SSC; Science Board Chair-elect	Japan
Hiroko Sasaki	National Research Institute of Far Seas Fisheries	Japan
Tsutomu Tamura	Institute of Cetacean Research	Japan
Ken Drinkwater	Institute of Marine Research	Norway
Niki Diogou	Oregon State University	USA
Alyson Fleming	Smithsonian Institute	USA
Cathy Foy		USA
Elliott Hazen	Southwest Fisheries Science Center (NOAA)	USA
George Hunt	University of Washington	USA
Jaime Jahncke	Point Blue	USA
Ivonne Ortiz	University of Washington	USA
Rolf Ream	Alaska Fisheries Science Center	USA
William Sydeman	Farallon Institute	USA
Julie Thayer	Farallon Institute	USA
Peter Warzybok	Point Blue	USA
Russ Vetter	Southwest Fisheries Science Center	USA

S-MBM Endnote 4

Summary report for S5 on
"***Understanding our changing oceans through species distributions and habitat models based on remotely sensed data*"**

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

In this session we identified and explored processes underlying or driving distributions and abundances of marine organisms. Satellite remote sensing oceanography products directly measured habitat characteristics such as bathymetric features or ice-extent/coverage or were used as proxies for features such as convergent fronts or water masses. Increasingly Species Distribution Models (SDM) are based on Regional Ocean Modelling System (ROMS) data assimilation models – this is proving to be a very powerful development for accurately predicting species distributions and/or abundances particularly with respect to climate change and changing ocean conditions.

The talks were diverse yet shared key characteristics – they all discussed how species distributed themselves and explored the how and why (as per Robert Suryan's plenary talk) they distribute themselves the way they do, with the help of remote sensing and remote sensing based oceanography products as indices of potential distribution drivers. The talks varied in that they explored relationships among species abundance/ distributions, or aggregations within and/or among species, with a variety of remotely sensed variables as predictors including but not limited to SST, SSH, bathymetry, and Chl_a. These relationships were explored over a range of spatial and temporal scales, from basin level to mesoscale and from decadal to daily. In some cases, relationships were explored to better understand factors driving species distributions and abundances, and in other cases, model output had direct applications such as fisheries management and threat mitigation. Talks focused on a range of taxa from planktonic to squid/saury to top predators.

There were participants from Japan (5), China (1), USA (10), Russia (1), Canada (1) and Mexico (1) in this session. Several talks explored the relationship between at-sea distribution/abundances or movement data with remotely sensed data and/or oceanography products based on these data (often refered to as biophysical parameters). Palacios et al. used remotely sensed variables as proxies for mechanisms favoring krill aggregations to model blue whale movement behaviour, and Santora *et al*. discussed the importance of remotely sensed bathymetry and in particular shelf incising canyons for modeling krill aggregations themselves. Others explored seasonal patterns in these relationships such as distributions of Short-tailed Shearwater and their prey with SST in the in the Bering and Chukchi Seas (Nishizawa *et al*.), the Laysan Albatross off Mexico (Munguía-Cajigas *et al*.), salmon prey assemblages in the California Current (Friedman *et al*.), and gonate squid in the Northwest Pacific (Kulik *et al*.). Some of the talks explored these relationships over longer term variation such as ENSO (Joyce *et al*.), and climate change effects in the Bering Sea on ice and seabirds (Hunt et al.) and bioclimatic velocity for Walleye Pollock (Alabia *et al*.), and in the northwest Pacific on gonate squid (Kulik *et al*.). There was an even mixture of talks that looked at single species response to oceanography or multiple species. Of note Joyce *et al*. discussed seabird-tuna-dolphin aggregations and ENSO, Friedman et al. relate salmon prey assemblages with oceanographic conditions, Dick et al. predicted seabird assemblages, and Baker et al. used environmental thresholds to predict changes in species interactions to inform multispecies models. There were two talks from the Southwest Fisheries Science Center (NOAA) that described developments towards dynamic ocean management – Becker *et al*. explored the utility of ROMS as a basis for near real time cetacean SDMS and Hazen et al. used Earth Observation data as a basis for habitat modeling and ultimately bycatch mitigation for a number of species including leatherback turtles, sea lions, and blue sharks. Two talks from Japan also had direct applications in that they described modeling projects oriented to support and manage fishing industries such as Pacific Saury (Syah *et al*.) and flying squid (Igarashi *et al*.). IPCC scenarios and habitat models were used to predicted distribution changes for saury in the Northwest Pacific by Syah *et al*. and a suite of seabird species in the California Current Ecosystem by Dori Dick *et al*.

There was a brief discussion near the end of the session during the time slot for a talk that was cancelled at the last minute. During this discussion, the convenors explored interest in submitting the talks as papers in a special edition of a primary publication. Although only half of the authors were present, all agreed that they would be interested in submitting, including – Daniel Palacios, Daniella Munguía-Cajigas, Dori Dick Irene Alabia, Matthew Baker, Vladimir Kulik, and Sei-Ichi Saithoh (on behalf of Syah). The convenors will follow up with the authors and those remaining (Elizabeth Becker, Jarrod Santora, Brian Wells, Trevor Joyce, Bungo Nishizawa, and George Hunt) to further solidify this interest as well as draft plans for submissions.

S-MBM Endnote 5

Summary report for S6 on
"*What factors make or break trophic linkages?*"

Rationale

PICES is organized into specific expert groups through their parent committees, *i.e.*, BIO, POC, FIS yet there remains a need for integration across to achieve FUTURE goals and missions. Specifically, we suggest a detailed examination from physics to top predators across PICES ecosystems. The goal of this session was to examine how physical forcing translates to individual movement, population dynamics, and ultimately ecosystem functioning using a combination of models and measurements.

Co-convenors: Ellitott Hazen (USA), Jennifer Boldt (Canada), Jameal Samhouri (USA – *in absentia*), Shin-Ichi Ito (Japan – *in absentia*)

Overview

Mechanistic linkages from physics to phytoplankton to zooplankton to fish remain a central goal of understanding climate forcing on marine ecosystems. Thus, this session aimed to understand how ecosystem linkages and species distributions 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 across different North Pacific ecosystems. We had chosen three study areas, the California, the Kuroshio Current, and the Bering Sea to examine from physics to phytoplankton, phytoplankton to zooplankton, zooplankton to fish, birds and mammals, and fish to birds and mammals but received talks from many more ecosystems. By looking particularly across multiple ecosystems and trends and anomalies at multiple trophic linkages, we can better understand how climate variability and anthropogenic forcing may cascade through these marine ecosystems. S6 presentations included topics that (a) examine how physical oceanography in both study areas lead to long term trends or anomalous responses in primary production, zooplankton, fish, and top predators (b) assess how primary productivity results in spatial patterning of mid and high trophic levels, (c) how trophic relationships may respond to physical forcing, changes in spatial distribution, and species abundances, and (d) test for threshold responses (non-linearity) across trophic levels to changes in physical oceanography and the abundance of other species (competitors, prey, and predators).

Masashi Kiyota (Invited) gave a talk titled "*Response of commercial fisheries and a top predator to long-term ecosystem fluctuations in the western North Pacific Ocean off northeastern Japan*". Dr. Kiyota presented general concepts overarching four main topics: the classification and characterization of oceanic ecosystems using scientific survey data/samples, top predators as indicators of ecosystem change, commercial fisheries as consumers in marine food webs, and information feedback to the commercial market and general public.

Charles Stock presented information on "*Trophodynamic drivers of global fisheries catch*". Dr. Stock combined three observational and modeling advances to examine whether primary production could explain fishery catches. He showed that processes may amplify projected trends under climate change.

Jennifer Boldt presented her talk titled "*Juvenile Pacific Herring (Clupea pallasi) trophic linkages in the Strait of Georgia, British Columbia*". She examined bottom-up, top-down, and competitive factors that might affect herring abundance and condition.

George Hunt gave a talk titled "*Life at the ice edge; does timing of ice retreat set the table?*" He discussed the variation in ice retreat timing and its effects on zooplankton abundance, size composition, and pollock survival.

Sonia Batten's presentation was titled "*A comparison of trophic linkages across the PICES region, based on Continuous Plankton Recorder (CPR) data*". She gave an overview of three projects that have used CPR data to show mechanistic linkages between plankton and higher trophic levels.

Kenneth Rose (Invited) gave a talk titled "*Linear and non-linear responses of marine and coastal fish populations to habitat: a view from the virtual world*". He talked about how we sometimes confuse model inputs and emergent properties. He summarized three examples of modeling and showed that the capabilities for assessing habitat effects on upper trophic level dynamics is limited and behavioural movement drives model results.

Konstantin Rogachev gave a presentation titled "*Effects of freshwater discharge and tidal currents on zooplankton aggregations in the coastal Sea of Okhotsk*". He showed that changes in freshwater and coastal circulation altered the abundance of zooplankton.

Julie Keister's presentation was titled "*Cryptic trophic connections to juvenile salmon survival are revealed by a zooplankton time series*". She examined factors, including copepod abundance and community composition, that might control coho salmon survival.

Anela Choy gave a talk titled "*New insights on the trophic diversity of pelagic "forage species" in the central North Pacific and northern California Current ecosystems*". She showed that marine fish sampling methodologies have biases. She examined long-nosed lancetfish as samplers of the fish community and that different sampling methodologies may reveal different perspectives on trophic food webs.

Hitomi Oyaizu gave a talk titled "*Modeling recruitment variability of Pacific saury (Cololabis saira) using an individual-based model*". He investigated the spatio–temporal variability in growth and migration of fish associated with environmental conditions.

Kelly Kearney's talked was titled "*A comparison of Bering Sea ecosystem energy pathways in warm versus cold years*". She used a modeling approach to compare primary production pathways in warm and cold years. She also examined the effects of mesozooplankton and benthos to different food pathways.

Brian Wells' talk was titled "*Caught in the middle: bottom-up drivers of top-down impacts on Chinook salmon*". He examined the effects of upwelling, prey, and seabirds on Chinook salmon.

Yoichi Miyake gave a talk titled "*Shoreward intrusions of Kuroshio waters may influence the recruitment of a top predator in river ecosystems*". He examined how Japanese eels, a top predator in river ecosystems, accomplish cross-shelf migration using warm water intrusions of the Kuroshio current.

Adam J. Schlenger's talk was titled "*Temporal variability of net primary production drives global patterns of structure and function across multiple marine ecosystems*". He examined holistic approaches to complex systems. He looked at temporal variability of net primary production and patterns across multiple indices of structure and function.

Kirstin Holsman's talk was titled "*Suboptimal thermal conditions and spatial mismatch between predators and prey and may limit walleye pollock growth under climate change*". She used a regional downscaled model and bioenergetics model to project climate change effects on pollock.

Brian Hunt gave a talk titled "*Salmon as integrative samplers of high seas food web*". He used isotope data to understand food-web dynamics and life history conditions that Sockeye salmon experience at sea.

Overall, the session covered a suite of topics across multiple PICES interests. Ten talks primarily used data and 5 primarily employed models. The talks focused on phytoplankton (1), zooplankton (8), fish (13), top predators (4), and humans (1) as well as ecosystem linkages to these groups, highlighting the cross-disciplinary nature of the session. In addition, the session highlighted that, in moving forward, there is a need to include both the top and bottom of the food web. There were some unique topics focusing on trophic methodologies, such as Dr. Rose's talk on how animal behaviour may drive trophic interactions in an individual-based model. In addition, the comparison of diet studies to shipboard-surveys, as presented by Dr. Choy, highlighted some of the methodological limitations in understanding trophic interactions. The idea of a review paper was brought up at the end of the session and discussions may continue via email. The attendance was high throughout the day, so a follow-up topic session would likely be successful in the future.

S-MBM Endnote 6

PICES Observer Report on the 2016 IWC Scientific Committee Meeting

Tsutomu Tamura
The Institute of Cetacean Research,Tokyo, Japan.

The 66bth International Whaling Commission's Scientific Committee (IWC SC) meeting was held in Bled, Slovenia from June 7 to 19, 2016, under the chairmanship of Dr. Caterina Fortuna (Italy).

Participants

National Delegates: 107 (Argentina: 2; Australia: 5; Austria: 1; Belgium: 2; Brazil: 3; Chile: 1; Costa Rica: 1; Denmark: 1; France: 3; Germany: 2; Guinea, Rep. OF: 1; Iceland: 4; Italy: 6; Japan: 19; Korea: 5; Luxembourg: 2; Mexico: 1; Netherlands: 2; New Zealand: 2; Norway: 6; Russian Federation: 3; Slovak Republic: 2; Slovenia: 1; Spain: 1; Switzerland: 1; UK: 6; USA: 24)

Invited Participants (IP): 61

Representatives of intergovernmental organizations: 5

IWC Secretariat: 16

Sub-Committees and Working Groups

A number of sub-committees and working groups were established in 2016. The reports of each sub-committee and working group were presented to the plenary meeting of the IWC SC during the last three days of the meeting:

- Sub-committee on the Revised Management Procedure (RMP),
- Standing Working Group on an Aboriginal Whaling Management Procedure (AWMP),
- Sub-Committee on Bowhead, Right and Gray Whales (BRG),
- Sub-Committee on In-Depth Assessments (IA),
- Sub-Committee on Other Southern Hemisphere Whale Stocks (SH),
- Working Group on Stock Definition (SD),
- Working Group on Non-Deliberate Human-Induced Mortality of Cetaceans (HIM),
- Standing Working Group on Environmental Concerns (E),

- Working Group to Address Multi-species and Ecosystem Modelling Approaches (EM),
- Sub-Committee on Small Cetaceans (SM),
- Sub-Committee on Whalewatching (WW),
- Working Group on DNA testing (DNA),
- Working Group on Sanctuaries (SAN),
- *Ad hoc* Working Group on Guidelines for Photo-Identification Databases,
- *Ad hoc* Abundance Group.

Outputs of the IWC SC meeting with regard North Pacific whale stocks

- Sub-committee on the Revised Management Procedure (RMP)

This sub-committee deals with the use of the RMP for the management of commercial whaling. The RMP is the process developed by the IWC SC to estimate sustainable catch limits for commercial whaling of baleen whales. The application of the RMP on a species in a given geographical region is through a process called RMP *Implementation* or *Implementation Review*, which last for two years. Different kind of scientific information is required for an *Implementation* such as stock structure, abundance and biological parameters.

As in each year the RMP sub-committee dealt with i) general matters of the RMP and ii) *Implementation* for different species and geographical areas. Some outputs from this year meeting were:

- There were some developments of methods to estimate MSYR using the individual based model (IBM) in relation to *Catch Limit Algorithm* (*CLA*) process.
- The next *Implementation Review* of North Pacific common minke whale will start in 2018.
- The *Implementation Review* for North Pacific Bryde's whales will be held in 2017, with an intersessional workshop in March 2017. The IWC SC agreed that this will be a full *Implementation Review* given there is considerable new information on stock structure and abundance.

- Sub-Committee on Bowhead, Right and Gray Whales (BRG)

This sub-Committee discusses information on stock structure, movement, abundance and biological parameters of bowhead, right and gray whales. Management advice for bowhead and gray whales is made at the Standing Working Group on an Aboriginal Whaling Management Procedure, based on the information discussed at the BRG sub-committee. Below are some outputs from this sub-committee related to North Pacific:

- Results of the Third Workshop on the Range wide Review of the Population Structure and Status of North Pacific Gray Whales held in La Jolla California from 18-20 April 2016, were discussed. A workshop will be also held the next year.
- The sub-committee recommended its continued involvement in conservation and research efforts for western gray whales.
- The Russian Federation reminded the IWC SC of its previous request to evaluate the reasons why gray whales may be 'stinky' and the implications for quotas provided by the gray whale *Strick Limit Algorithm* (*SLA)*. Given the current rate of hunting, the Russian Federation noted that the quota may be exceeded during the current block quota, especially if stinky whales are considered part of the quota. The IWC SC can examine options for taking into account stinky whales, if the Commission should request. The Russian Federation expressed its intention of bringing this information to the Commission for their consideration in this year.

- To better understand the movements of gray whales in the western Pacific and assist range wide efforts, the Committee recommends: (a) increased collaborative efforts to compare photos from the whales seen in Japan with other photo-identification catalogues for gray whales in the North Pacific; and (b) increased efforts to conduct post-mortem analyses with experienced veterinarians.

- Sub-Committee on In-Depth Assessments (IA)

This sub-Committee discusses scientific information required for the assessment of several whale species. An *in-depth assessment* includes the examination of stock structure, current stock size, recent population trends, carrying capacity and productivity. Below are some outputs from this sub-committee related to North Pacific whale stocks:

- For the assessment of the NP sei whale, the IWC SC agreed to proceed on the basis of two alternative stock structure hypotheses: (i) a single stock for the entire North Pacific; and (ii) a five-stock hypothesis.
- The IWC SC recommended the preparation for eventual assessments of North Pacific blue whales in the Central and Western Pacific.
- For NP right whales, the IWC SC recommended that scientists from Russia and Japan summarize sightings data from the Sea of Okhotsk and in the offshore western Pacific at next year's meeting.
- After examining the available information, the IWC SC agreed that the information is sufficient to initiate an *in-depth assessment* of NP humpback whales at a pre-meeting next year.
- A plan for a systematic sighting survey in the Northern Okhotsk Sea in 2016 by Russia was presented. The sighting data from 2015 and 2016 surveys will be analyzed using standard techniques. Results will be submitted to the next IWC SC meeting in 2017.
- The IWC SC reviewed results and future plan for NP sighting survey cruise (IWC/POWER). The SC received results from the 2015 survey conducted in waters comprised between 20°-30°N, and between 170°E and 160°W (Figure 1). The IWC SC discussed the sighting survey plan for IWC POWER 2017, which will be conducted in the Bering Sea (Figure 2).

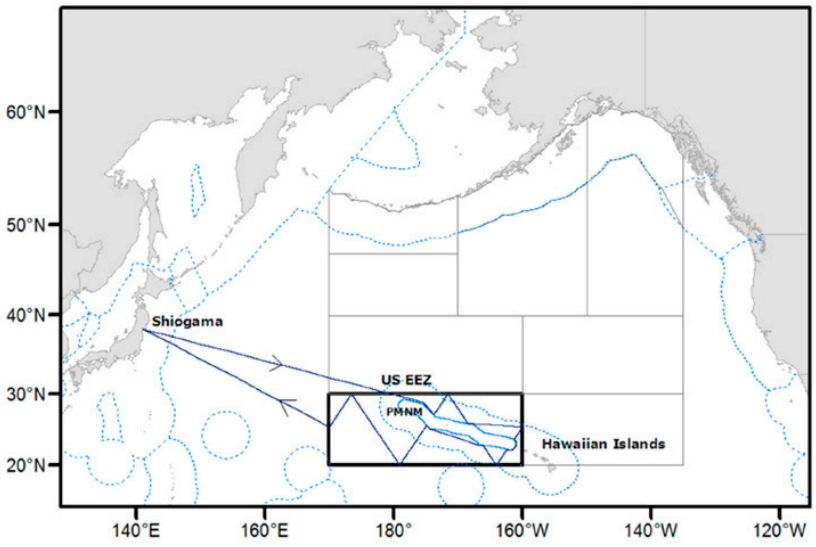

Figure 1. Research area of the 2015 IWC/POWER cruise.

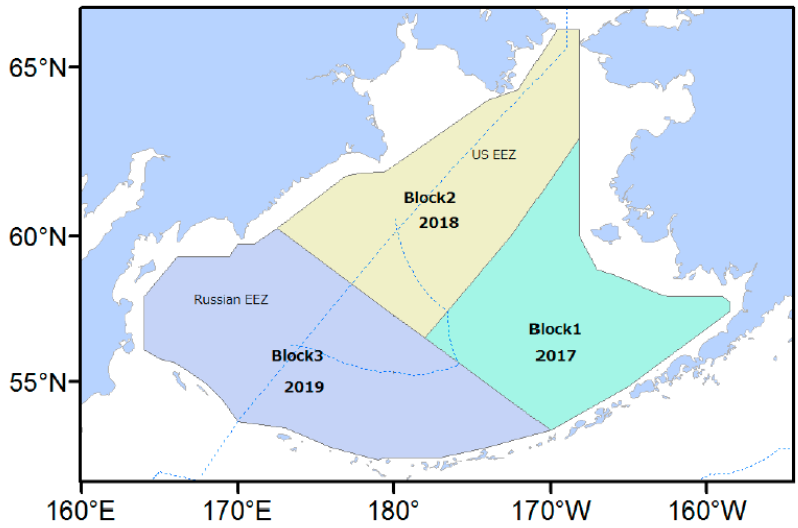

Figure 2. Proposed research area for IWC/POWER sighting surveys between 2017 and 2019.

- Final Review of the Japanese Whale Research Program under Special Permit in the western North Pacific (JARPNII)

- The final review workshop of JARPNII was held in Tokyo, on February 2016. The workshop report (SC/66B/Rep06) was reported and discussed at the IWC SC. The IWC SC endorsed the report, which included a number of scientific recommendations that will be address by Japanese scientists.
- Japan announced that a new whale research plan is being prepared for the North Pacific following the Committee's guidelines (so-called 'Annex P'). The IWC SC will carry out a workshop (January/ February 2017) to review the new plan.

The complete 2016 IWC SC meeting report can be found at http://archive.iwc.int/?r=6127 (SC/66B/Rep01).

- IWC SC-related meetings schedule

- Workshop to review the new Japanese whale research program under special scientific permit in the North Pacific: January 30–February 3, 2017 (Tokyo, Japan);
- Workshop on the RMP *Implementation Review* of North Pacific Bryde's whales: March 21–24, 2017 (Tokyo, Japan);
- Workshop to forward the modelling process to understand the status of North Pacific gray whales: April 27–29, 2017 (La Jolla, USA);
- 2017IWC SC meeting (SC/67a): May 9–21, 2017 (Bled, Slovenia).

S-MBM Endnote 7

Proposed Terms of Reference revision

1. Provide information and scientific expertise to the PICES community and the FUTURE program, as well as to BIO and other scientific and technical committees when requested, about the biology and ecological roles of marine birds and mammals (MBMs) in the PICES region;
2. Identify important problems, scientific questions, and knowledge gaps for understanding the impacts of climate change and anthropogenic factors on MBMs and ecosystems in the PICES region through Workshops, Topic Sessions and Scientific Reports;
3. Assemble information on the status and key ~~demographic~~ parameters of MBMs, and contribute to the Status Reports and Outlooks—and improve collaborative, interdisciplinary research with MBM experts and the PICES scientific community.

S-MBM Endnote 8

Proposal for a 1-day Topic Session on
"S*easonal and climatic influences on prey consumption by marine birds, mammals, and predatory fishes*" at PICES-2017

Convenors: A.W. Trites (Canada), R.M. Suryan (USA), M. Seki (USA), T. Tamura (Japan)

Rationale

Marine birds, mammals, and fishes exert substantial top-down forcing on marine ecosystems through consumption of key mid-trophic level forage species. These predators are indicators of changes in food webs, and have been implicated in trophic cascades in marine ecosystems. The goal of this session is to gain deeper insight into the relative importance of seasonal and climatic influences on prey consumption — and to inform understanding of North Pacific food-web dynamics under changing ocean conditions. This session contributes to the goals of FUTURE by bringing forward new knowledge needed to forecast North Pacific ecosystem dynamics relative to climate change and anthropogenic influences. In addition, results of this session will contribute to the S-MBM's 3- to 5-year focus on climate and trophic ecology of marine birds and mammals.

Overview

Prey consumption by mid to upper trophic level marine birds, mammals, and predatory fishes is influenced by changes in prey abundance, prey availability, ocean climate and anthropogenic stressors. However, the extent to which predators can adapt to such changes and still meet their minimum energy requirements is uncertain. Understanding dietary changes of predators under varying environmental conditions is critical to informing prey consumption models and estimating relative contributions of bottom-up vs. top-down forcing in marine systems. Understanding how prey consumption of marine birds, mammals and predatory fishes will respond to climate change is also needed to predict changes in energy flow pathways in ecosystems, and has consequences for conservation initiatives and ensuring the sustainability of commercially important fishery resources.

For this session, we will request presentations on topics that address (a) the significance of seasonal changes in prey consumption on energy budgets and ecosystem dynamics, (b) the effects of changes in water temperature and other climatic variables on food requirements, (c) relationships between dietary shifts and population trends, (d) the limits of plasticity in prey selection, and (e) how prey consumption of birds, mammals, and predatory fishes is affected by the recent extreme climatic events—the blob, El Niño, ice cover changes, *etc*.