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РЕГИОНАЛЬНЫЙ СЕМИНАР В ПОМОЩЬ ОПИСАНИЮ ЭКОЛОГИЧЕСКИ ИЛИ БИОЛОГИЧЕСКИ ЗНАЧИМЫХ МОРСКИХ РАЙОНОВ В СЕВЕРНОЙ ЧАСТИ ТИХОГО ОКЕАНА
Москва, 25 февраля - 1 марта 2013 года

ДАННЫЕ ДЛЯ ОРИЕНТИРОВАНИЯ РАБОТЫ РЕГИОНАЛЬНОГО СЕМИНАРА КБР В ПОМОЩЬ ОПИСАНИЮ ЭКОЛОГИЧЕСКИ ИЛИ БИОЛОГИЧЕСКИ ЗНАЧИМЫХ МОРСКИХ РАЙОНОВ В СЕВЕРНОЙ ЧАСТИ ТИХОГО ОКЕАНА

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Data to inform the CBD Workshop to Facilitate the Description of Ecologically or Biologically Significant Marine Areas in the North Pacific

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25 February – 1 March 2013

Prepared for the Secretariat of the Convention on Biodiversity (SCBD)

Marine Geospatial Ecology Lab

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Contents

Figures

1 Background

The Marine Geospatial Ecology Lab at Duke University, in conjunction with international partners, has identified and mapped a large number of data sets and analyses for consideration by the Convention on Biological Diversity (CBD) Workshop to Facilitate the Description of Ecologically or Biologically Significant Marine Areas (EBSAs) in the North Pacific. Both biological and physical data sets are included. The data are intended to be used by the expert regional workshop convened by the CBD to aid in identifying EBSAs through application of scientific criteria in annex I of decision IX/20 as well as other relevant compatible and complementary nationally and inter-governmentally agreed scientific criteria. Each data set may be used to meet one or more of the EBSA criteria.

Printed maps will be available for annotation at the workshop. Digital versions of these maps are also available online: http://mgel.env.duke.edu/np-ebsa

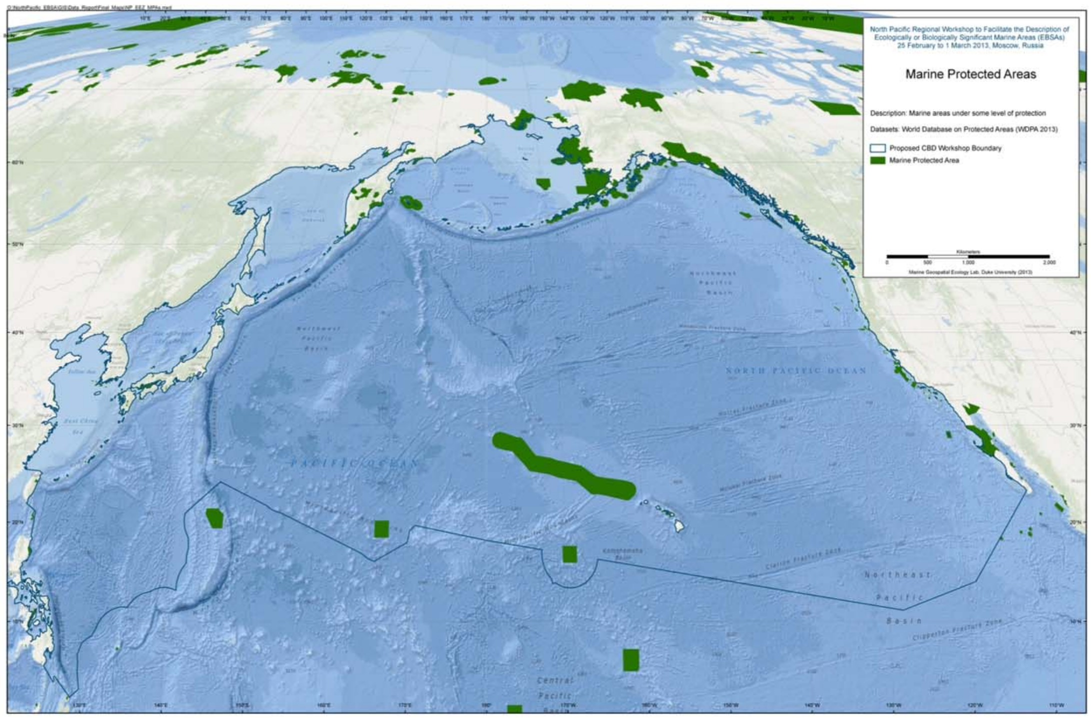

Figure 1.1-1 Proposed workshop scope and existing Marine Protected Areas

2 Biogeographic Classifications

2.1 Global Open Ocean and Deep Seabed (GOODS) biogeographic classification

The classification was produced by an international and multidisciplinary group of experts under the auspices of a number of international and intergovernmental organizations as well as governments, and under the ultimate umbrella of the United Nations Educational, Scientific and Cultural Organization (UNESCO) and its Intergovernmental Oceanographic Commission (IOC). (source: http://ioc-unesco.org/index.php?option=com_content&task=view&id=146&Itemid=76)

Excerpt from executive summary in the full report:

A new biogeographic classification of the world's oceans has been developed which includes pelagic waters subdivided into 30 provinces as well as benthic areas subdivided into three large depth zones consisting of 38 provinces (14 bathyal, 14 abyssal and 10 hadal). In addition, 10 hydrothermal vent provinces have been delineated. This classification has been produced by a multidisciplinary scientific expert group, who started this task at the workshop in Mexico City in January 2007. It represents the first attempt at comprehensively classifying the open ocean and deep seafloor into distinct biogeographic regions.

The biogeographic classification classifies specific ocean regions using environmental features and – to the extent data are available – their species composition. This represents a combined physiognomic and taxonomic approach. Generalized environmental characteristics of the benthic and pelagic environments (structural features of habitat, ecological function and processes as well as physical features such as water characteristics and seabed topography) are used to select relatively homogeneous regions with respect to habitat and associated biological community characteristics. These are refined with direct knowledge or inferred understanding of the patterns of species and communities, driven by processes of dispersal, isolation and evolution; ensuring that biological uniqueness found in distinct basins and water bodies is also captured in the classification. This work is hypothesis-driven and still preliminary, and will thus require further refinement and peer review in the future. However, in its present format it provides a basis for discussions that can assist policy development and implementation in the context of the Convention on Biological Diversity and other fora. The major open ocean pelagic and deep sea benthic zones presented in this report are considered a reasonable basis for advancing efforts towards the conservation and sustainable use of biodiversity in marine areas beyond the limits of national jurisdiction in line with a precautionary approach. Ongoing work may further refine and improve the classification provided here, however the authors of this report believe that any further refinement to biogeographical provinces need not delay action to be undertaken towards this end, and that such action be supported by the best available scientific information.

Reference:
UNESCO. 2009. *Global Open Oceans and Deep Seabed (GOODS) – Biogeographic Classification*. Paris, UNESCO-IOC. (IOC Technical Series, 84.)

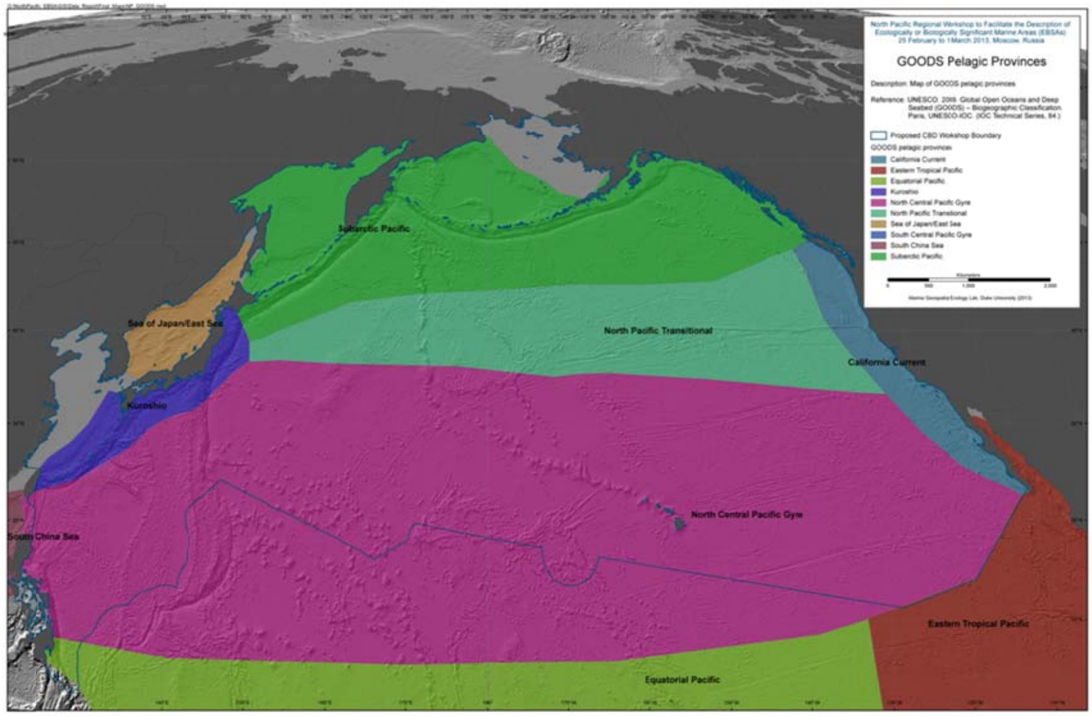

Figure 2.1-1 GOODS Pelagic Provinces

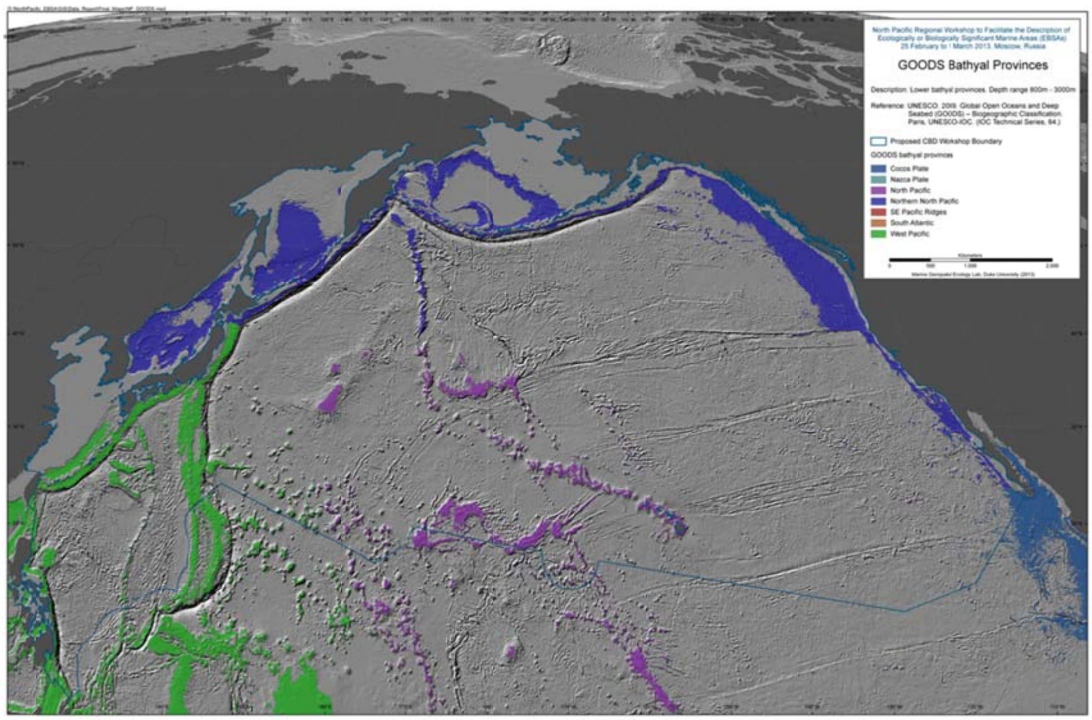

Figure 2.1-2 GOODS Bathyal Provinces

2.2 Marine Ecoregions of the World (MEOW)

MEOW is a biogeographic classification of the world's coasts and shelves. It is the first-ever comprehensive marine classification system with clearly defined boundaries and definitions and was developed to closely link to existing regional systems. The ecoregions nest within the broader biogeographic tiers of Realms and Provinces.

MEOW represents broad-scale patterns of species and communities in the ocean, and was designed as a tool for planning conservation across a range of scales and assessing conservation efforts and gaps worldwide. The current system focuses on coast and shelf areas (as this is where the majority of human activity and conservation action is focused) and does not consider realms in pelagic or deep benthic environment. It is hoped that parallel but distinct systems for pelagic and deep benthic biotas will be devised in the near future.

The project was led by The Nature Conservancy (TNC) and the World Wildlife Fund (WWF), with broad input from a working group representing key NGO, academic and intergovernmental conservation partners.
(source: http://www.worldwildlife.org/science/ecoregions/marine/item1266.html)

Reference:
Spalding, M. D. Fox, H. E. Allen, G. R. Davidson, N. Ferdana, Z. A. Finlayson, M. Halpern, B. S. Jorge, M. A. Lombana, A. Lourie, S. A., (2007). Marine Ecoregions of the World: A Bioregionalization of Coastal and Shelf Areas. Bioscience 2007, VOL 57; numb 7, pages 573-584.

Data available from: http://www.marineregions.org/sources.php#meow

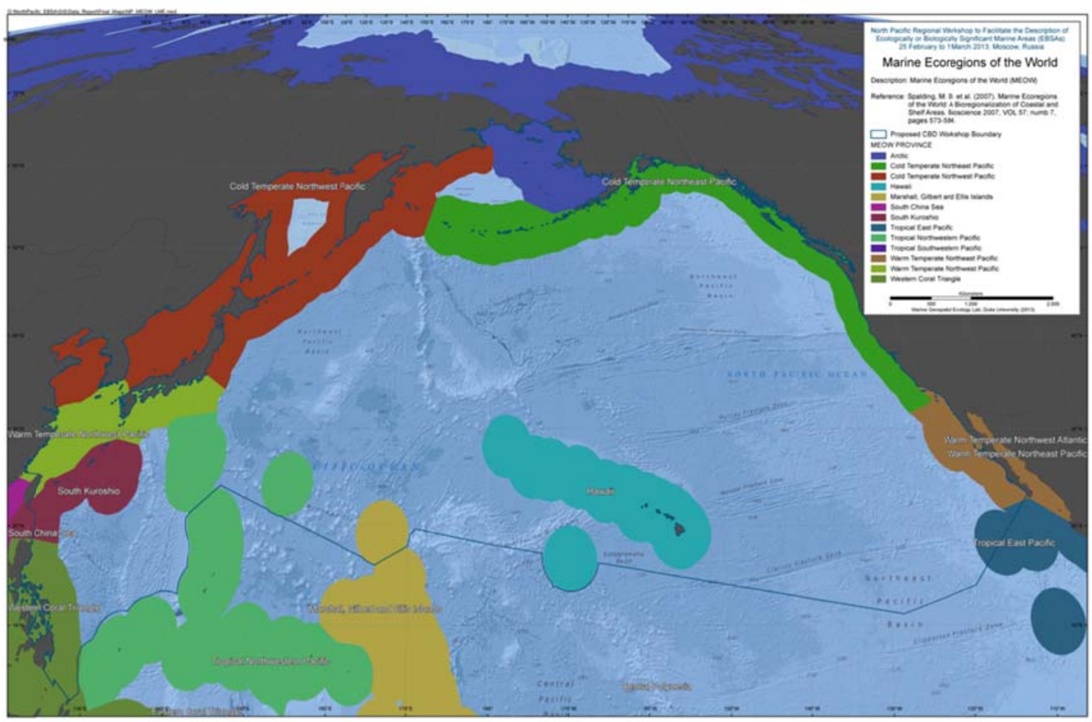

Figure 2.2-1 MEOW Provinces

2.3 Large Marine Ecosystems (LMEs)

Large Marine Ecosystems (LMEs) are regions of ocean space encompassing coastal areas from river basins and estuaries to the seaward boundary of continental shelves and the seaward margins of coastal current systems. Fifty of them have been identified. They are relatively large regions (200 000 km^2 or more) characterized by distinct bathymetry, hydrography, productivity and trophically dependent populations.

The LME approach uses five modules:

- *productivity module* considers the oceanic variability and its effect on the production of phyto and zooplankton
- *fish and fishery module* concerned with the sustainability of individual species and the maintenance of biodiversity
- *pollution and ecosystem health module* examines health indices, eutrophication, biotoxins, pathology and emerging diseases
- *socio-economic module* integrates assessments of human forcing and the long-term sustainability and associated socio-economic benefits of various management measures, and
- *governance module* involves adaptive management and stakeholder participation.

(source: http://www.fao.org/fishery/topic/3440/en)

Reference:

Sherman, K. and Hempel, G. (Editors) 2009. The UNEP Large Marine Ecosystem Report: A perspective on changing conditions in LMEs of the world's Regional Seas. UNEP Regional Seas Report and Studies No. 182. United Nations Environment Programme. Nairobi, Kenya.

Data available from: http://www.lme.noaa.gov/

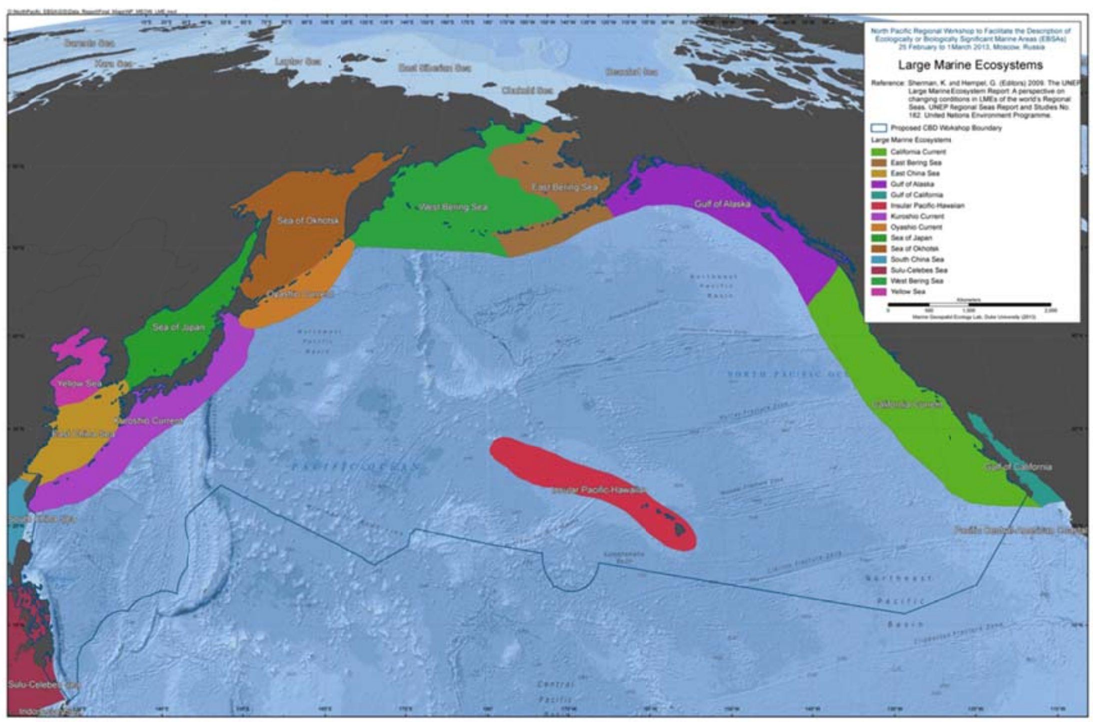

Figure 2.3-1 Large Marine Ecosystems

2.4 Longhurst Marine Provinces

This dataset represents a partition of the world oceans into provinces as defined by Longhurst (1995; 1998; 2006), and are based on the prevailing role of physical forcing as a regulator of phytoplankton distribution. The dataset represents the initial static boundaries developed at the Bedford Institute of Oceanography, Canada. Note that the boundaries of these provinces are not fixed in time and space, but are dynamic and move under seasonal and interannual changes in physical forcing. At the first level of reduction, Longhurst recognized four principal biomes (also referred to as domains in earlier publications): the Polar Biome, the Westerlies Biome, the Trade-Winds Biome, and the Coastal Boundary Zone Biome. These four Biomes are recognizable in every major ocean basin. At the next level of reduction, the ocean basins are partitioned into provinces, roughly ten for each basin. These partitions provide a template for data analysis or for making parameter assignments on a global scale.

(source: VLIZ (2009). Longhurst Biogeographical Provinces. Available online at http://www.marineregions.org/. Consulted on 2013-01-14.)

References:
Longhurst, A.R. (2006). Ecological Geography of the Sea. 2nd Edition. Academic Press, San Diego, 560p.

Data available from: http://www.marineregions.org/sources.php#longhurst

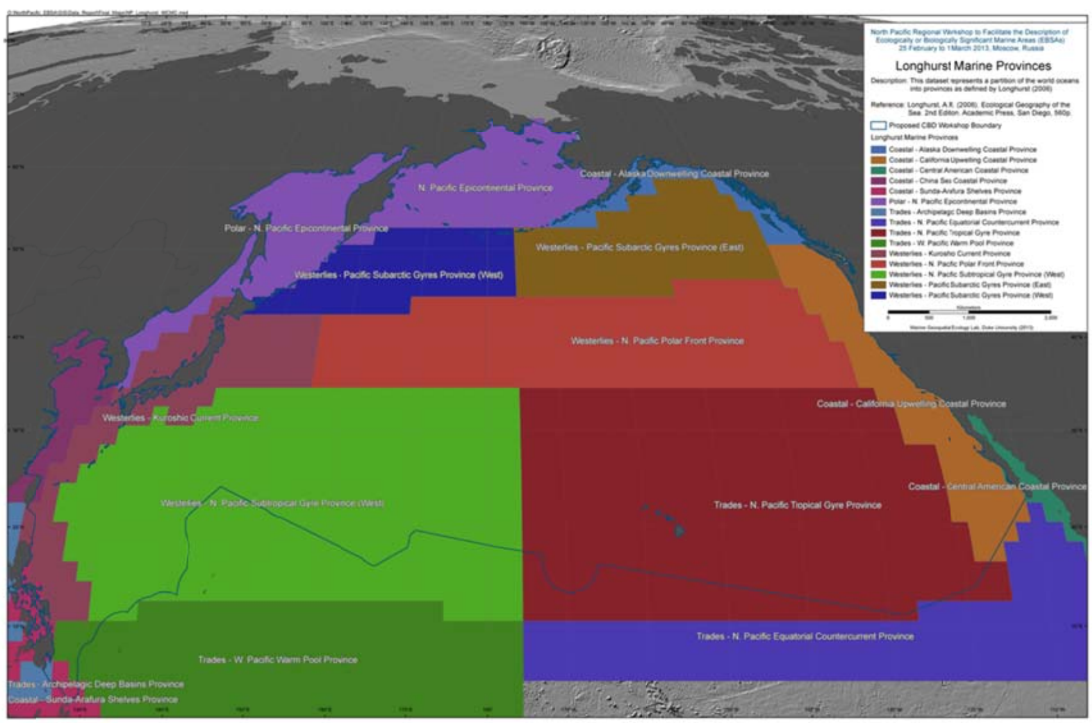

Figure 2.4-1 Longhurst Marine Provinces

3 Biological Data

3.1 Distribution of Coral Reefs, Seagrasses and Mangroves

The UNEP World Conservation Monitoring Centre (UNEP-WCMC) is a collaboration between the United Nations Environment Programme, the world's foremost intergovernmental environmental organization, and WCMC (UK), a UK-based charity. UNEP-WCMC is UNEP's specialist biodiversity assessment arm, and the Centre for UNEP's collaboration with WCMC 2000.
(source: http://www.unep-wcmc.org/about-us_17.html)

Global Distribution of Coral Reefs (2010) data available from:
http://data.unep-wcmc.org/datasets/13

Global Distribution of Seagrasses (2005) data available from:
http://data.unep-wcmc.org/datasets/10

Global Distribution of Mangroves (1997) data available from:
http://data.unep-wcmc.org/datasets/6

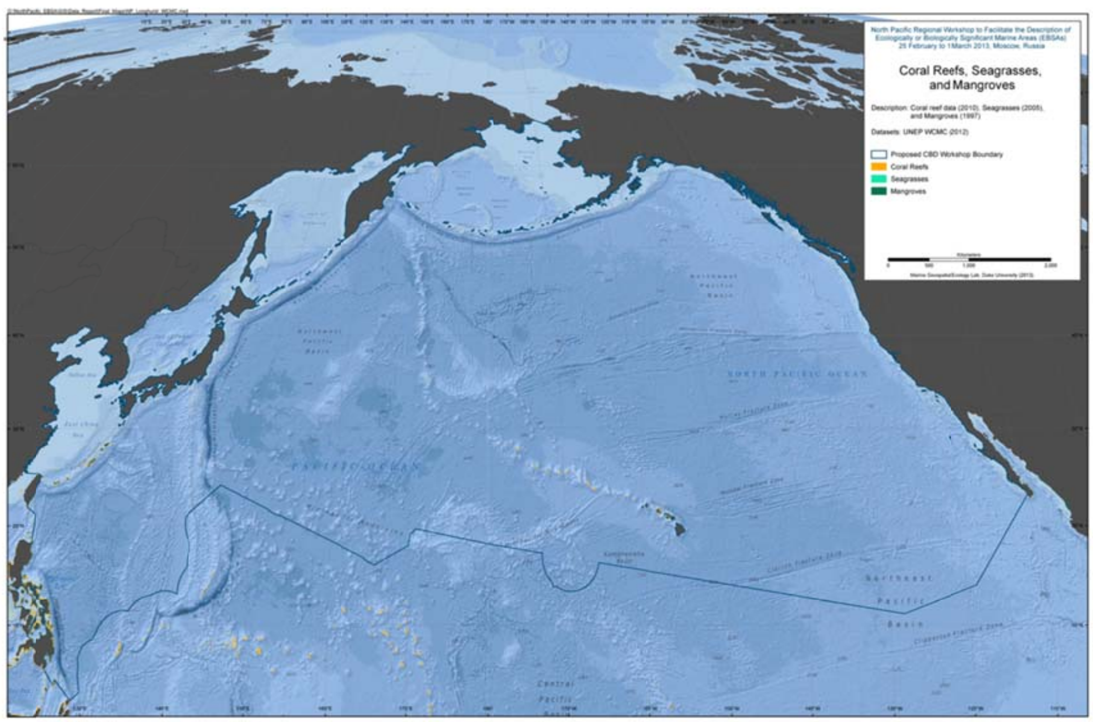

Figure 3.1-1 Coral Reefs, Seagrasses, and Mangroves

3.2 Historical Whale Captures

The Wildlife Conservation Society (WCS) has digitally captured the Townsend Whaling Charts that were published as a series of 4 charts with the article titled "The distribution of certain whales as shown by logbook records of American whale ships" by Charles Haskins Townsend in the journal Zoologica in 1935.

The 4 charts show the locations of over 50,000 captures of 4 whale species; sperm whales (36,908), right whales (8,415), humpback whales (2,883) and bowhead whales (5,114). Capture locations were transcribed from North American ("Yankee") pelagic whale vessel log books dating from 1761 to 1920 and plotted onto nautical charts in a Mercator projection by a cartographer. Each point plotted on the charts represents the location of a whaling ship on a day when one or more whales were taken and is symbolized by month of the year using a combination of color and open and closed circles.

Townsend and his cartographer plotted vessel locations as accurately as possible according to log book records. When plotting locations on an earlier sperm whale chart published in 1931 the cartographer spaced points where locations were very dense, "extending areas slightly" for a number of whaling grounds. However, for charts in preparation at this time, Townsend states that "this difficulty is avoided by omitting some of the data, rather than extend the ground beyond actual whaling limits." We assumed that this statement refers to the 1935 charts but there is still some question as to whether the cartographer did in fact space locations and thus expand whaling grounds.
(source: http://web.archive.org/web/20070926224128/http:/wcs.org/townsend_charts)

Using a geographic information system (ArcMap 10.x, ESRI, Redlands, CA), capture point locations for each species were aggregated into 1-degree cells.

References:

Smith TD, Reeves RR, Josephson EA, Lund JN (2012) Spatial and Seasonal Distribution of American Whaling and Whales in the Age of Sail. PLoS ONE 7:e34905.

Townsend, C.H. 1931. Where the nineteenth century whaler made his catch. Zoologica 34, No. 6:173-179.

Townsend, C.H. 1935. The distribution of certain whales as shown by logbook records of American whaleships. Zoologica 19, No. 1:1-50, 4 charts.

3.2.1 Sperm Whales

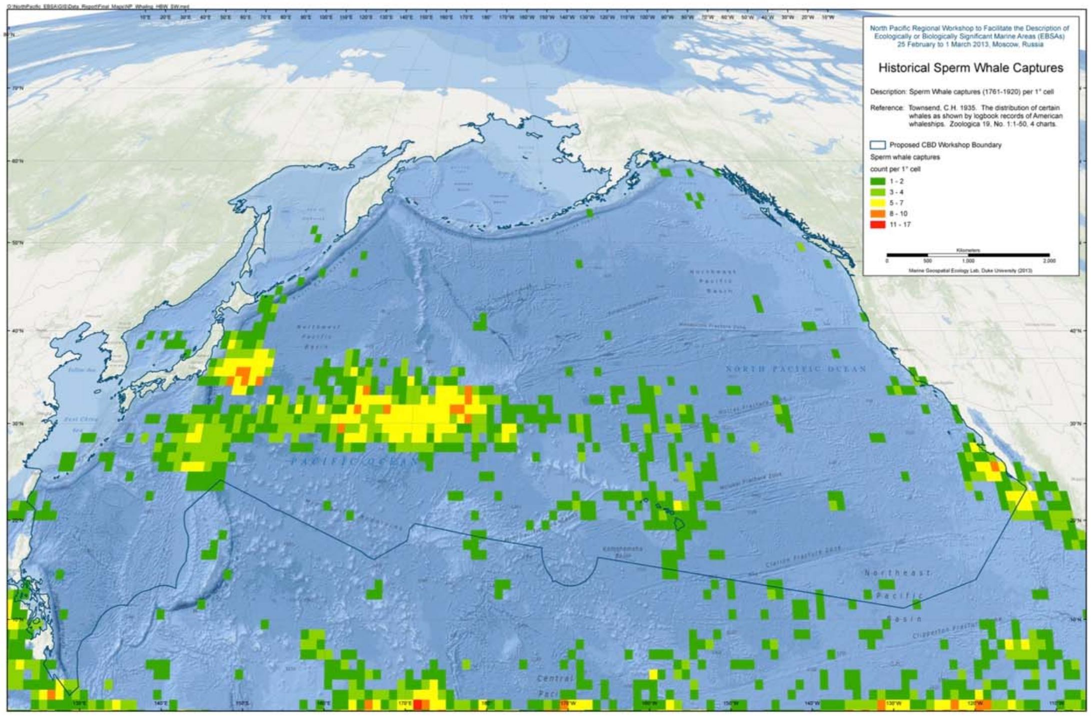

Figure 3.2-1 Historical Sperm Whale Captures

3.2.2 Right Whales

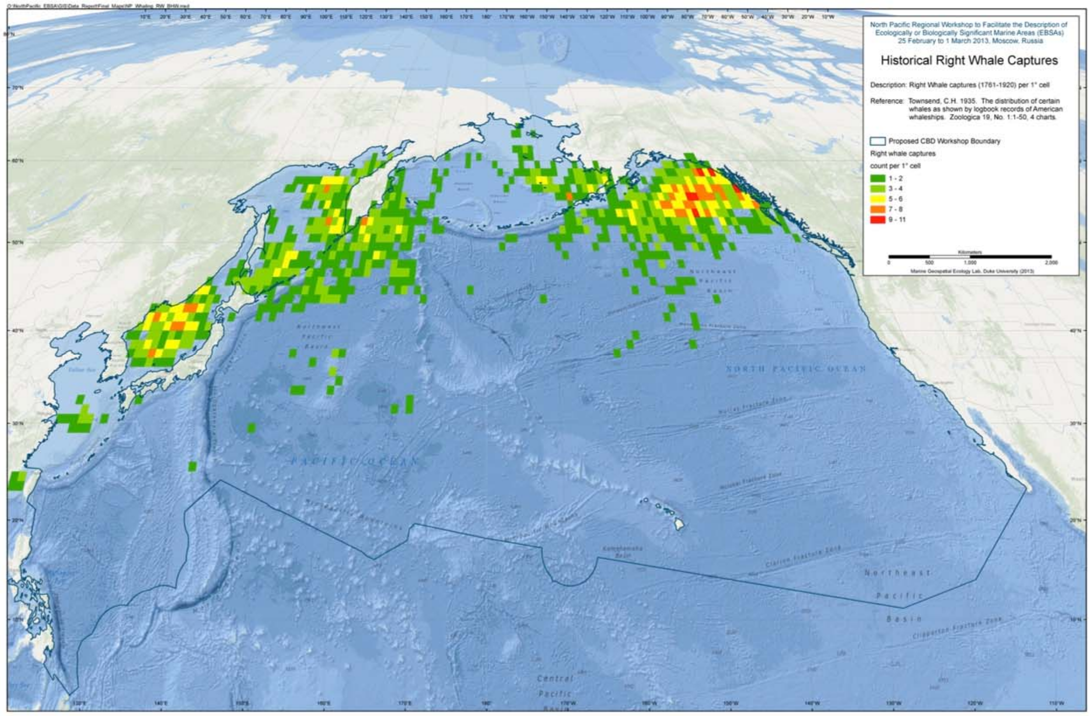

Figure 3.2-2 Historical Right Whale captures

3.2.3 Humpback Whales

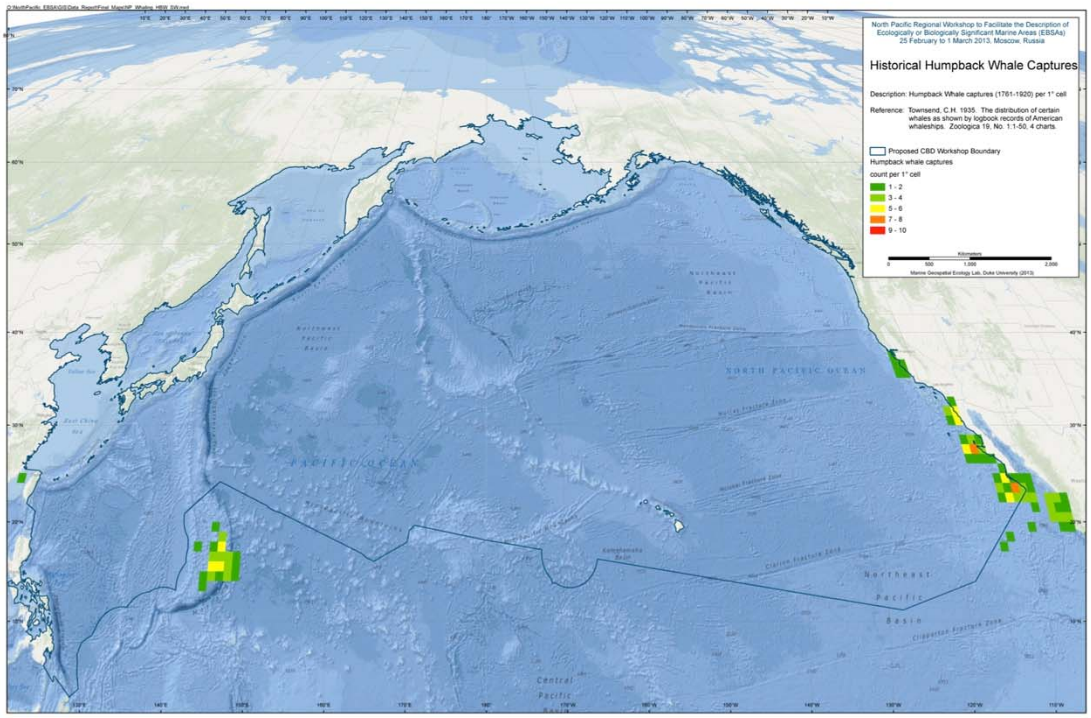

Figure 3.2-3 Historical Humpback Whale Captures

3.2.4 Bowhead Whales

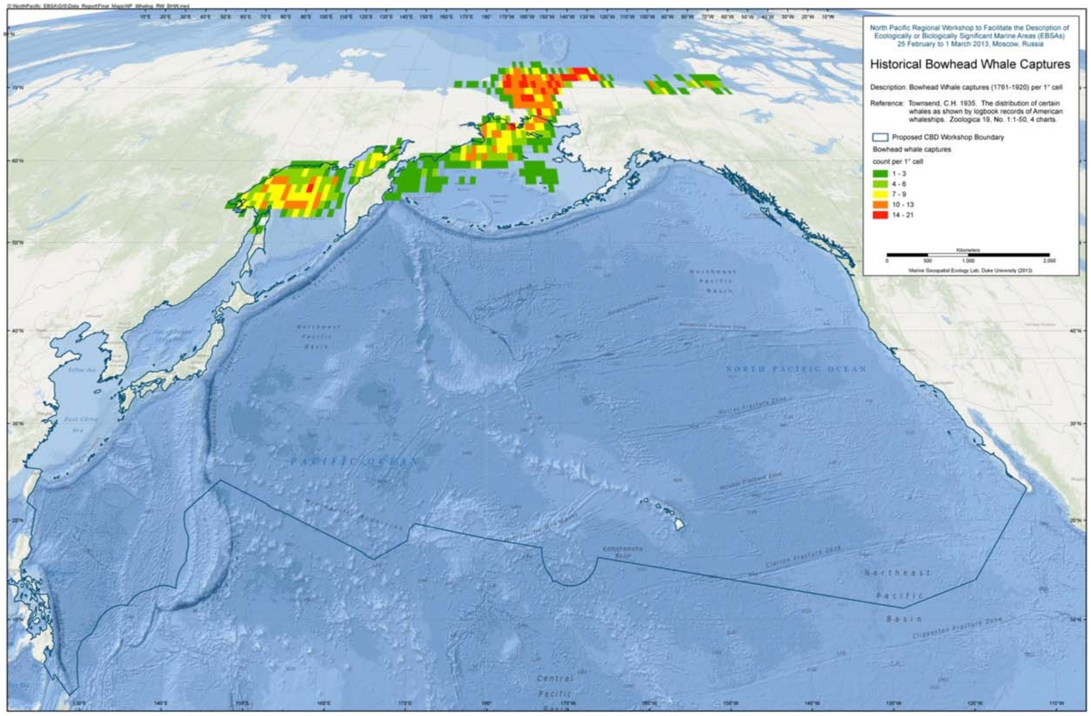

Figure 3.2-4 Historical Bowhead Whale Captures

3.3 Catches of Commercial Pelagic Species

Figures of pelagic commercial species catch were drawn from the FAO Tuna Atlas data service. This service summarizes catch data in 5-degree squares, aggregating data submitted to FAO by Regional Fisheries Management Organizations. Gaps may exist, depending on RFMO submission. Maps show total catch from 1993-2010 for Albacore, Bigeye, and Skipjack and Pacific Bluefin tuna. The symbols used represent total catch by all gear types, with the maximum recalculated for each species– the representation of total catch is not comparable between maps. Longline catch is also identified with secondary green symbols, showing the proportion of total catch that was harvested with that specific gear.

Reference: http://www.fao.org/figis/geoserver/tunaatlas/

3.3.1 Pacific Bluefin Tuna

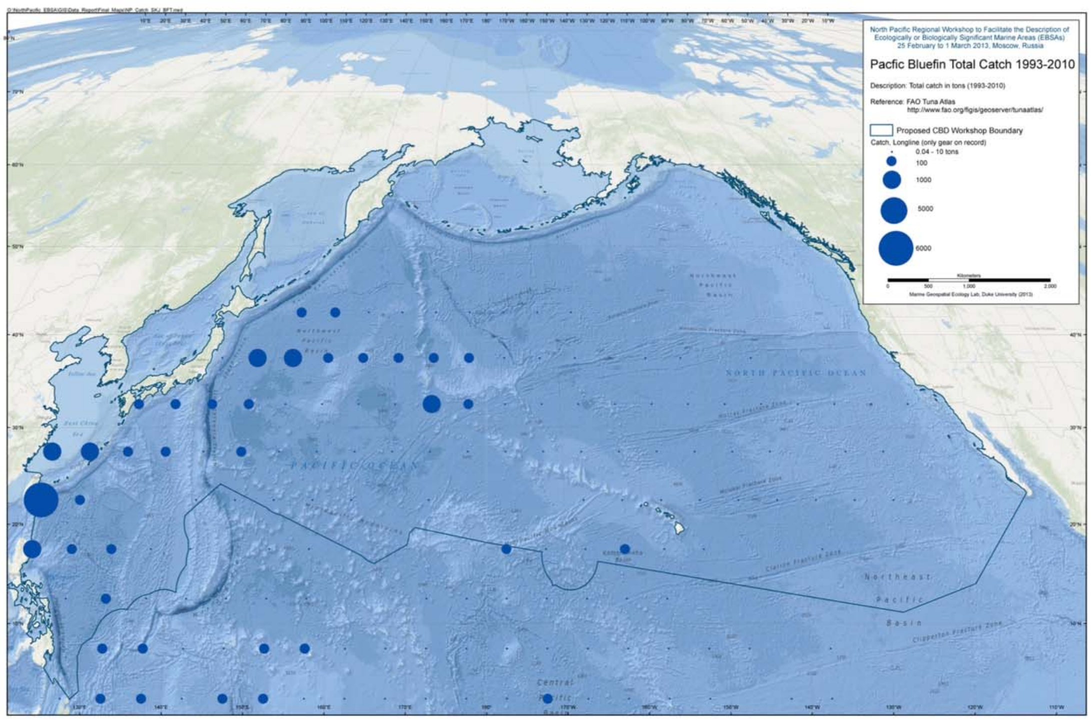

Figure 3.3-1 Pacific Bluefin Tuna Catch Statistics (5 deg)

3.3.2 Bigeye Tuna

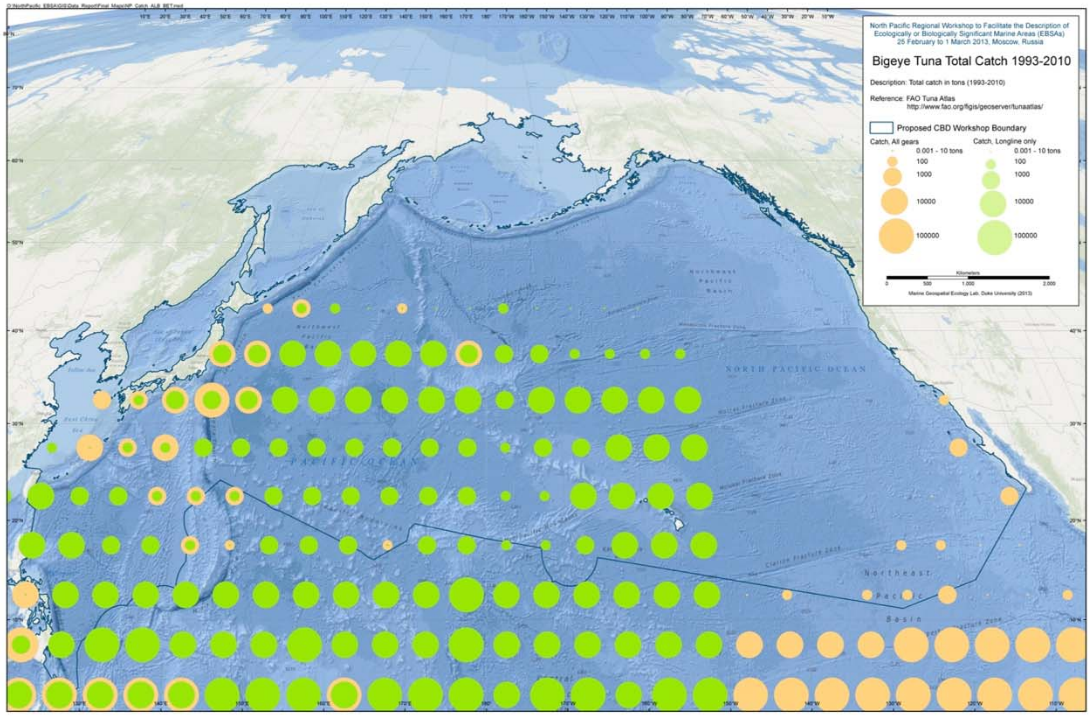

Figure 3.3-2 Bigeye Tuna Catch Statistics (5 deg)

3.3.3 Skipjack Tuna

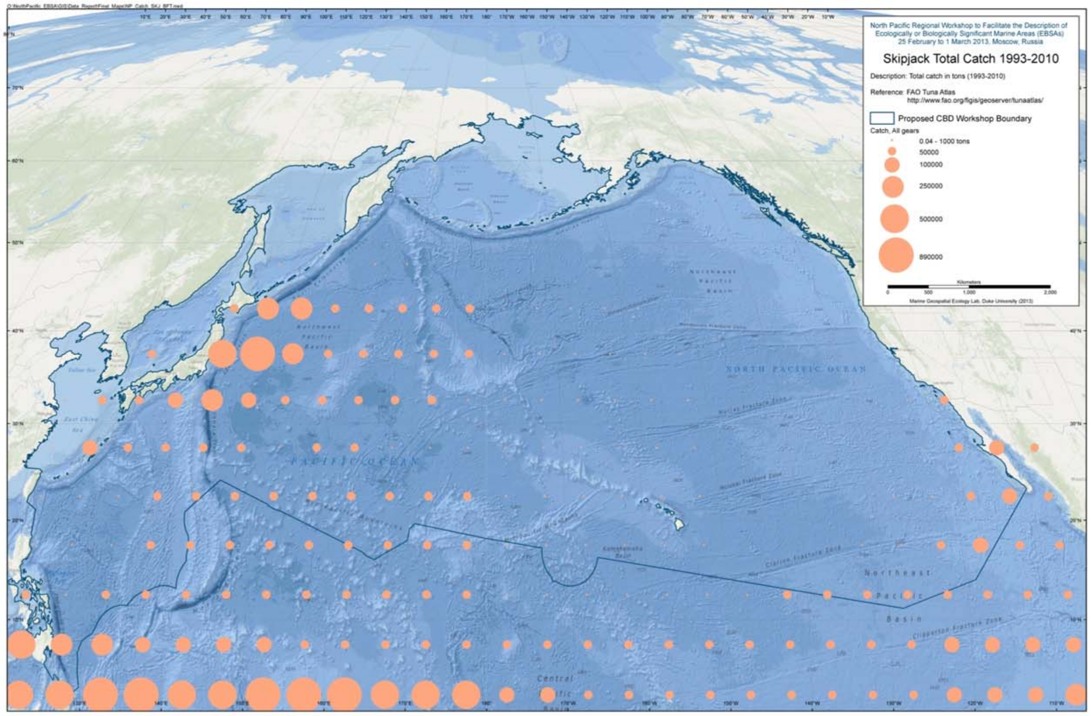

Figure 3.3-3 Skipjack Tuna Catch Statistics (5 deg)

3.3.4 Albacore Tuna

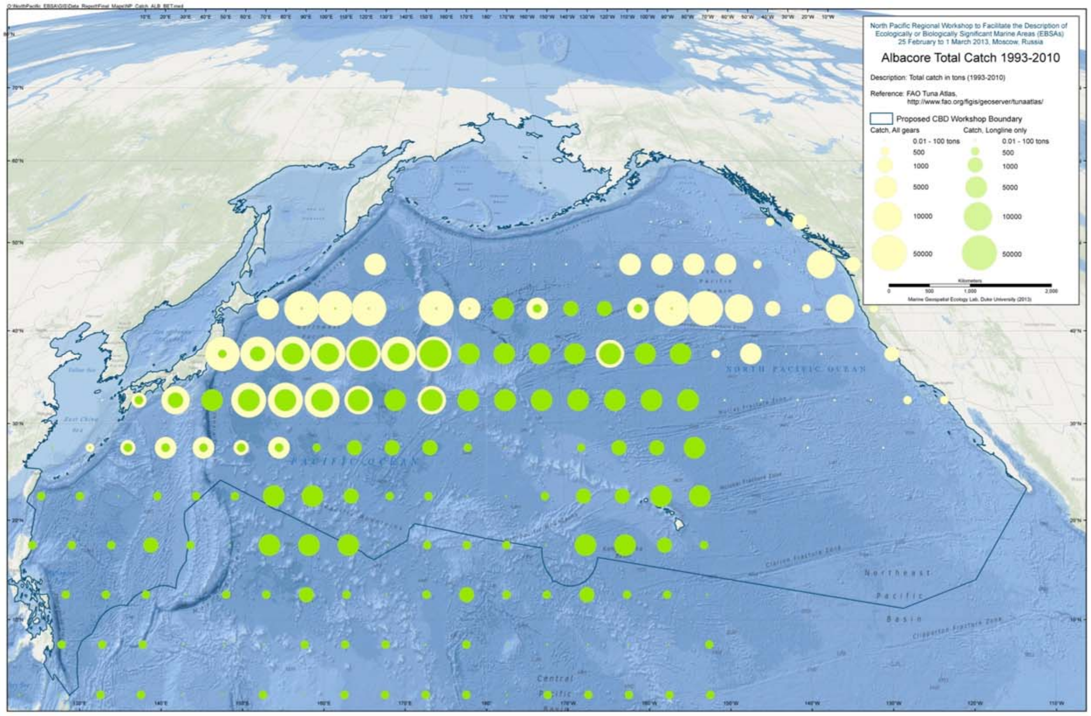

Figure 3.3-4 Albacore Tuna Catch Statistics (5 deg)

3.4 Sea Turtle Nesting Beaches

SWOT — the State of the World's Sea Turtles — is a partnership led by the Sea Turtle Flagship Program at Conservation International (CI), the IUCN Marine Turtle Specialist Group (MTSG), and supported by the Marine Geospatial Ecology Lab (MGEL) at Duke University.

However, the lifeblood of the effort is the network of more than 550 people and projects that contribute data to the SWOT database, the only comprehensive, global database of sea turtle nesting sites. The SWOT team has completed six years of data collection including the global nesting locations of all seven marine turtle species: green, leatherbacks, loggerheads, hawksbills, flatbacks, olive and Kemp's ridleys. SWOT now collects data for all species in its annual data collection.

In addition to collating nesting abundance and distribution information for all species, SWOT now hosts data compiled by the MTSG Burning Issues Working Group that includes Regional Management Units for all seven marine turtle species, including all available georeferenced mtDNA and nDNA stocks. These files can be viewed on the SWOT website and downloaded for analyses once the Terms of Use are agreed to. Furthermore, SWOT also supports recommendations for monitoring effort schemes that will allow for comparison of long-term nesting abundance and trend estimates for regional and global populations of sea turtle species. These advances will solidify SWOT as the premier global monitoring system for sea turtles. Information on Minimum Data Standards are available at http://seaturtlestatus.org/data/standards.

The current SWOT database contains sea turtle nesting records from over 120 countries all over the world. This online tool, hosted by OBIS-SEAMAP, builds on previous work initiated and supported by WIDECAST organization as well as data from several other regional sea turtle organizations. Records coming from projects that are both a part of a regional organization are flagged as such. The WIDECAST Atlas can still be accessed as a stand-alone application. New data from the WIDECAST network is added to the SWOT database annually.
(source: http://mgel.env.duke.edu/projects/swot/)

Reference:

DiMatteo, A., E. Fujioka, B. Wallace, B. Hutchinson, J. Cleary and P. Halpin. 2009. SWOT Database Online. Data provided by the SWOT Team. World Wide Web electronic publication.

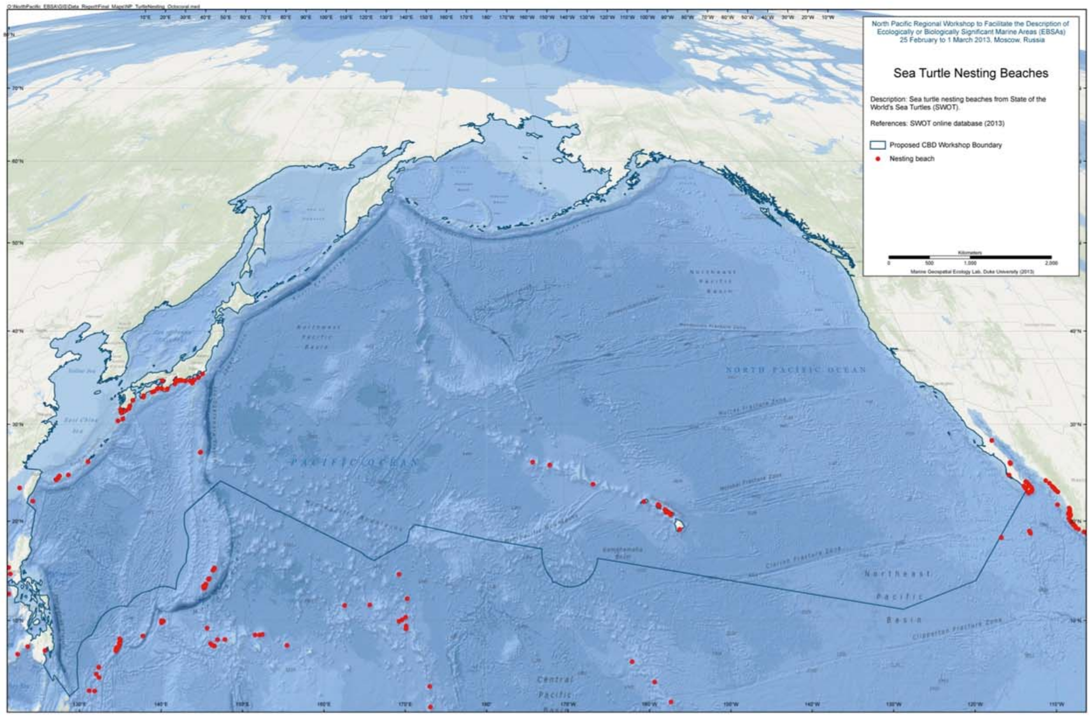

Figure 3.4-1 Sea Turtle Nesting Beaches

3.5 Ocean Biogeographic Information System (OBIS)

The Ocean Biogeographic information System (OBIS) seeks to absorb, integrate, and assess isolated datasets into a larger, more comprehensive picture of life in our oceans. The system hopes to stimulate research about our oceans to generate new hypotheses concerning evolutionary processes, species distributions, and roles of organisms in marine systems on a global scale. The abstracts that OBIS generates are maps that contribute to the 'big picture' of our oceans: a comprehensive, collaborative, worldwide view of our oceans.

OBIS provides a portal or gateway to many datasets containing information on where and when marine species have been recorded. The datasets are integrated so you can search them all seamlessly by species name, higher taxonomic level, geographic area, depth, and time; and then map and find environmental data related to the locations.
(source: http://www.iobis.org/about/index)

The data provided here are summaries of available OBIS data. Species Richness and Hurlbert's Index (ES[50]) data summaries for 1 degree grids are provided for all species, mammals, turtles, shallow species (<100m depth), deep species(>100m depth), and species on the IUCN Red List. Data gaps do exist in OBIS and thus these summaries are not exhaustive.

Reference: Intergovernmental Oceanographic Commission (IOC) of UNESCO. The Ocean Biogeographic Information System. Web. http://www.iobis.org. (Consulted on 15/01/13)

3.5.1 All Species – Biodiversity

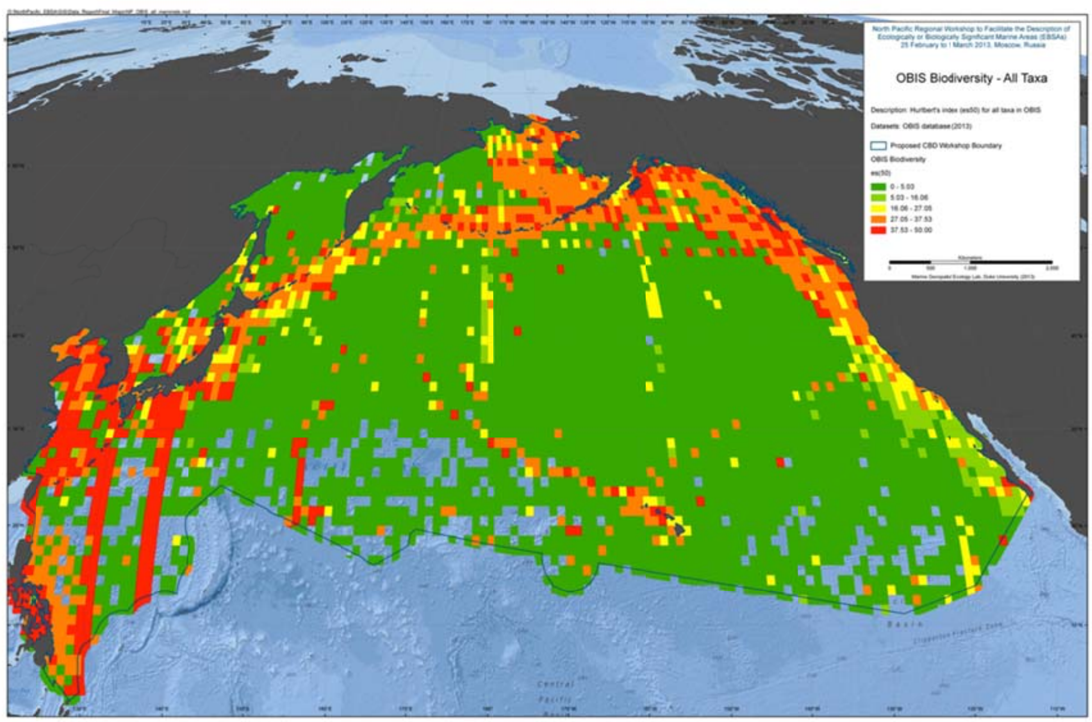

Figure 3.5-1 ES(50) for All Taxa

3.5.2 Marine Mammals - Species Richness

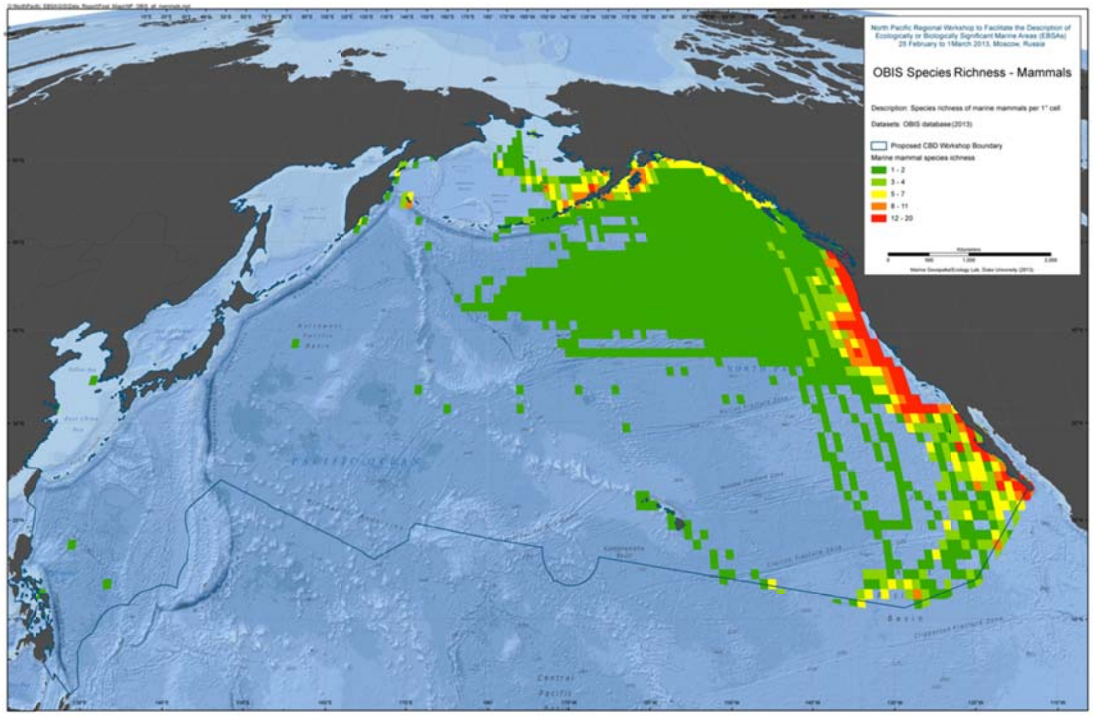

Figure 3.5-2 Species Richness for Marine Mammals

3.5.3 Sea Turtles – Species Richness

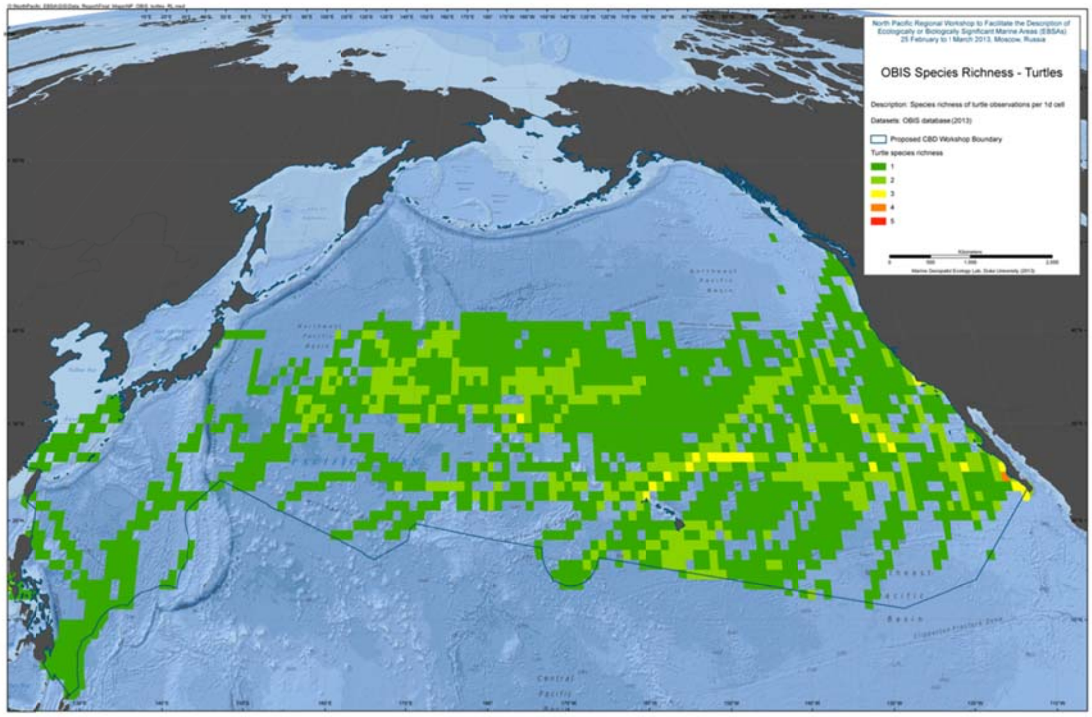

Figure 3.5-3 Species Richness for Sea Turtles

3.5.4 Shallow Species - Biodiversity

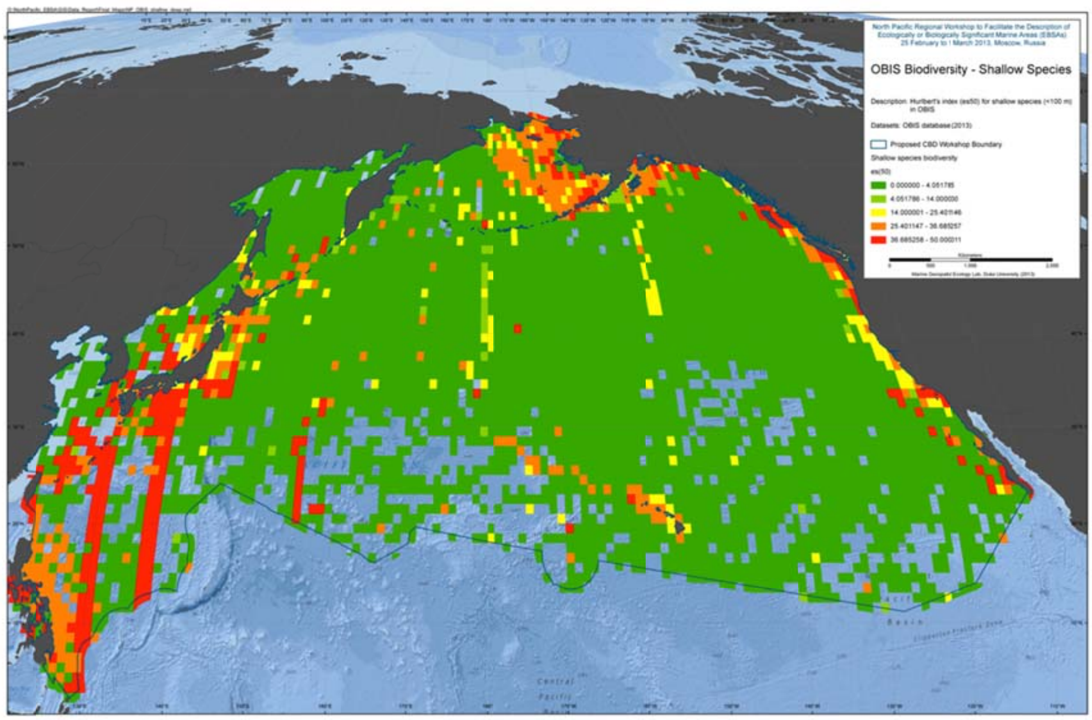

Figure 3.5-4 ES(50) for Shallow Species

3.5.5 Deep Species - Biodiversity

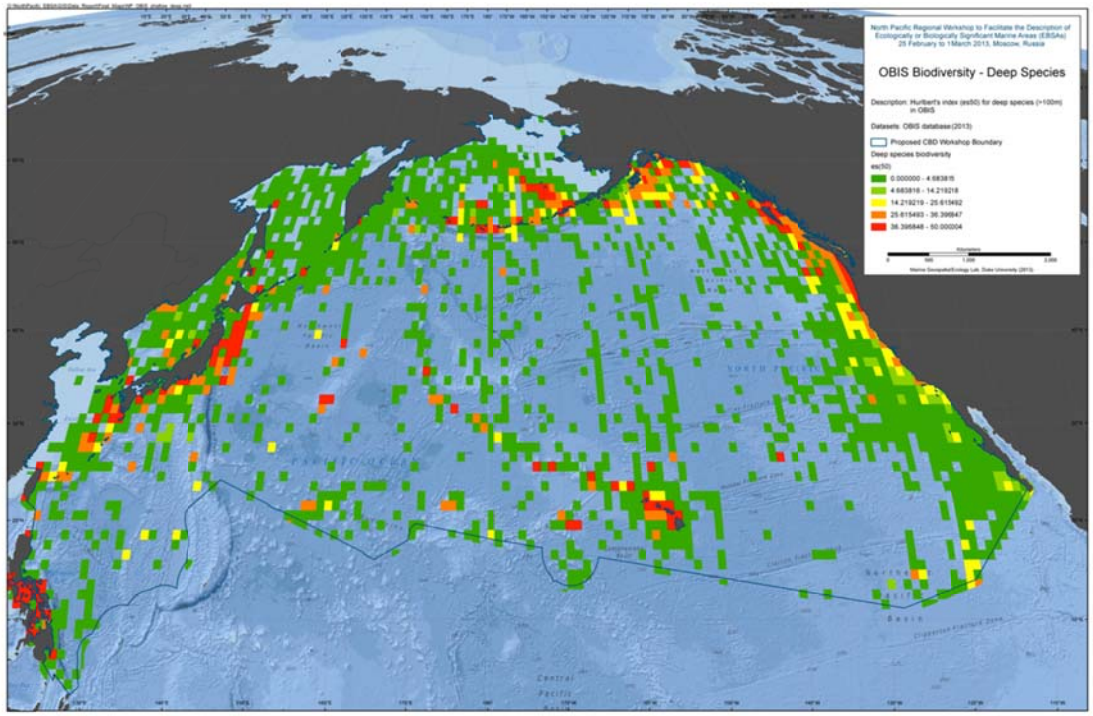

Figure 3.5-5 ES(50) for Deep Species

3.5.6 IUCN Red List species – Species Richness

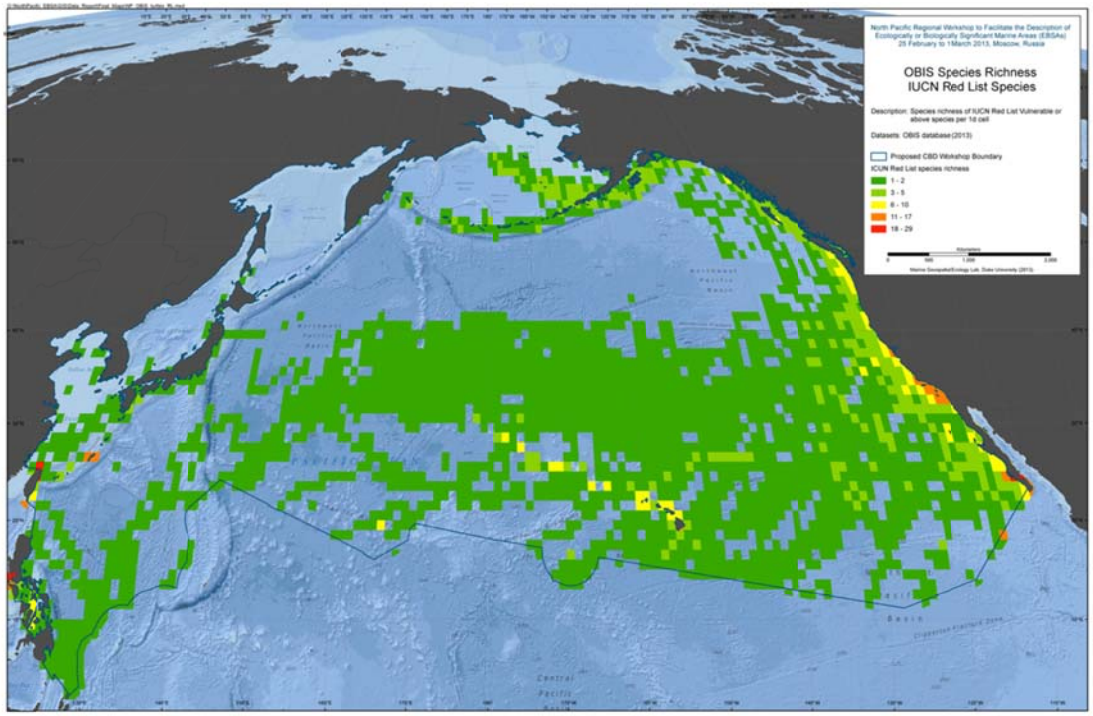

Figure 3.5-6 Species Richness for IUCN Red List species

3.6 Predictions of Deep Sea Corals

Abstract:
Predictive habitat models are increasingly being used by conservationists, researchers and governmental bodies to identify vulnerable ecosystems and species' distributions in areas that have not been sampled. However, in the deep sea, several limitations have restricted the widespread utilisation of this approach. These range from issues with the accuracy of species presences, the lack of reliable absence data and the limited spatial resolution of environmental factors known or thought to control deep-sea species' distributions. To address these problems, global habitat suitability models have been generated for five species of framework-forming scleractinian corals by taking the best available data and using a novel approach to generate high resolution maps of seafloor conditions. High-resolution global bathymetry was used to resample gridded data from sources such as World Ocean Atlas to produce continuous 30-arc second (1 km^2) global grids for environmental, chemical and physical data of the world's oceans. The increased area and resolution of the environmental variables resulted in a greater number of coral presence records being incorporated into habitat models and higher accuracy of model predictions. The most important factors in determining cold-water coral habitat suitability were depth, temperature, aragonite saturation state and salinity. Model outputs indicated the majority of suitable coral habitat is likely to occur on the continental shelves and slopes of the Atlantic, South Pacific and Indian Oceans. The North Pacific has very little suitable scleractinian coral habitat. Numerous small scale features (i.e., seamounts), which have not been sampled or identified as having a high probability of supporting cold-water coral habitat were identified in all ocean basins. Field validation of newly identified areas is needed to determine the accuracy of model results, assess the utility of modeling efforts to identify vulnerable marine ecosystems for inclusion in future marine protected areas and reduce coral bycatch by commercial fisheries.

Reference:
Davies AJ, Guinotte JM (2011) *Global Habitat Suitability for Framework-Forming Cold-Water Corals*. PLoS ONE 6(4): e18483. doi:10.1371/journal.pone.0018483

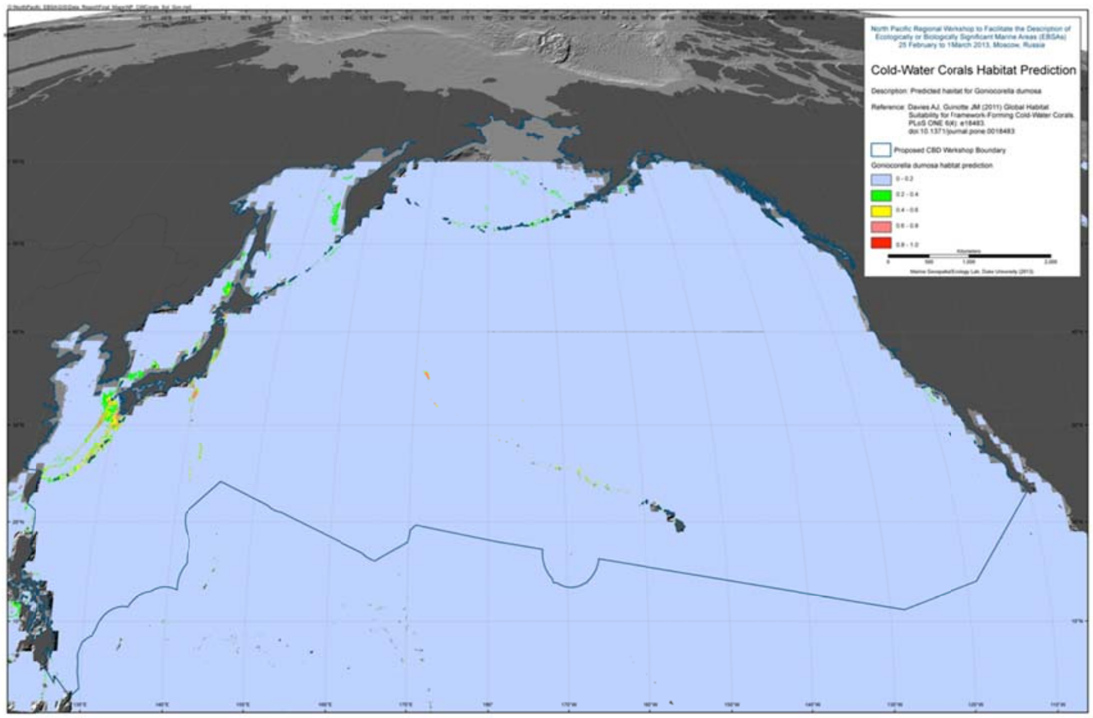

Figure 3.6-1 Goniocorella dumosa Habitat Prediction

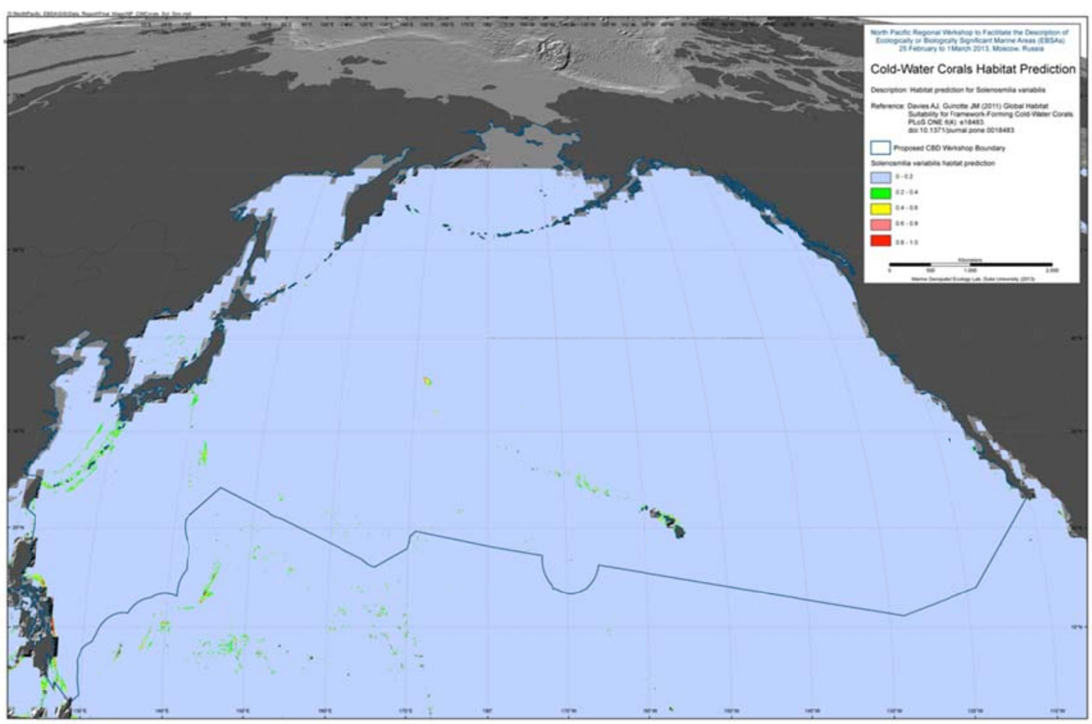

Figure 3.6-2 Solenosmilia variabilis Habitat Prediction

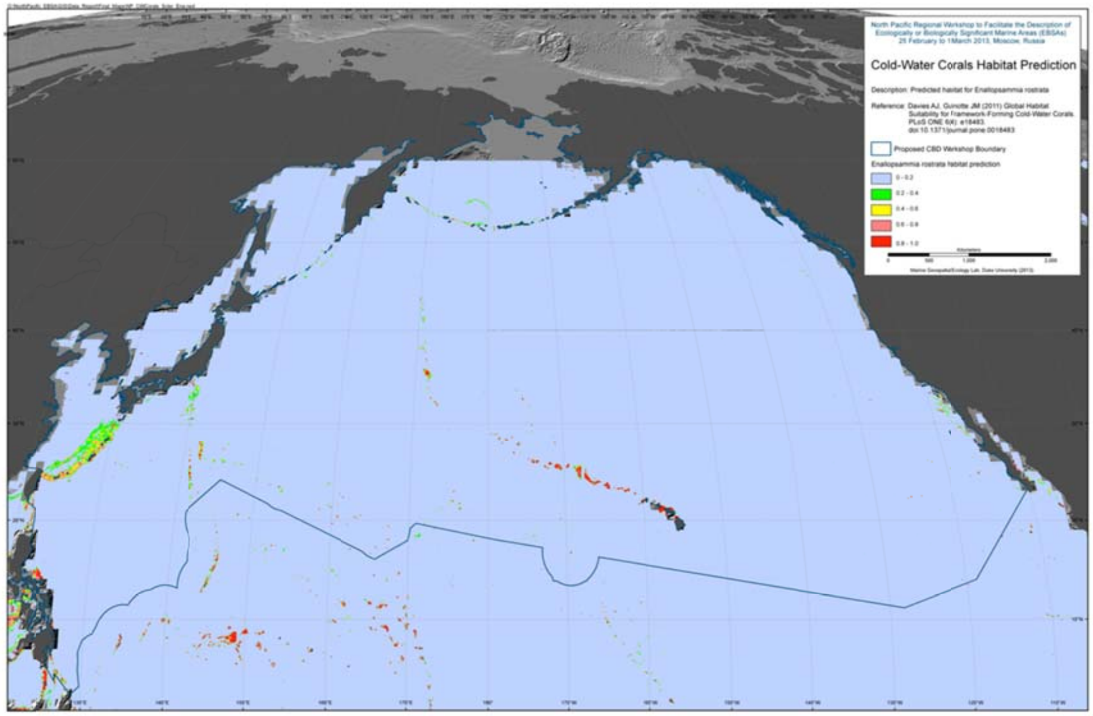

Figure 3.6-3 Enallopsammia rostrata Habitat Prediction

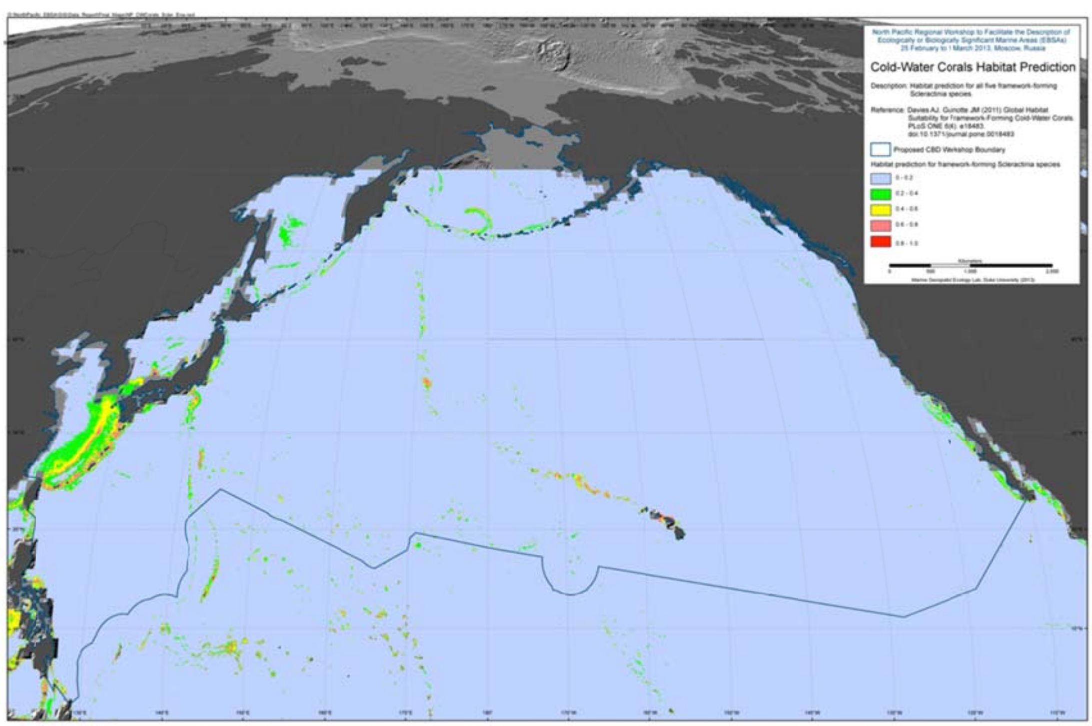

Figure 3.6-4 Framework-forming Scleractinia spp. Habitat Prediction

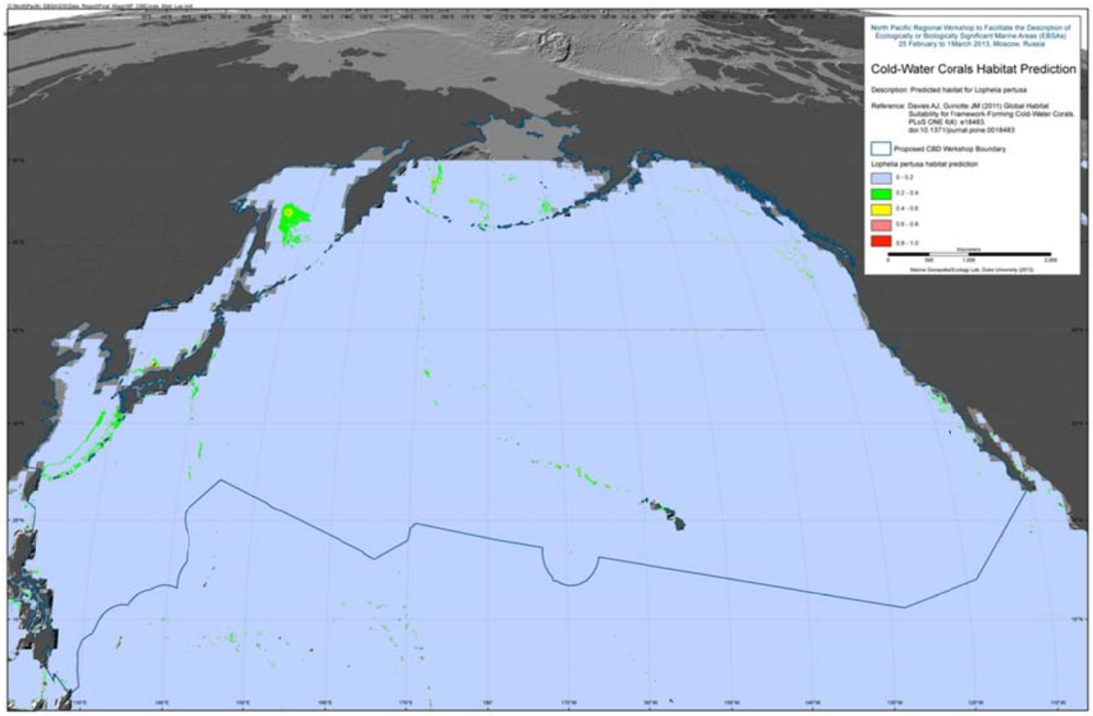

Figure 3.6-5 Lophelia pertusa Habitat Prediction

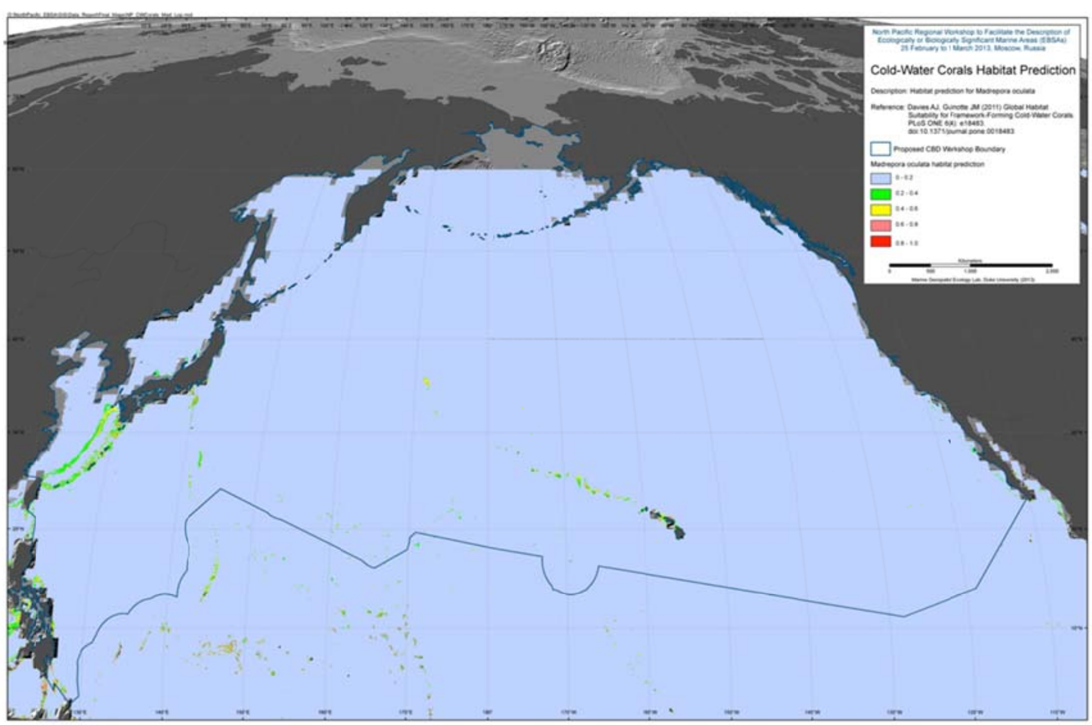

Figure 3.6-6 Madrepora oculata Habitat Prediction

3.7 Predictions of Deep-Sea Octocorals

Abstract:

Three-quarters of Octocorallia species are found in deep waters. These cold- water octocoral colonies can form a major constituent of structurally complex habitats. The global distribution and the habitat requirements of deep-sea octocorals are poorly understood given the expense and difficulties of sampling at depth. Habitat suitability models are useful tools to extrapolate distributions and provide an understanding of ecological requirements. Here, we present global habitat suitability models and distribution maps for seven suborders of Octocorallia: Alcyoniina, Calcaxonia, Holaxonia, Scleraxonia, Sessiliflorae, Stolonifera and Subselliflorae.

Reference:
Yesson C, Taylor ML, Tittensor DP, Davies AJ, Guinotte J, Baco A, Black J, Hall-Spencer JM, Rogers AD (2012) *Global habitat suitability of cold-water octocorals*. Journal of Biogeography 39:1278–1292.

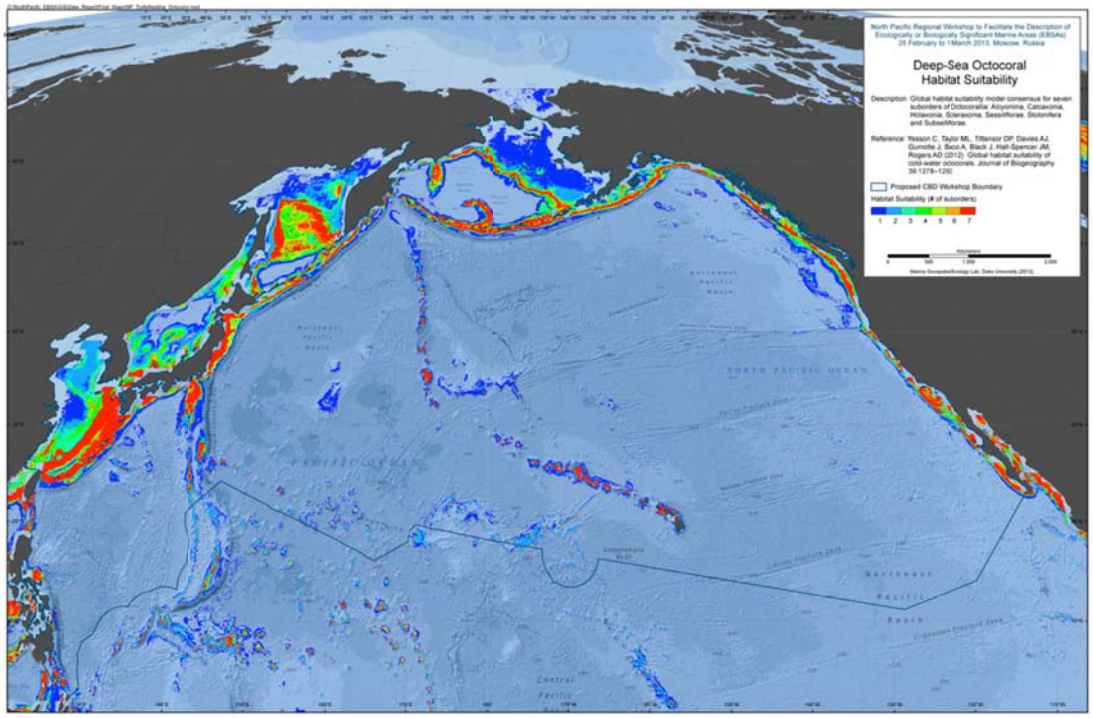

Figure 3.7-1 Deep-Sea Octocoral Habitat Suitability - Consensus

3.8 Synthesis of marine predator migrations, distribution, species overlap, and use of Pacific Ocean Exclusive Economic Zones

Dissertation Abstract:

"Many marine predator populations are commercially important and are threatened by human activities. As a result, many of these populations are heavily depleted, declining, or are recovering from past depletion. Recovery and management of threatened and exploited marine predators are complicated by life histories that 1) span international waters, 2) are dynamic in space and time, and 3) are hidden from direct observation. My goal with this dissertation was to attain a synthetic understanding of the implications of marine predator migratory life histories on the spatio-temporal dynamics of distribution, species overlap, and residency in Exclusive Economic Zones of countries. I analyzed an electronic tracking dataset provided by the Tagging of Pacific Predators program that contained location data for pinnipeds, seabirds, sharks, tuna, turtles, and whales. This dataset included 257,133 daily locations recorded from 1,679 individuals representing 18 species of pelagic predators electronically tracked in the Pacific Ocean during an eight-year period."

Reference:

Harrison, A.-L. *A synthesis of marine predator migrations, distribution, species overlap, and use of Pacific Ocean Exclusive Economic Zones*. Ph.D. dissertation, University of California at Santa Cruz, 2012.

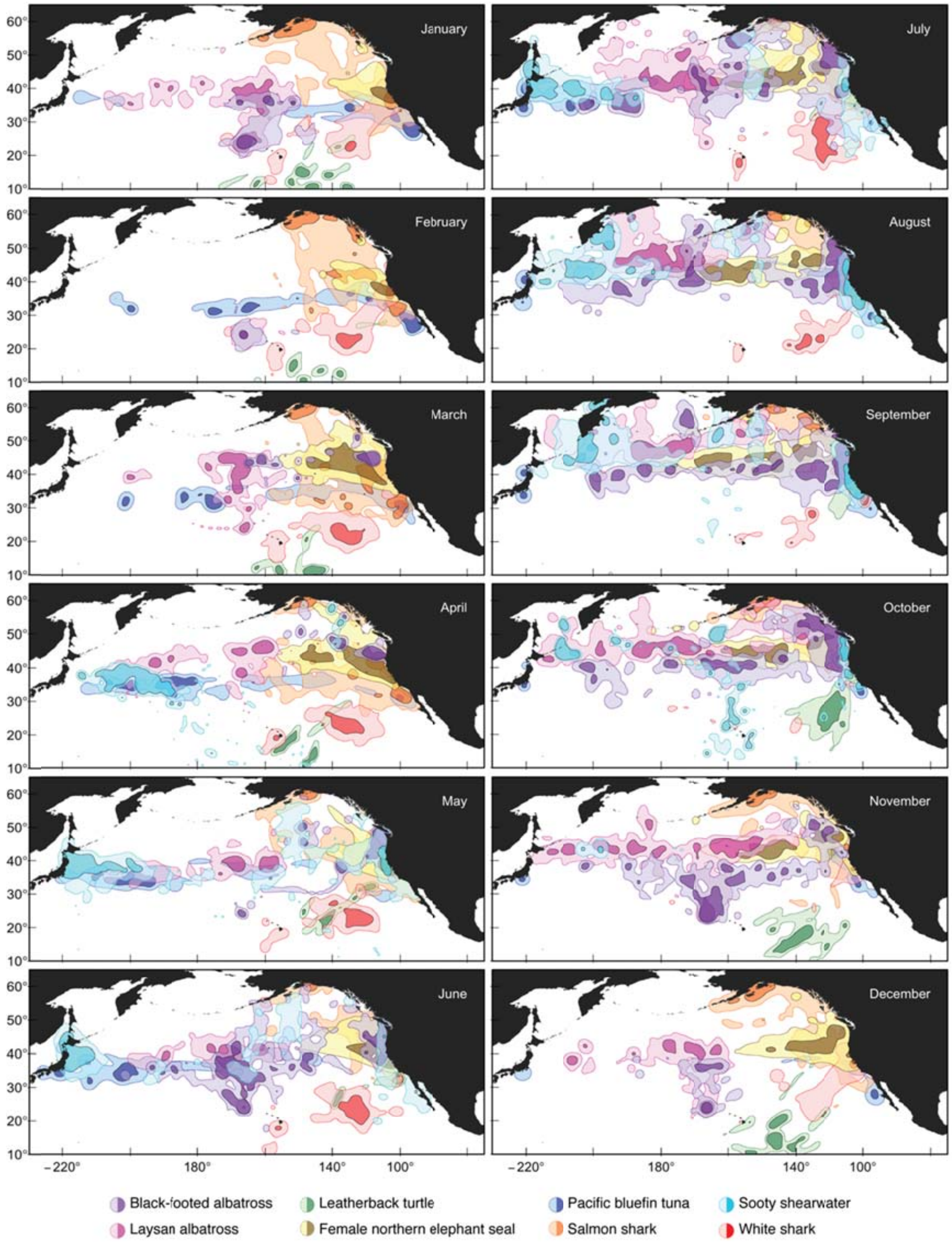

Figure 3.8-1 Estimated monthly utilization distributions (1-degree bandwidths) of 8 marine predator populations electronically tracked during 2002-2008.

For each species, color gradients represent the 95% (light), and 50% (dark) UD contours. (Figure 3.3 from Harrison 2012)

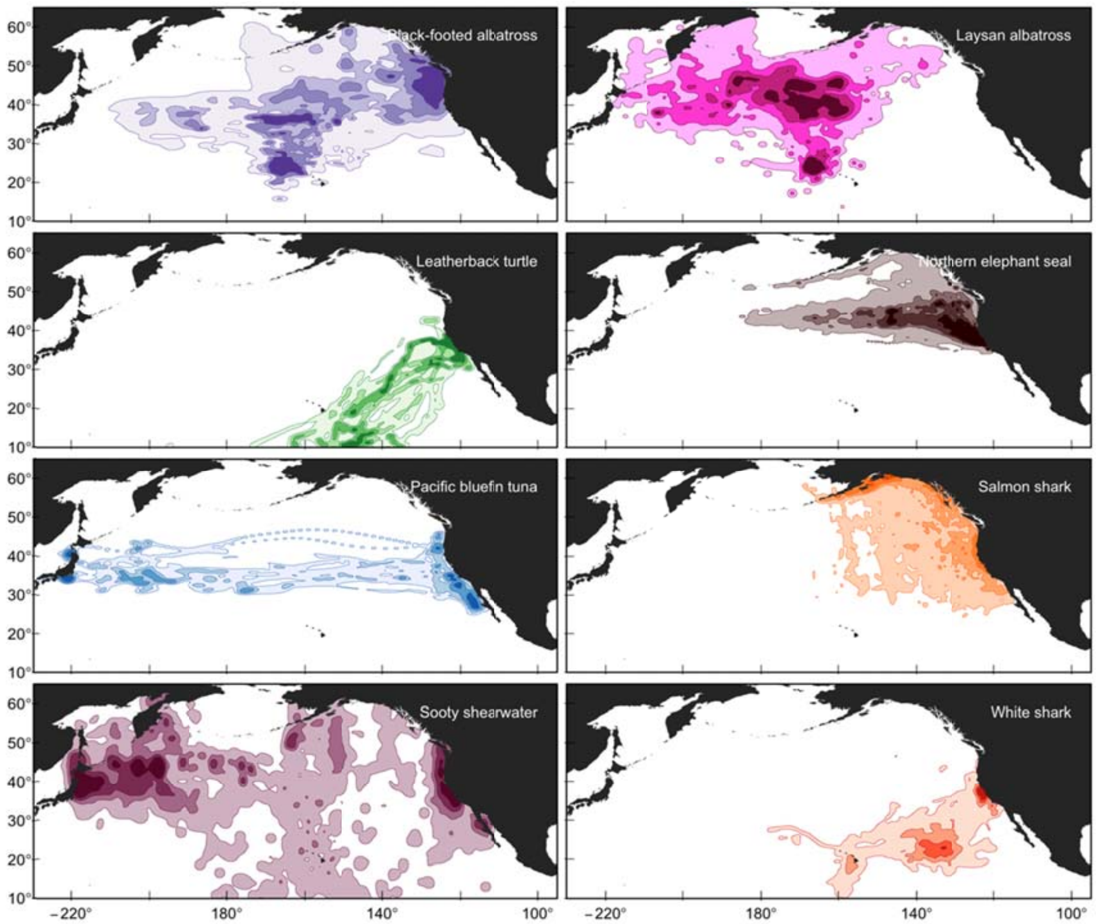

Figure 3.8-2 Estimated month-normalized annual utilization distributions (ISJ band- widths) of 8 marine predator populations electronically tracked during 2002-2008.

Color gradients represent from light to dark the 95%, 75%, 50% and 25% UD contours. (Figure 3.7 from Harrison 2012)

3.9 Predicted habitat shifts of Pacific top predators in a changing climate

Abstract:
To manage marine ecosystems proactively, it is important to identify species at risk and habitats critical for conservation. Climate change scenarios have predicted an average sea surface temperature (SST) rise of 1–6 °C by 2100 (refs 1, 2), which could affect the distribution and habitat of many marine species. Here we examine top predator distribution and diversity in the light of climate change using a database of 4,300 electronic tags deployed on 23 marine species from the Tagging of Pacific Predators project, and output from a global climate model to 2100. On the basis of models of observed species distribution as a function of SST, chlorophyll *a* and bathymetry, we project changes in species-specific core habitat and basin-scale patterns of biodiversity. We predict up to a 35% change in core habitat for some species, significant differences in rates and patterns of habitat change across guilds, and a substantial northward displacement of biodiversity across the North Pacific. For already stressed species, increased migration times and loss of pelagic habitat could exacerbate population declines or inhibit recovery. The impending effects of climate change stress the urgency of adaptively managing ecosystems facing multiple threats.

References:
Hazen EL, Jorgensen S, Rykaczewski RR, Bograd SJ, Foley DG, Jonsen ID, Shaffer SA, Dunne JP, Costa DP, Crowder LB, Block BA (2012) *Predicted habitat shifts of Pacific top predators in a changing climate*. Nature Clim. Change advance online publication.

Block BA, Jonsen ID, Jorgensen SJ, Winship AJ, Shaffer SA, Bograd SJ, Hazen EL, Foley DG, Breed GA, Harrison A-L, Ganong JE, Swithenbank A, Castleton M, Dewar H, Mate BR, Shillinger GL, Schaefer KM, Benson SR, Weise MJ, Henry RW, Costa DP (2011) *Tracking apex marine predator movements in a dynamic ocean.* Nature 475:86–90.

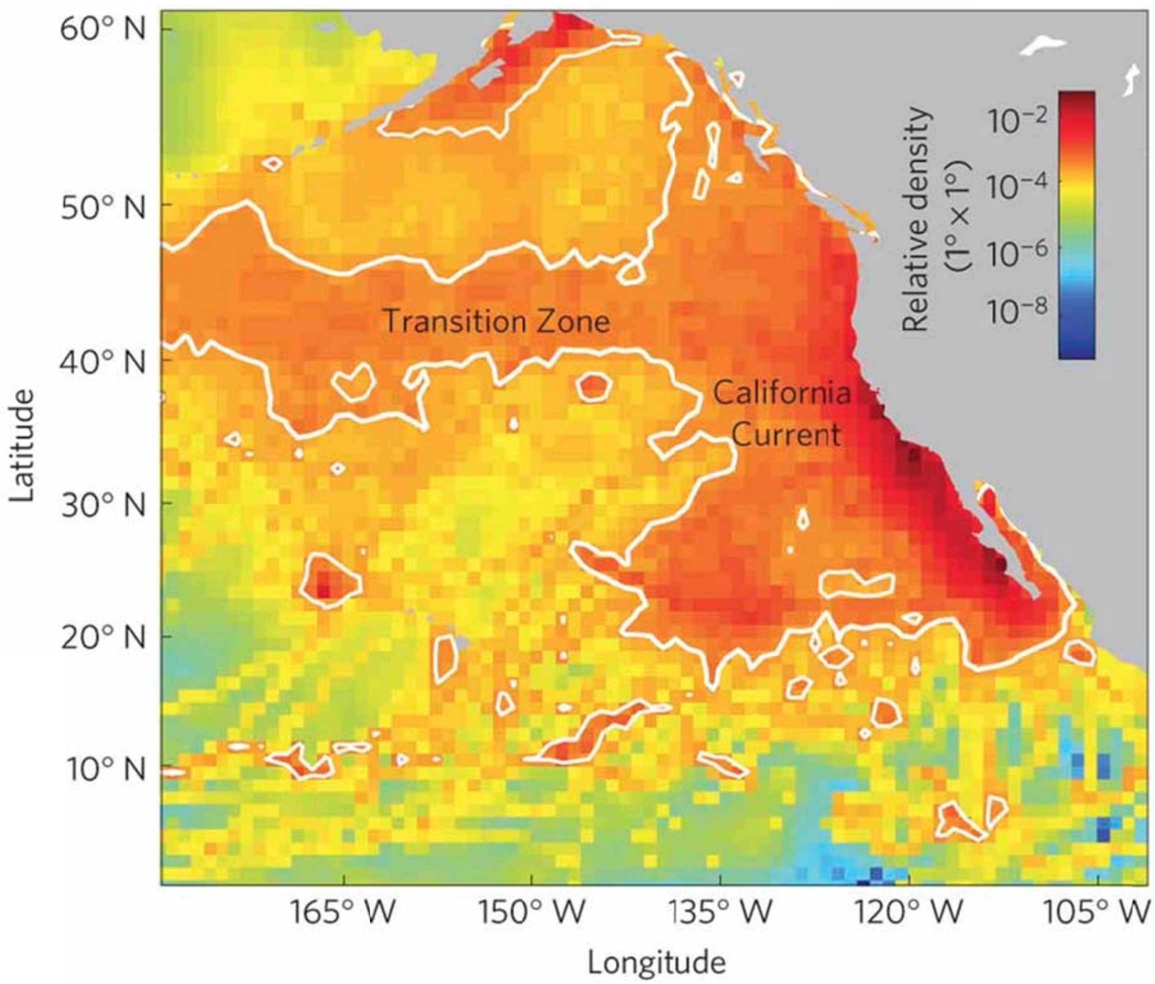

Figure 3.9-1 Density of top predators within the eastern North Pacific

(Fig 1, Hazen et.al. 2012)

3.10 Important Bird Areas

BirdLife Important Bird Areas (IBAs) have been used to inform the identification of EBSAs in previous EBSA regional workshops. Previously the data provided has been used to either support the designation of an EBSA for a range of taxa and habitats, or to identify EBSAs solely on the basis of bird data.

IBAs have been identified using several data sources:

1. Terrestrial seabird breeding sites are shown with point locality and species that qualifies at the IBA
   – see http://www.birdlife.org/datazone/site/search
2. Marine areas around breeding colonies have been identified based on literature review where possible to guide the distance required by each species. Where literature is sparse or lacking, extensions have been applied on a precautionary basis.
   – see http://seabird.wikispaces.com/
3. Sites identified by satellite tracking data via kernel density analysis, first passage time analysis and bootstrapping approaches.
   - www.seabirdtracking.org

Together these IBAs form a network of sites of importance to coastal, pelagic, resident and or migratory species. EBSA criteria of particular relevance are “important for life-history stages”, “threatened species”, “diversity” and “fragility”. For further information Google “IBAs vs EBSAs”.

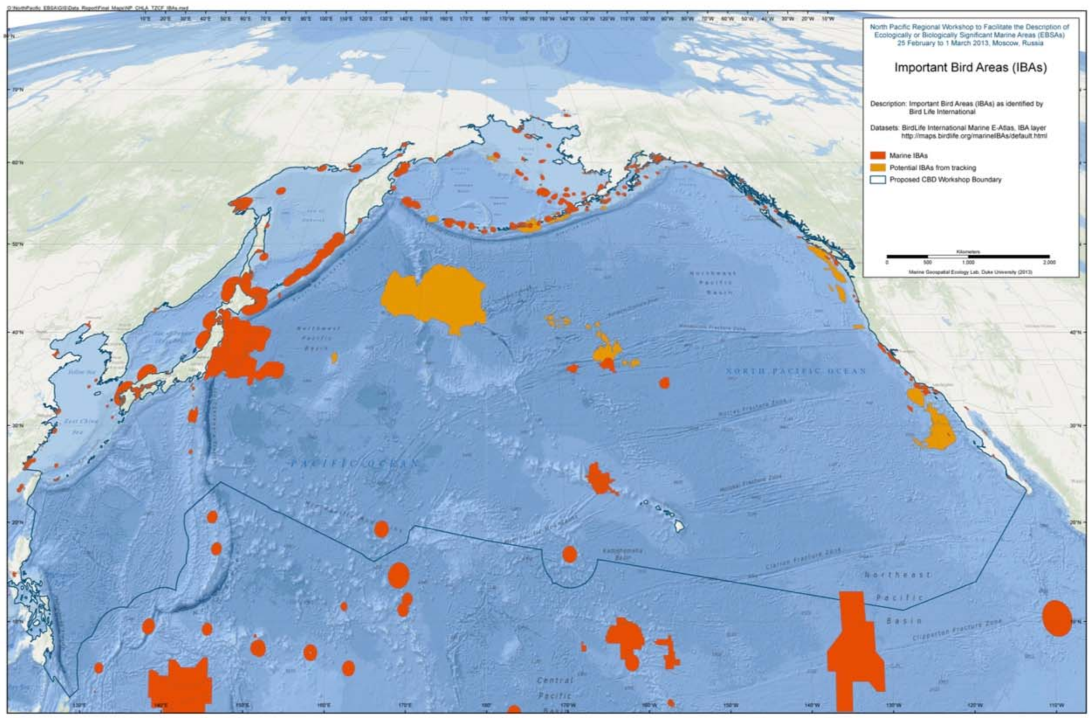

Figure 3.10-1 Important Bird Areas (IBAs)

4 Physical Data

4.1 Seamounts

Abstract:
Seamounts and knolls are 'undersea mountains', the former rising more than 1000 m from the seafloor. These features provide important habitats for aquatic predators, demersal deep-sea fish and benthic invertebrates. However most seamounts have not been surveyed and their numbers and locations are not well known. Previous efforts to locate and quantify seamounts have used relatively coarse bathymetry grids. Here we use global bathymetric data at 30 arc-second resolution to identify seamounts and knolls. We identify 33,452 seamounts and 138,412 knolls, representing the largest global set of identified seamounts and knolls to date. We compare estimated seamount numbers, locations, and depths with validation sets of seamount data from New Zealand and Azores. This comparison indicates the method we apply finds 94% of seamounts, but may overestimate seamount numbers along ridges and in areas where faulting and seafloor spreading creates highly complex topography. The seamounts and knolls identified herein are significantly geographically biased towards areas surveyed with shipbased soundings. As only 6.5% of the ocean floor has been surveyed with soundings it is likely that new seamounts will be uncovered as surveying improves. Seamount habitats constitute approximately 4.7% of the ocean floor, whilst knolls cover 16.3%. Regional distribution of these features is examined, and we find a disproportionate number of productive knolls, with a summit depth of o1.5 km, located in the Southern Ocean. Less than 2% of seamounts are within marine protected areas and the majority of these are located within exclusive economic zones with few on the High Seas. The database of seamounts and knolls resulting from this study will be a useful resource for researchers and conservation planners.

Reference:
Yesson, C., et al., The global distribution of seamounts based on 30 arc seconds bathymetry data. Deep-Sea Research I (2011), doi:10.1016/j.dsr.2011.02.004

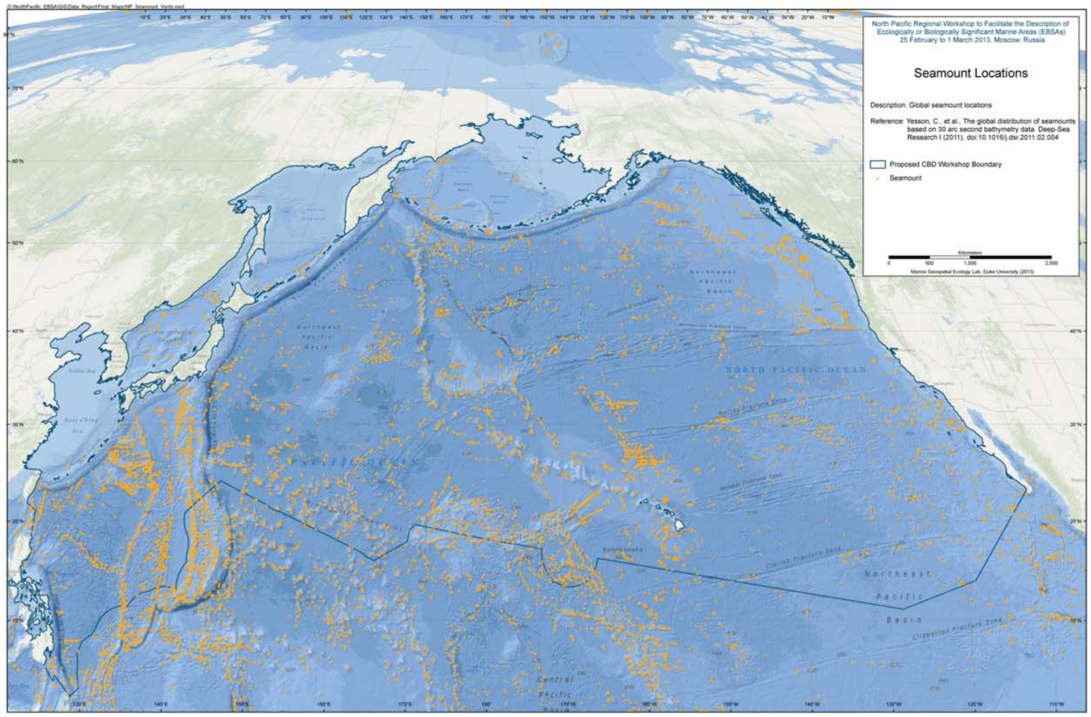

Figure 4.1-1 Seamount Locations

4.2 Vents and Seeps

ChEss (Chemosynthetic Ecosystem Science) was a field project of the Census of Marine Life programme (CoML). The main aim of ChEss was to determine the biogeography of deep-water chemosynthetic ecosystems at a global scale and to understand the processes driving these ecosystems. ChEss addressed the main questions of CoML on diversity, abundance and distribution of marine species, focusing on deep-water reducing environments such as hydrothermal vents, cold seeps, whale falls, sunken wood and areas of low oxygen that intersect with continental margins and seamounts. (source: http://www.noc.soton.ac.uk/chess/)

ChEssBase is a dynamic relational database available online since December 2004. The aim of ChEssBase is to provide taxonomical, biological, ecological and distributional data of all species described from deep-water chemosynthetic ecosystems, as well as bibliography and information on the habitats. These habitats include hydrothermal vents, cold seeps, whale falls, sunken wood and areas of minimum oxygen that intersect with the continental margin or seamounts.

Since the discovery of hydrothermal vents in 1977 and of cold seep communities in 1984, over 500 species from vents and over 200 species from seeps have been described (Van Dover et al., 2002. Science 295: 1253-1257). The discovery of chemosynthetically fuelled communities on benthic OMZs and large organic falls to the deep-sea such as whales and wood have increased the number of habitats and fauna for investigation. New species are continuously being discovered and described from sampling programmes around the globe.
(source: http://www.noc.soton.ac.uk/chess/database/db_home.php)

ChEssBase: http://www.noc.soton.ac.uk/chess/database/db_home.php
InterRidge: http://www.interridge.org/irvents/maps

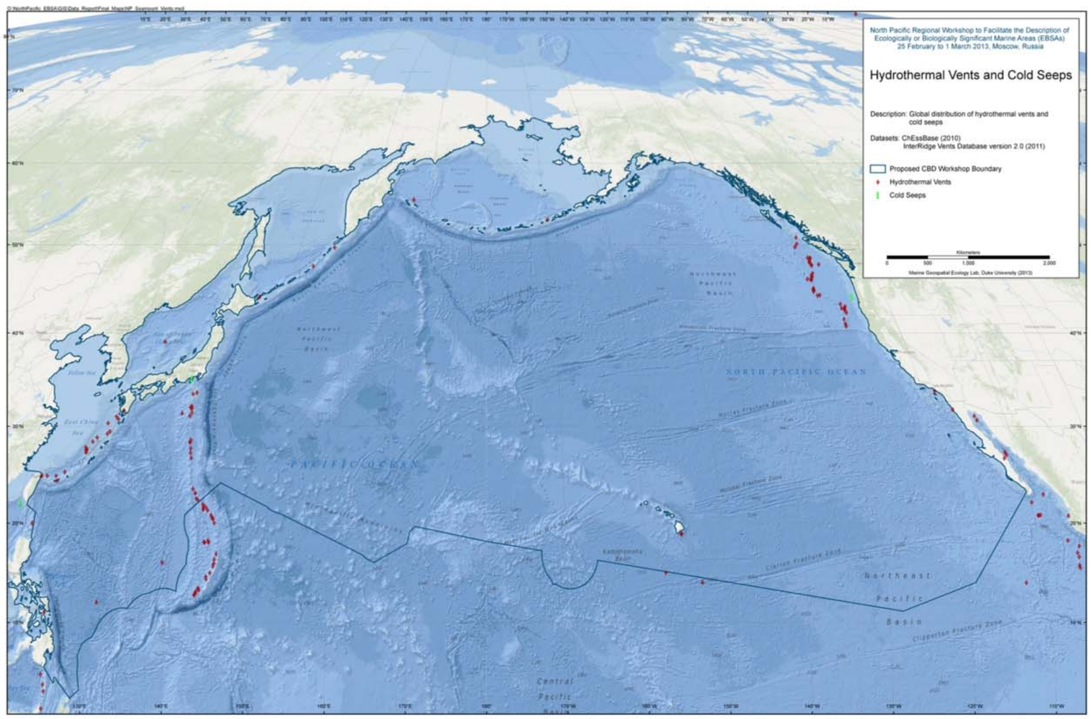

Figure 4.2-1 Hydrothermal Vents and Cold Seeps

4.3 Bathymetry (GEBCO)

The GEBCO_08 Grid is a global 30 arc-second grid largely generated by combining quality controlled ship depth soundings with interpolation between sounding points guided by satellite derived gravity data. However, in areas where they improve on the existing GEBCO 08 grid, data sets generated by other methods have been included. Land data are largely based on the Shuttle Radar Topography Mission (SRTM30) gridded digital elevation model.
(source: http://www.gebco.net/data_and_products/gridded_bathymetry_data/)

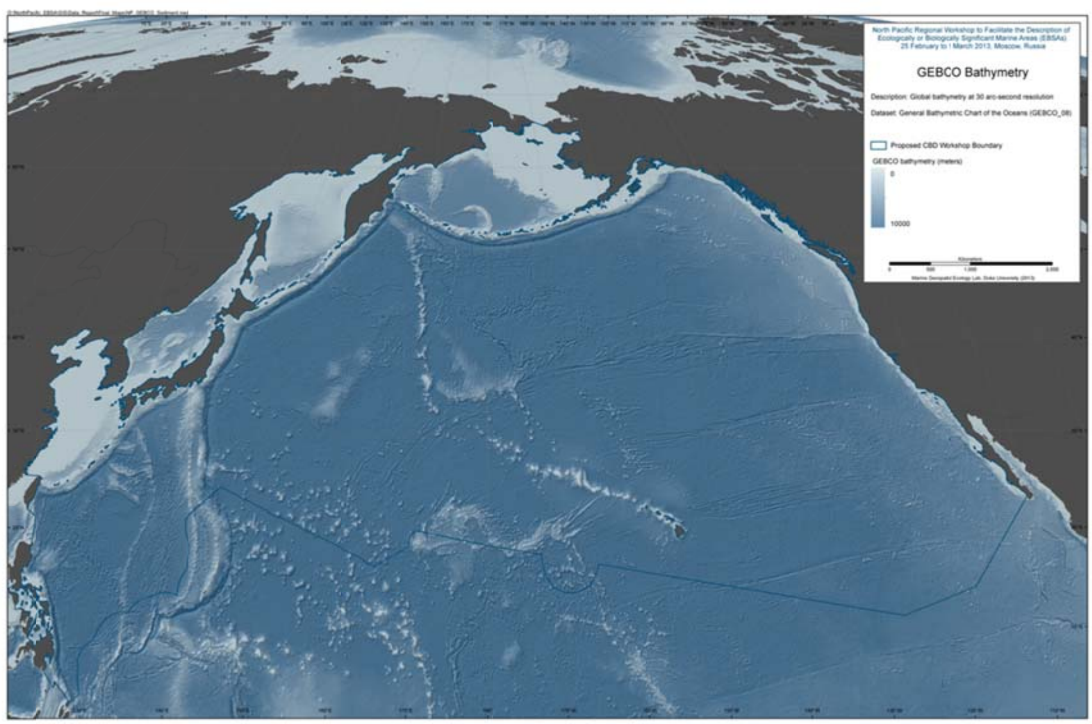

Figure 4.3-1 GEBCO 30 Arc-second Bathymetry

4.4 Distribution of Large Submarine Canyons

Abstract:
The aim of this study is to assess the global occurrence of large submarine canyons to provide context and guidance for discussions regarding canyon occurrence, distribution, geological and oceanographic significance and conservation. Based on an analysis of the ETOPO1 data set, this study has compiled the first inventory of 5849 separate large submarine canyons in the world ocean. Active continental margins contain 15% more canyons (2586, equal to 44.2% of all canyons) than passive margins (2244, equal to 38.4%) and the canyons are steeper, shorter, more dendritic and more closely spaced on active than on passive continental margins. This study confirms observations of earlier workers that a relationship exists between canyon slope and canyon spacing (increased canyon slope correlates with closer canyon spacing). The greatest canyon spacing occurs in the Arctic and the Antarctic whereas canyons are more closely spaced in the Mediterranean than in other areas.

Reference:
Harris and Whiteway 2011. Global distribution of large submarine canyons: Geomorphic differences between active and passive continental margins. Marine Geology 285 (2011) 6986.
doi:10.1016/j.margeo.2011.05.008

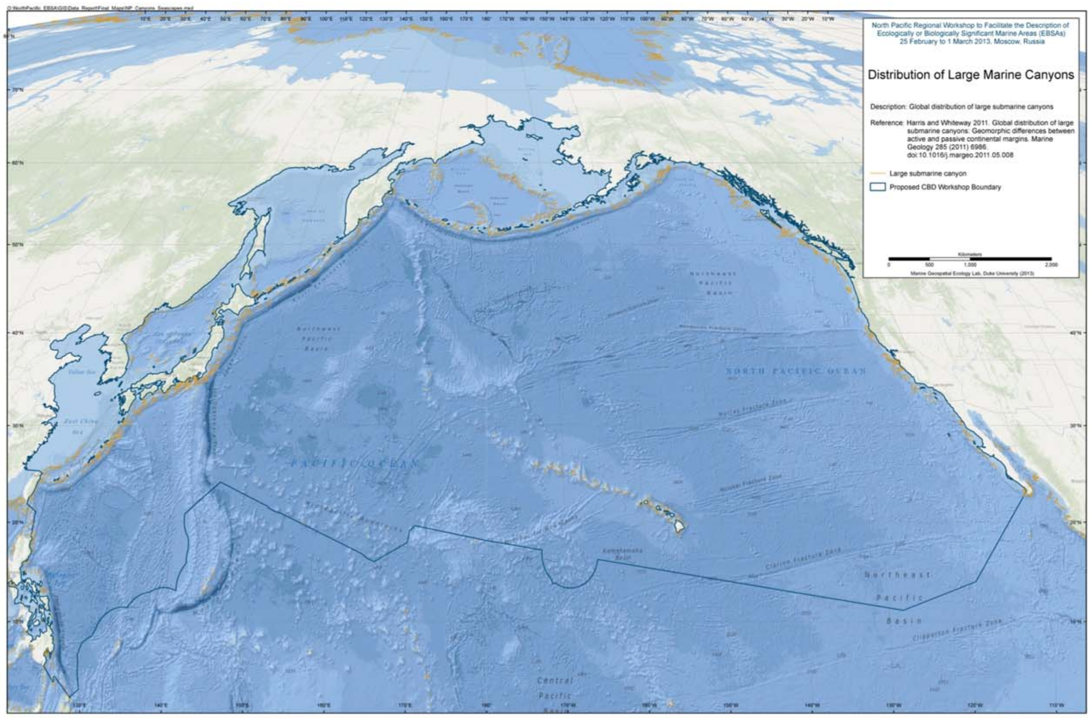

Figure 4.4-1 Large Marine Canyons

4.5 Total Sediment Thickness of the Worlds Oceans & Marginal Seas

A digital total-sediment-thickness database for the world's oceans and marginal seas has been compiled by the NOAA National Geophysical Data Center (NGDC). The data were gridded with a grid spacing of 5 arc-minutes by 5 arc-minutes. Sediment-thickness data were compiled from three principle sources: (i) previously published isopach maps including Ludwig and Houtz [1979], Matthias et al. [1988], Divins and Rabinowitz [1990], Hayes and LaBrecque [1991], and Divins [2003]; (ii) ocean drilling results, both from the Ocean Drilling Program (ODP) and the Deep Sea Drilling Project (DSDP); and (iii) seismic reflection profiles archived at NGDC as well as seismic data and isopach maps available as part of the IOC's International Geological-Geophysical Atlas of the Pacific Ocean [Udinstev, 2003].

The distribution of sediments in the oceans is controlled by five primary factors:

1. Age of the underlying crust
2. Tectonic history of the ocean crust
3. Structural trends in basement
4. Nature and location of sediment source, and
5. Nature of the sedimentary processes delivering sediments to depocenters

The sediment isopach contour maps for the Pacific were digitized by Greg Cole of Los Alamos National Laboratory, for the Indian Ocean by Carol Stein of Northwestern University, and the South Atlantic and Southern Ocean by Dennis Hayes of Lamont-Doherty Earth Observatory. The digitized data were then gridded at NGDC using the algorithm for "Gridding with Continuous Curvature Splines in Tension" of Smith and Wessel [1990].

The data values are in meters and represent the depth to acoustic basement. It should be noted that acoustic basement may not actually represent the base of the sediments. These data are intended to provide a minimum value for the thickness of the sediment in a particular geographic region. Data are not available for all locations.
(source: http://www.ngdc.noaa.gov/mgg/sedthick/sedthick.html)

Reference: Divins, D.L., NGDC Total Sediment Thickness of the World's Oceans & Marginal Seas, Data retrieved 25 January 2012, http://www.ngdc.noaa.gov/mgg/sedthick/sedthick.html

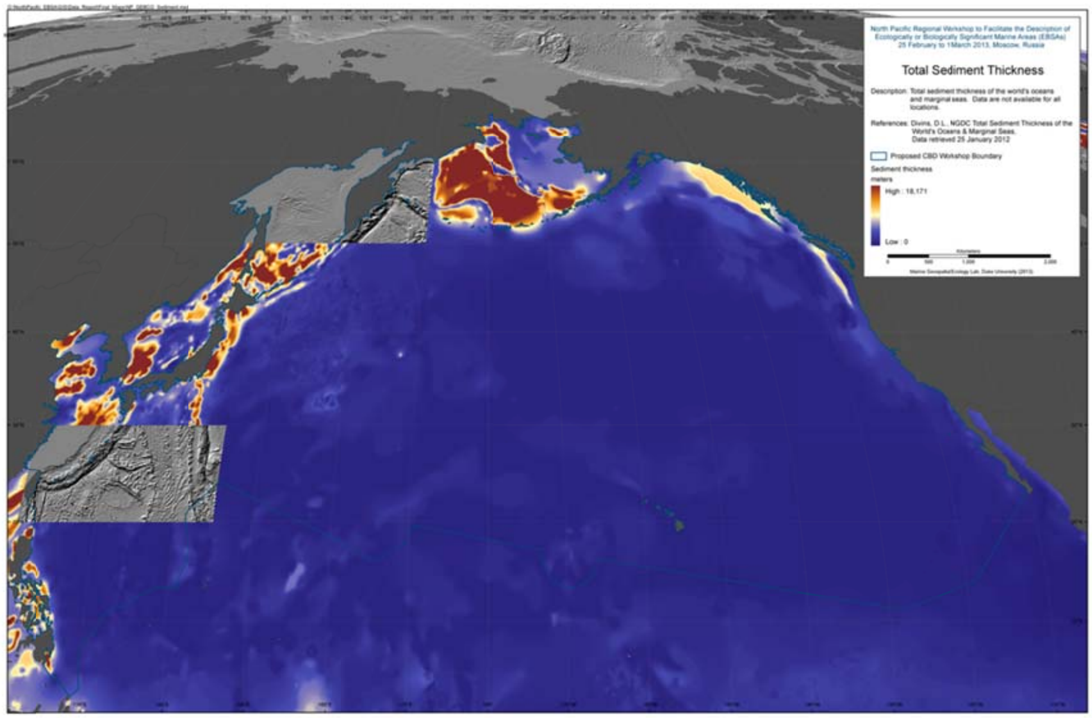

Figure 4.5-1 Total Sediment Thickness

4.6 Global Seascapes

Abstract:
Designing a representative network of high seas marine protected areas (MPAs) requires an acceptable scheme to classify the benthic (as well as the pelagic) bioregions of the oceans. Given the lack of sufficient biological information to accomplish this task, we used a multivariate statistical method with 6 biophysical variables (depth, seabed slope, sediment thickness, primary production, bottom water dissolved oxygen and bottom temperature) to objectively classify the ocean floor into 53,713 separate polygons comprising 11 different categories, that we have termed seascapes. A cross-check of the seascape classification was carried out by comparing the seascapes with existing maps of seafloor geomorphology and seabed sediment type and by GIS analysis of the number of separate polygons, polygon area and perimeter/area ratio. We conclude that seascapes, derived using a multivariate statistical approach, are biophysically meaningful subdivisions of the ocean floor and can be expected to contain different biological associations, in as much as different geomorphological units do the same. Less than 20% of some seascapes occur in the high seas while other seascapes are largely confined to the high seas, indicating specific types of environment whose protection and conservation will require international cooperation. Our study illustrates how the identification of potential sites for high seas marine protected areas can be accomplished by a simple GIS analysis of seafloor geomorphic and seascape classification maps. Using this approach, maps of seascape and geomorphic heterogeneity were generated in which heterogeneity hotspots identify themselves as MPA candidates. The use of computer aided mapping tools removes subjectivity in the MPA design process and provides greater confidence to stakeholders that an unbiased result has been achieved.

Shallow, continental shelf areas <200 m in depth were excluded from the analysis, since the focus here is on the deep ocean and high sea areas. Also, due to the limited coverage of some data sets, the Arctic Ocean, Mediterranean Sea and a rectangular area south of Japan were also excluded.

Reference:
Harris and Whiteway 2009. High seas marine protected areas: Benthic environmental conservation priorities from a GIS analysis of global ocean biophysical data. Ocean & Coastal Management 52 2238. doi:10.1016/j.ocecoaman.2008.09.009

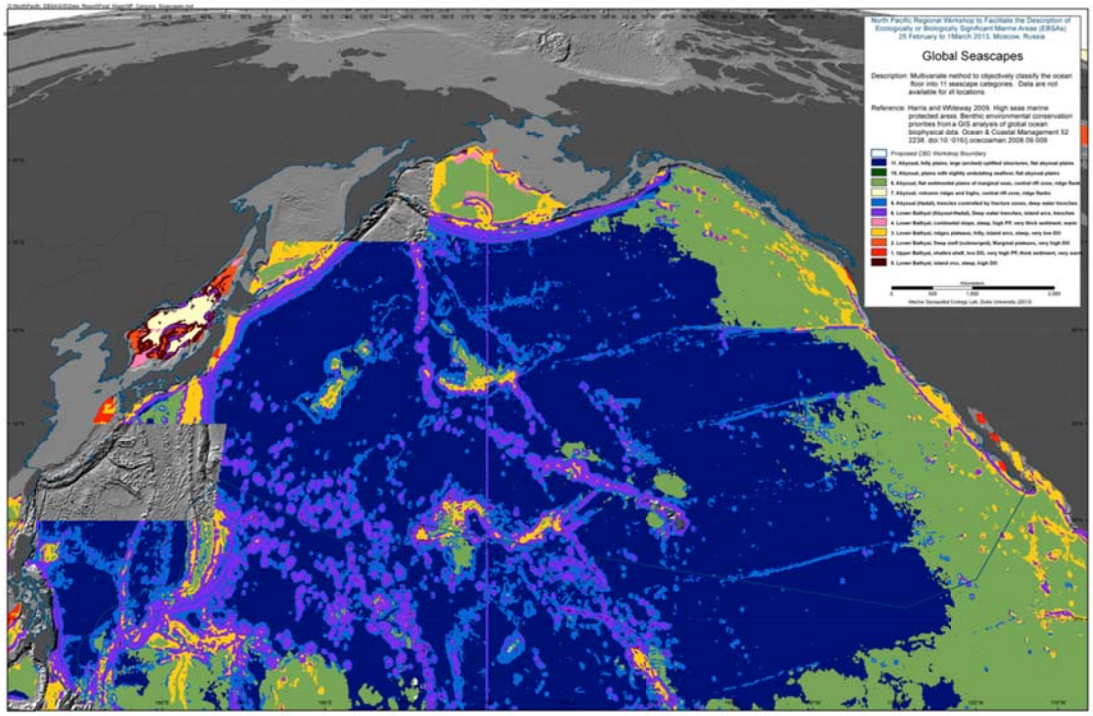

Figure 4.6-1 Global Seascapes

4.7 CSIRO Atlas of Regional Seas (CARS) Physical Ocean Climatologies

For items 4.7.1 through 4.7.6, data were downloaded and processed from the CSIRO Atlas of Regional Seas (CARS).

CARS is a digital climatology, or atlas of seasonal ocean water properties. It comprises gridded fields of mean ocean properties over the period of modern ocean measurement, and average seasonal cycles for that period. It is derived from a quality-controlled archive of all available historical subsurface ocean property measurements - primarily research vessel instrument profiles and autonomous profiling buoys. As data availability has enormously increased in recent years, the CARS mean values are inevitably biased towards the recent ocean state.

A number of global ocean climatologies are presently available, such as NODC's World Ocean Atlas. CARS is different as it employs extra stages of in-house quality control of input data, and uses an adaptive-lengthscale loess mapper to maximise resolution in data-rich regions, and the mapper's "BAR" algorithm takes account of topographic barriers. The result is excellent definition of oceanic structures and accuracy of point values.
(source: http://www.marine.csiro.au/~dunn/cars2009/)

References:

1. Primary CARS citation:
Ridgway K.R., J.R. Dunn, and J.L. Wilkin, Ocean interpolation by four-dimensional least squares - Application to the waters around Australia, J. Atmos. Ocean. Tech., Vol 19, No 9,1357-1375, 2002

2. Algorithm details:
Dunn J.R., and K.R. Ridgway, Mapping ocean properties in regions of complex topography, Deep Sea Research I : Oceanographic Research, 49 (3) (2002) pp. 591-604

3. CARS seasonal fields and MLD:
Scott A. Condie and Jeff R. Dunn (2006) Seasonal characteristics of the surface mixed layer in the Australasian region: implications for primary production regimes and biogeography. Marine and Freshwater Research, 2006, 57, 1-22.

4. Metadata:
CARS2009 metadata record: MarLIN record: 8539, Anzlic identifier: ANZCW0306008539

4.7.1 Salinity Climatology

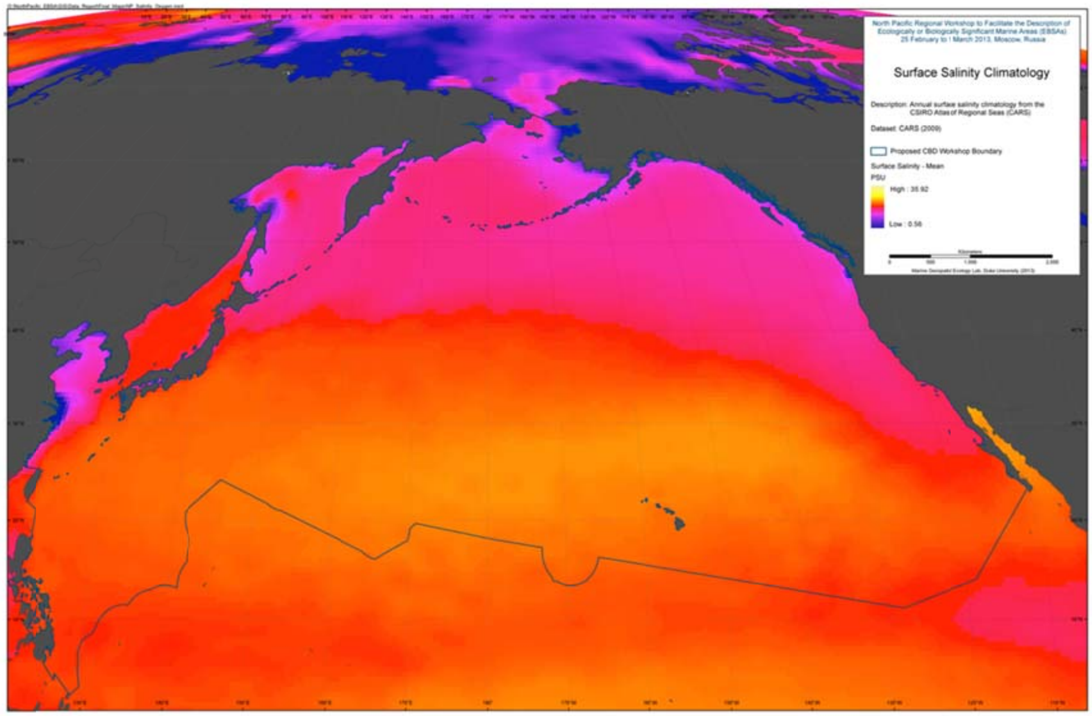

Figure 4.7-1 Surface Salinity Climatology

4.7.2 Oxygen Climatology

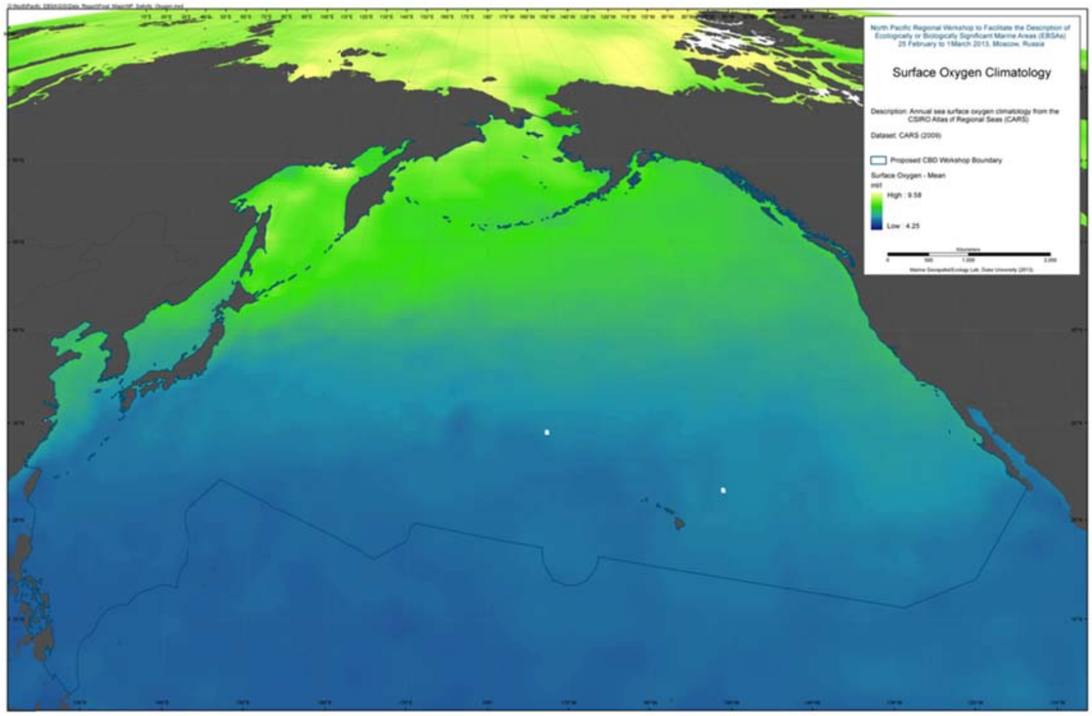

Figure 4.7-2 Surface Oxygen Climatology

4.7.3 Nitrate Climatology

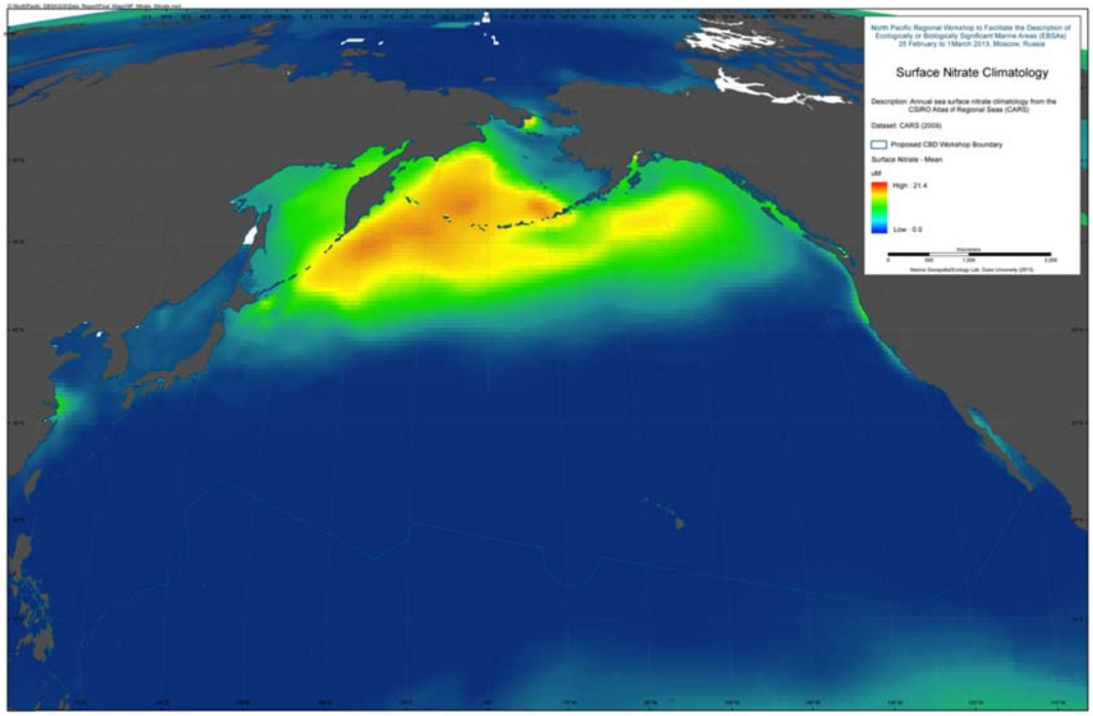

Figure 4.7-3 Surface Nitrate Climatology

4.7.4 Silicate Climatology

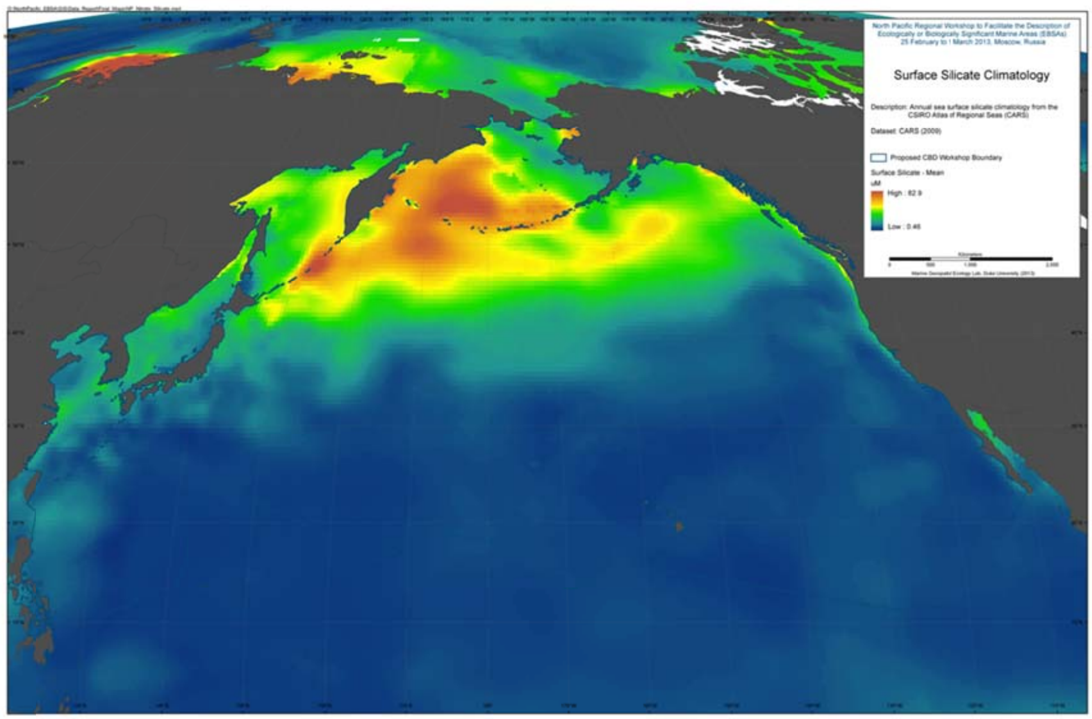

Figure 4.7-4 Surface Silicate Climatology

4.7.5 Phosphate Climatology

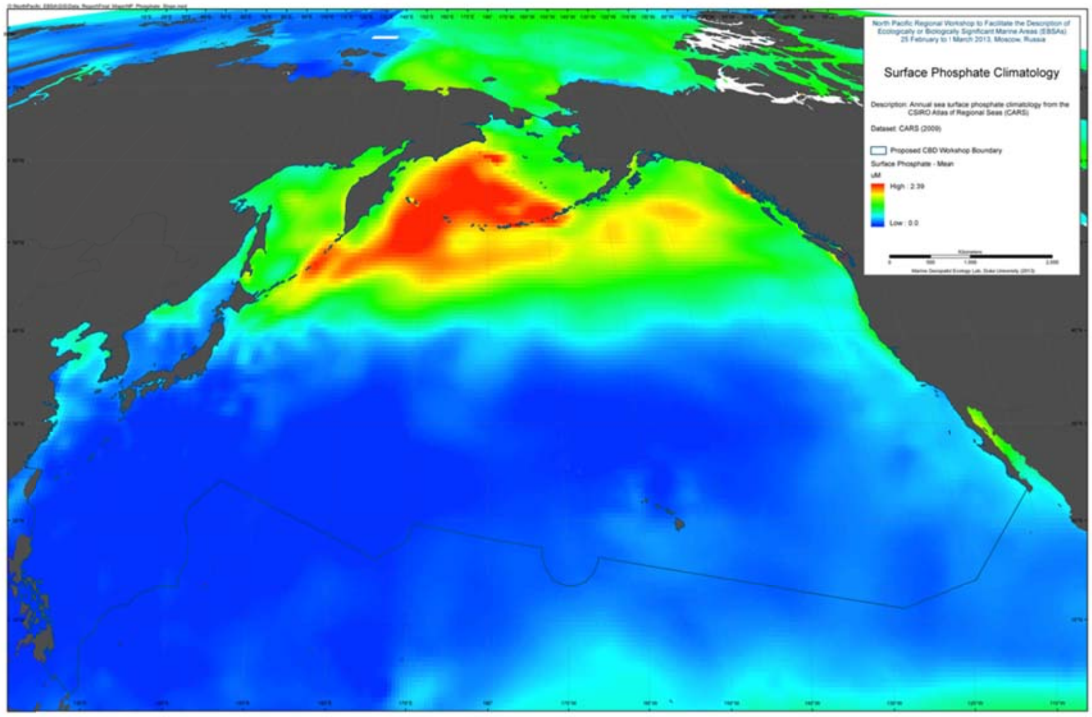

Figure 4.7-5 Surface Phosphate Climatology

4.7.6 Mixed Layer Depth Climatology

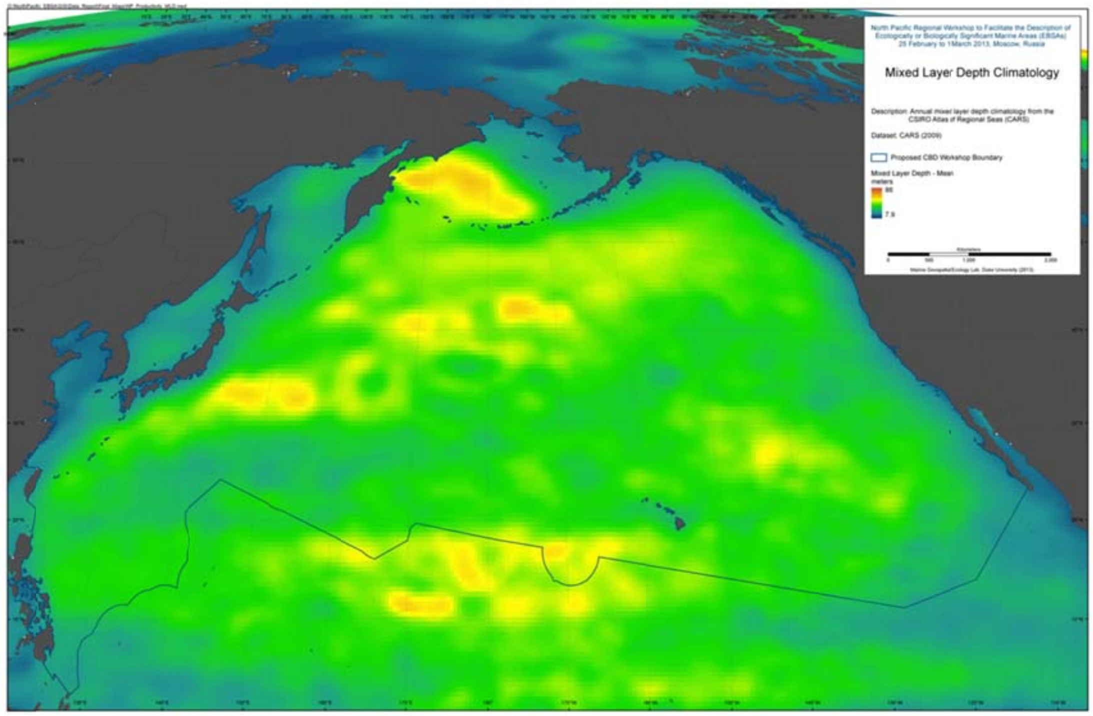

Figure 4.7-6 Mixed Layer Depth Climatology

4.8 Ocean Surface Temperature

The 4k AVHHR Pathfinder dataset, published by the NOAA National Oceanographic Data Center (NODC), provides a global, long-term, high-resolution record of sea surface temperature (SST) using data collected by NOAA's Polar-orbiting Operational Environmental Satellites (POES).

For this effort, a cumulative climatology (1982 - 2009) was created using the "Create Climatological Rasters for AVHHR Pathfinder V5 SST" tool in the Marine Geospatial Ecology Tools (MGET) for ArcGIS (Roberts et al., 2010).

References:

Casey,K.S., T.B. Brandon, P. Cornillon, and R. Evans (2010). "The Past, Present and Future of the AVHRR Pathfinder SST Program", in Oceanography from Space: Revisited, eds. V. Barale, J.F.R. Gower, and L. Alberotanza, Springer

Roberts, J.J., B.D. Best, D.C. Dunn, E.A. Treml, and P.N. Halpin (2010). Marine Geospatial Ecology Tools: An integrated framework for ecological geoprocessing with ArcGIS, Python, R, MATLAB, and C++. Environmental Modelling & Software 25: 1197-1207.

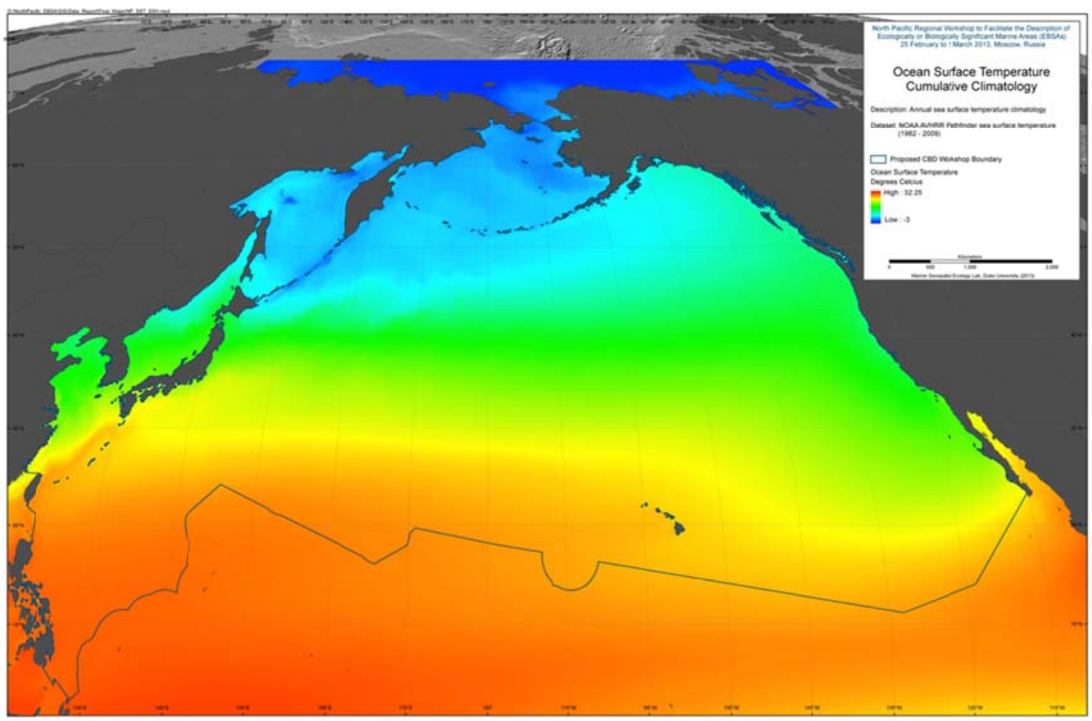

Figure 4.8-1 Ocean Surface Temperature – Cumulative Climatology

4.9 Sea Surface Temperature Front Probability

Dr. Peter Miller of the Plymouth Marine Laboratory provided composite maps of sea surface temperature fronts based on analyses of 9km resolution Advanced Very High Resolution Radiometer (AVHRR) and Sea-viewing Wide Field-of-view Sensor (SeaWiFS) data from 2006-2011. The composite front technique combines the location, gradient, persistence and proximity of all fronts observed over a given period into a single map. It is important to emphasize that: (a) front detection is based on local window statistics specific to frontal structures, not simply on horizontal SST gradients; and (b) fronts are not detected on monthly SST composites, but rather on individual SST 'snapshots' that reveal the detailed thermal structure without averaging artifacts. 8-day composite front maps were used to generate seasonal front climatologies that enabled identification of strong, persistent and frequently occurring features. Such frontal systems could be key factors influencing the distribution of productivity and diversity.

Reference:
Miller, P.I. (2009) Composite front maps for improved visibility of dynamic sea-surface features on cloudy SeaWiFS and AVHRR data. Journal of Marine Systems, 78(3), 327-336.

Miller P. and S. Christodoulou (in press) Frequent locations of ocean fronts as an indicator of pelagic diversity: application to marine protected areas and renewables. Marine Policy.

4.9.1 Front Probability (December – February)

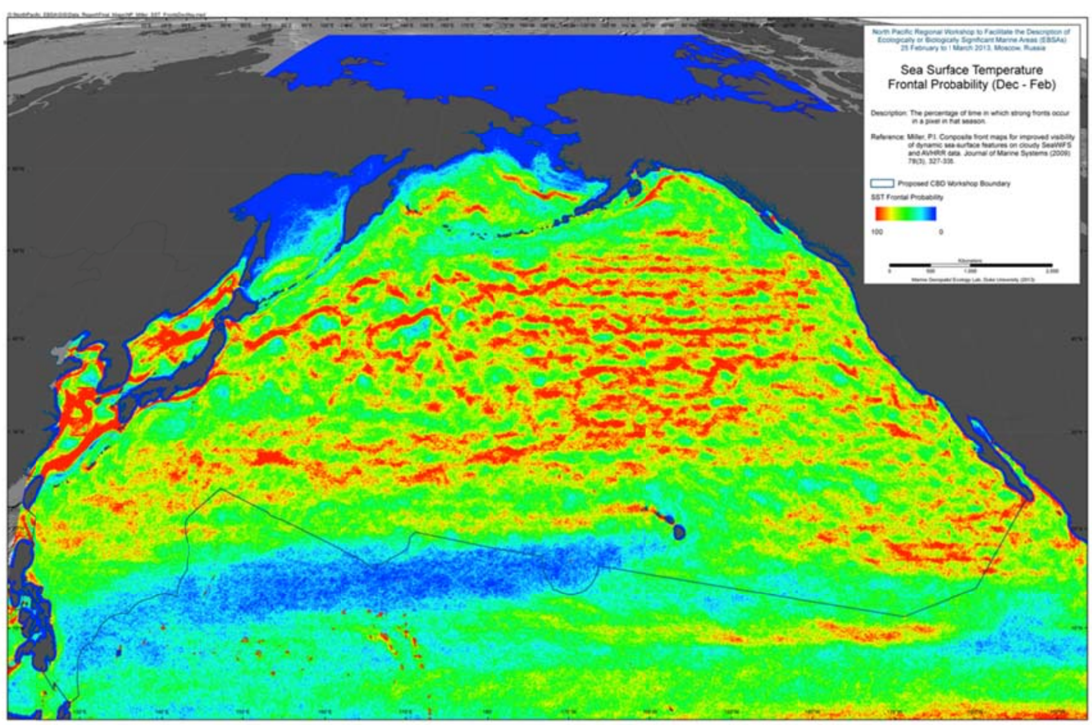

Figure 4.9-1 Sea Surface Temperature Front Probability (Dec – Feb)

4.9.2 Front Probability (March - May)

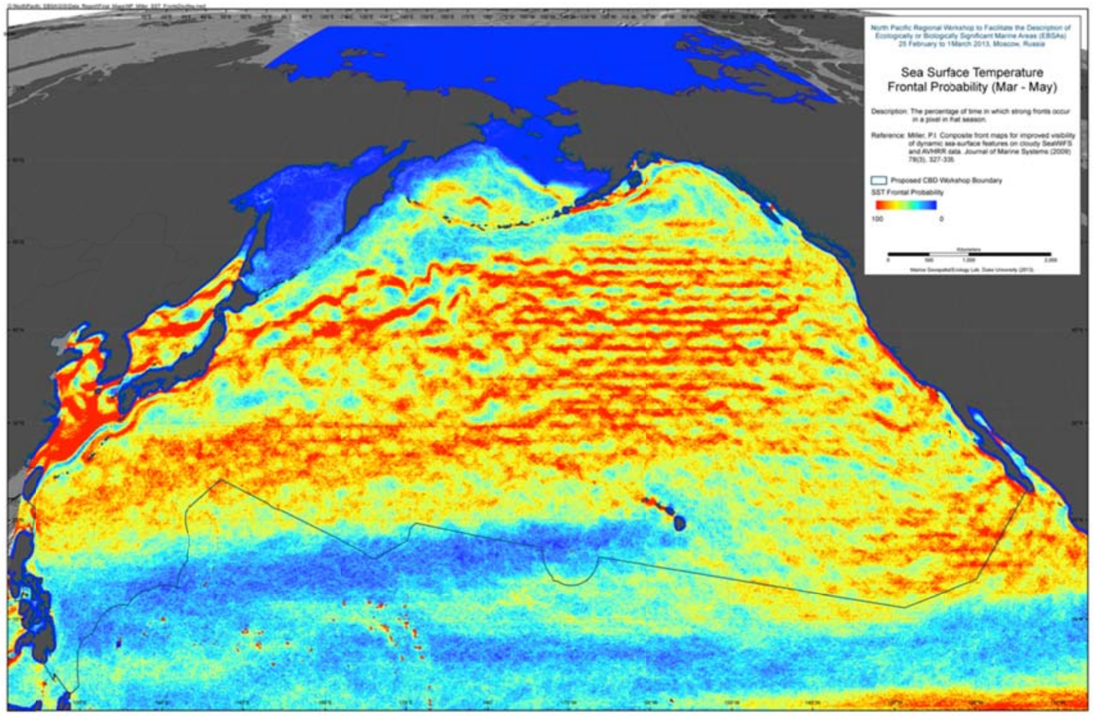

Figure 4.9-2 Sea Surface Temperature Front Probability (Mar - May)

4.9.3 Front Probability (June – August)

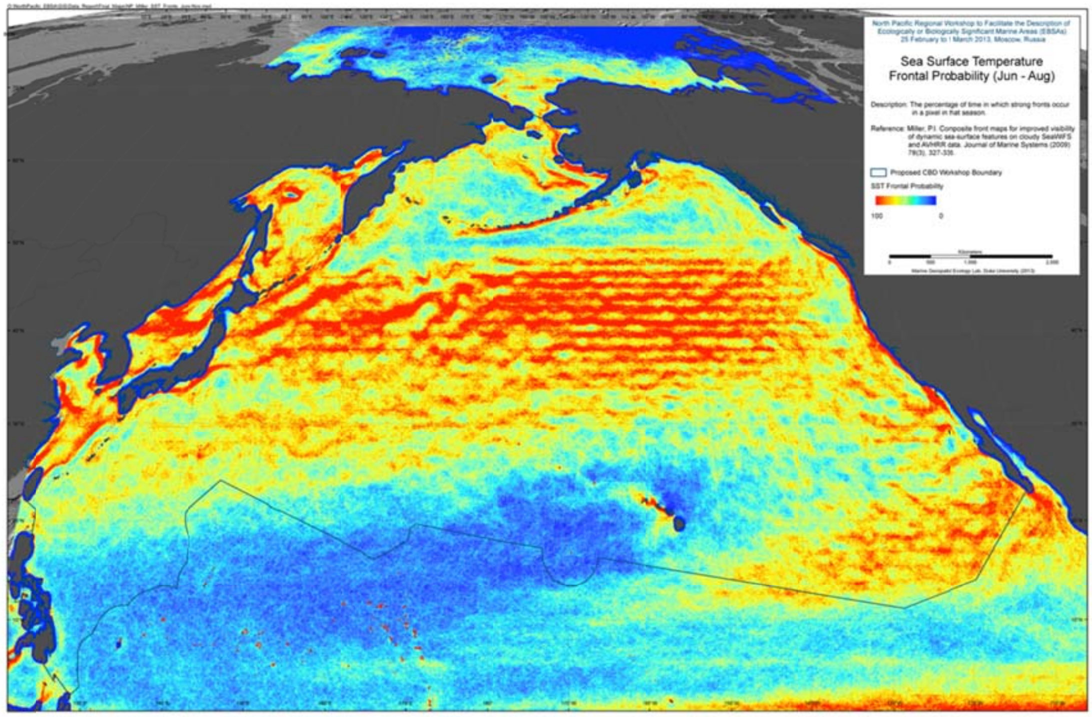

Figure 4.9-3 Sea Surface Temperature Front Probability (Jun - Aug)

4.9.4 Front Probability (September - November)

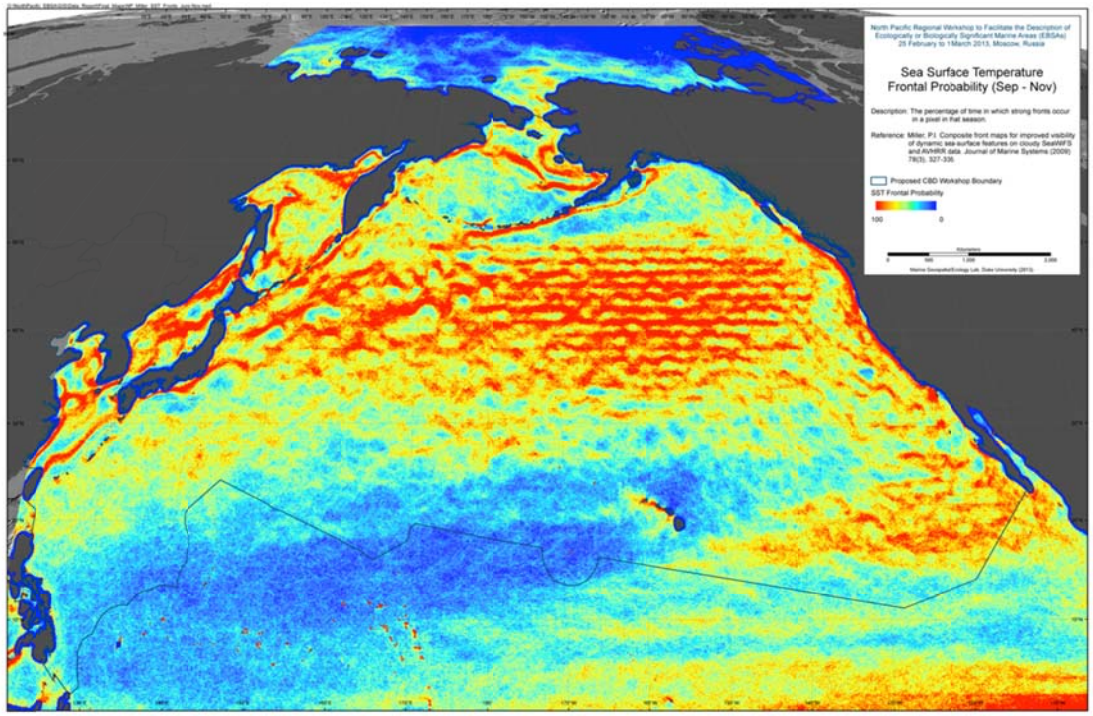

Figure 4.9-4 Sea Surface Temperature Front Probability (Sept - Nov)

4.10 Transition Zone Chlorophyll Front (TZCF)

Polovina et al (2001) discussed a chlorophyll front in the North Pacific basin between the low chlorophyll subtropical gyres and the high chlorophyll subarctic gyres. The front is over 8000 km long and moves from about 30–35°N latitude in the first quarter of the year (winter) to about 40–45°N in the third quarter of the year (summer), a distance of about 1000 km. The authors found that a chlorophyll density of 0.2 mg/m^3 is a good indicator of the position of the chlorophyll front.

Here, seasonal cumulative (1998-2009) chlorophyll A climatologies were created using the "Create Climatological Rasters for NASA OceanColor L3 SMI Product" tool in the Marine Geospatial Ecology Tools (MGET) for ArcGIS (Roberts et al., 2010). This tool uses data from the Sea-viewing Wide Field-of-view Sensor (SeaWiFS) Project. One climatology was generated for each quarter: January – March, April – June, July – September, October - December. In addition, the .2 mg/m^3 contour was created for each quarter using the standard "contour list" tool in ArcGIS.

Reference:

Polovina, J.J., E. Howell, D.R. Kobayashi, M.P. Seki (2001). The transition zone chlorophyll front, a dynamic global feature defining migration and forage habitat for marine resources. Progress in Oceanography ,vol. 49 (1-4) pp. 469-483

Roberts, J.J., B.D. Best, D.C. Dunn, E.A. Treml, and P.N. Halpin (2010). Marine Geospatial Ecology Tools: An integrated framework for ecological geoprocessing with ArcGIS, Python, R, MATLAB, and C++. Environmental Modelling & Software 25: 1197-1207.

4.10.1 Chlorophyll A Climatology and TZCF (January – March)

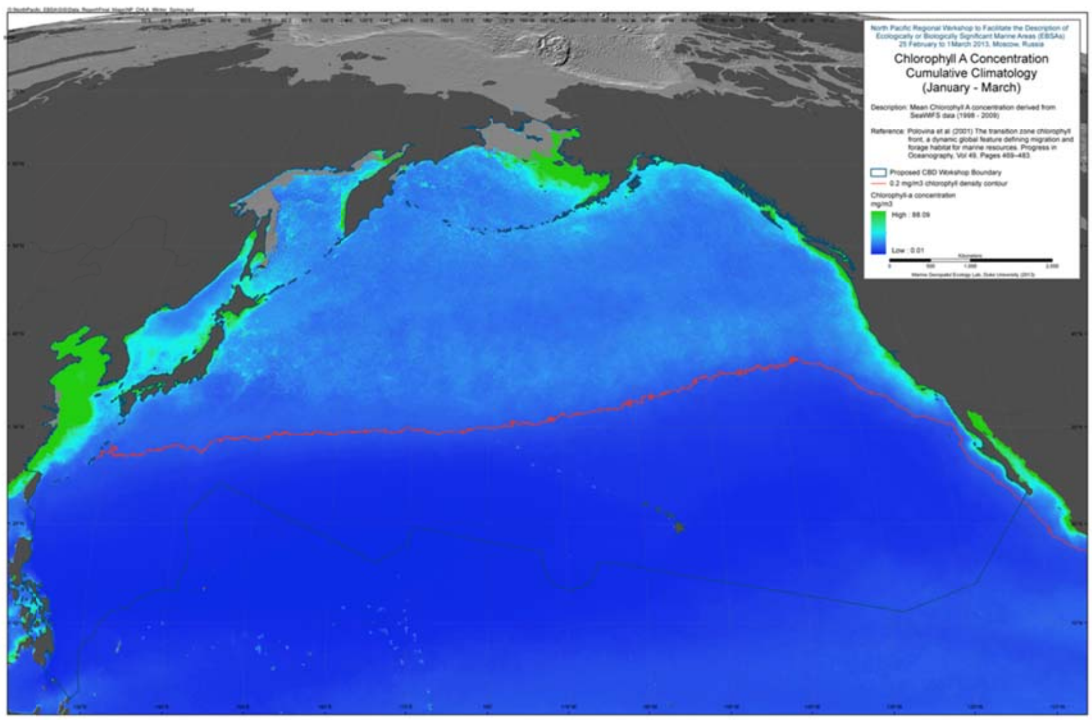

Figure 4.10-1 Chlorophyll A Concentration Cumulative Climatology (Jan - Mar)

4.10.2 Chlorophyll A Climatology and TZCF (April - June)

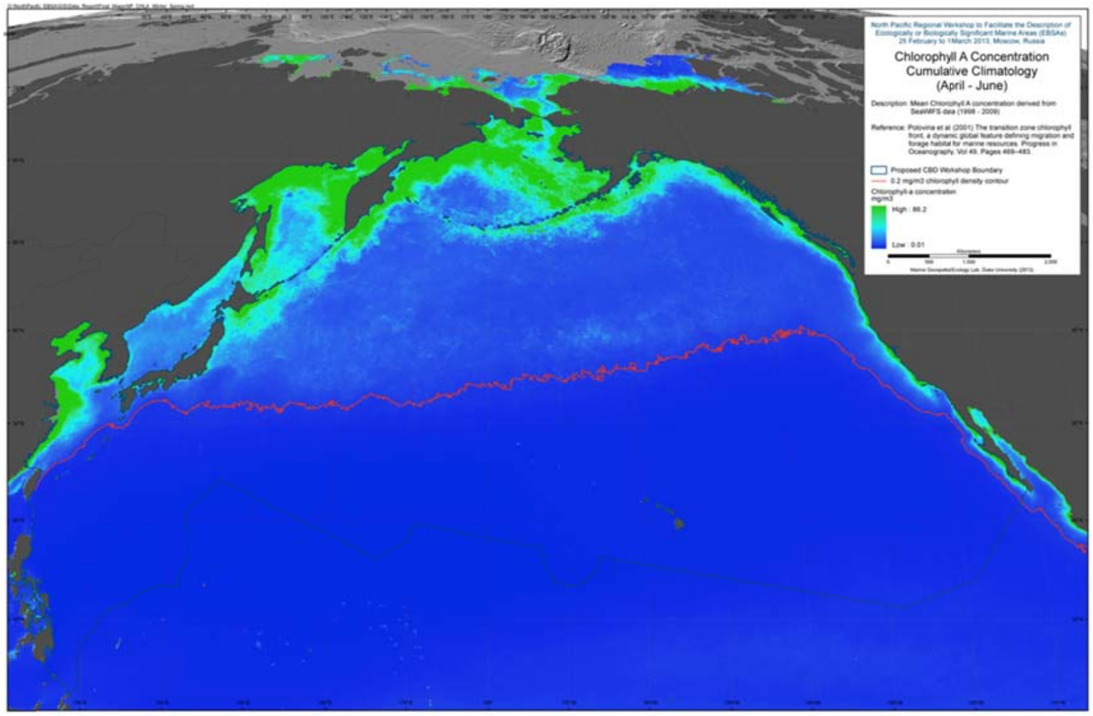

Figure 4.10-2 Chlorophyll A Concentration Cumulative Climatology (Apr - Jun)

4.10.3 Chlorophyll A Climatology and TZCF (July – September)

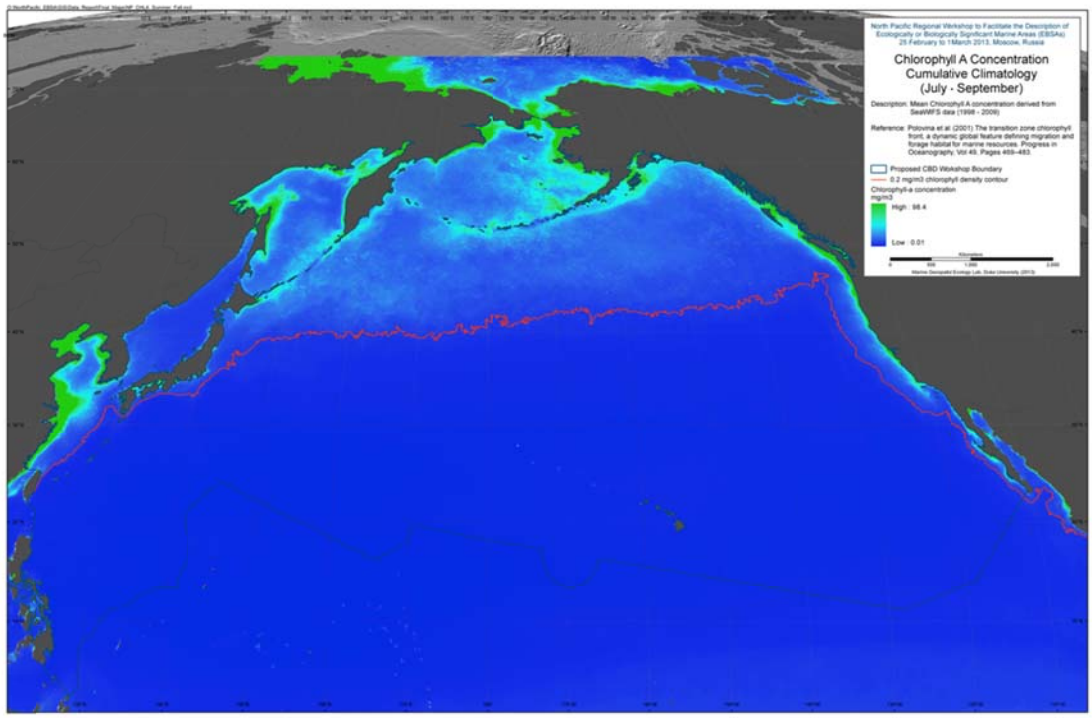

Figure 4.10-3 Chlorophyll A Concentration Cumulative Climatology (July - Sept)

4.10.4 Chlorophyll A Climatology and TZCF (October - December)

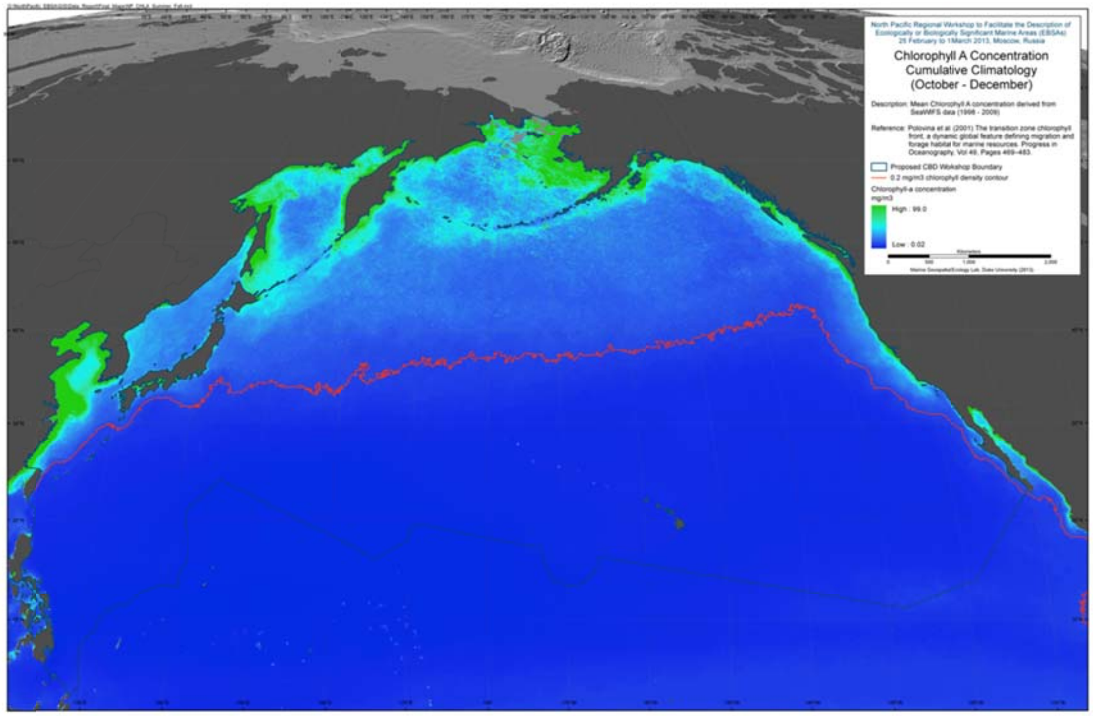

Figure 4.10-4 Chlorophyll A Concentration Cumulative Climatology (Oct - Dec)

4.10.5 Chlorophyll A Cumulative TZCF

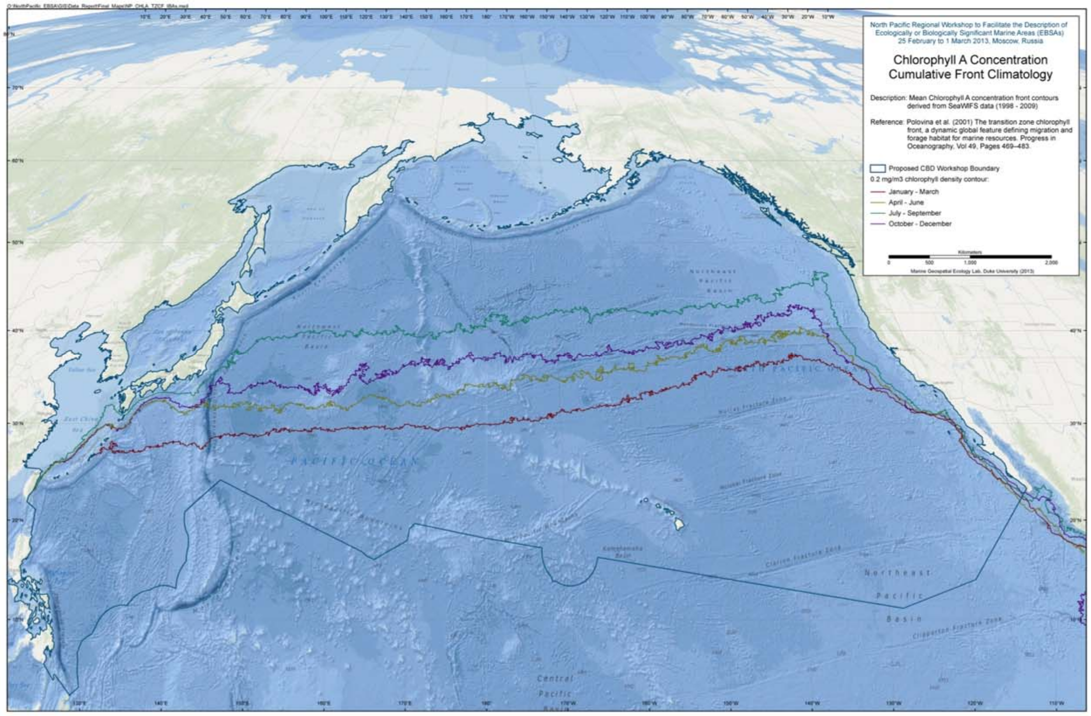

Figure 4.10-5 Chlorophyll A Concentration Cumulative Front Climatology

4.11 VGPM Ocean Productivity

Standard Ocean Productivity Products are based on the original description of the Vertically Generalized Production Model (VGPM) (Behrenfeld & Falkowski 1997), MODIS surface chlorophyll concentrations (Chl_{sat}), MODIS sea surface temperature data (SST), and MODIS cloud-corrected incident daily photosynthetically active radiation (PAR). Euphotic depths are calculated from Chl_{sat} following Morel and Berthon (1989).
(source: http://www.science.oregonstate.edu/ocean.productivity/standard.product.php)

For this effort, a cumulative climatology was created from Standard VGPM data derived from MODIS AQUA data from 2003-2007.

Reference:

Behrenfeld, M. J. & Falkowski, P. G. Photosynthetic rates derived from satellite-based chlorophyll concentration. *Limnology And Oceanography* 42, 1–20 (1997).

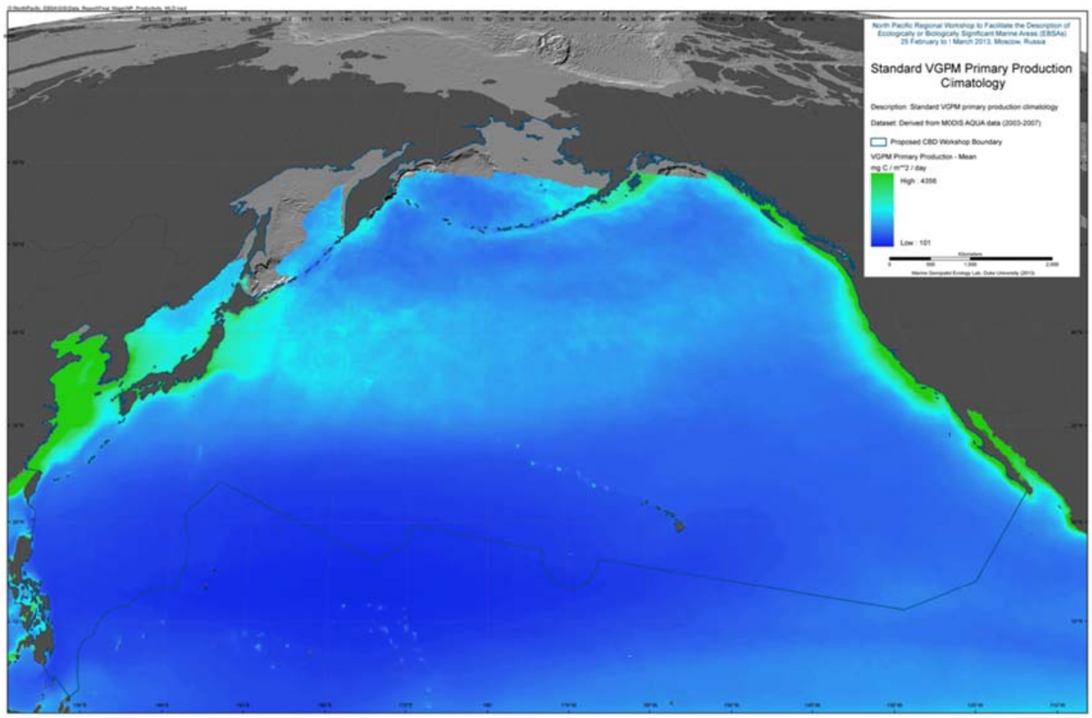

Figure 4.11-1 Standard VGPM Ocean Productivity

4.12 Oxygen Minimum Zone Depth

Data were derived from the World Ocean Atlas 2009 Oxygen dataset. An arbitrary dissolved oxygen level ($O2 <= 1.43$ ml/l ~ 60 uMol/kg), a commonly used threshold for hypoxia, was chosen to represent the depth of Oxygen Minimum Zone (OMZ). Data were extracted monthly and then compiled into seasonal depth climatologies. The OMZ is the oceanic layer within which dissolved oxygen values are a minimum, due to high rates of oxygen consumption and low rates of advective supply of oxygen-rich waters. Typically the OMZ is shallowest within the equatorial regions and the eastern boundary systems. Shoaling of the OMZ, as has been observed in recent decades, can restrict the usable habitat of many marine species and cause significant shifts in their habitat (e.g., Stramma et al., 2011).

References:

Garcia, H. E., R. A. Locarnini, T. P. Boyer, J. I. Antonov, O. K. Baranova, M. M. Zweng, and D. R. Johnson, 2010. World Ocean Atlas 2009, Volume 3: Dissolved Oxygen, Apparent Oxygen Utilization, and Oxygen Saturation. S. Levitus, Ed. NOAA Atlas NESDIS 70, U.S. Government Printing Office, Washington, D.C.

Stramma, L., E.D. Prince, S. Schmidtko, J. Luo, J.P. Hoolihan, M. Visbeck, D.W.R. Wallace, P. Brandt, and A. Kortzinger, 2011. Expansion of oxygen minimum zones may reduce available habitat for tropical fishes, Nature Climate Change, doi:10.1038/NCLIMATE1304.

4.12.1 Oxygen Minimum Zone Depth Climatology (January - March)

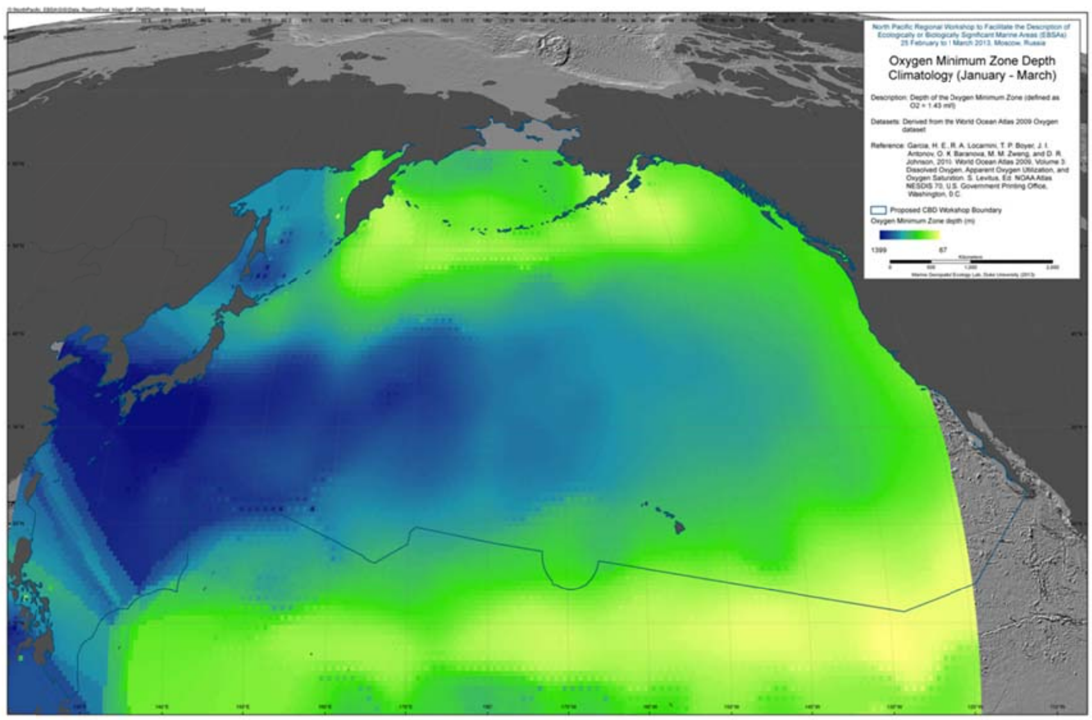

Figure 4.12-1 Oxygen Minimum Zone Depth Climatology (January - March)

4.12.2 Oxygen Minimum Zone Depth Climatology (April - June)

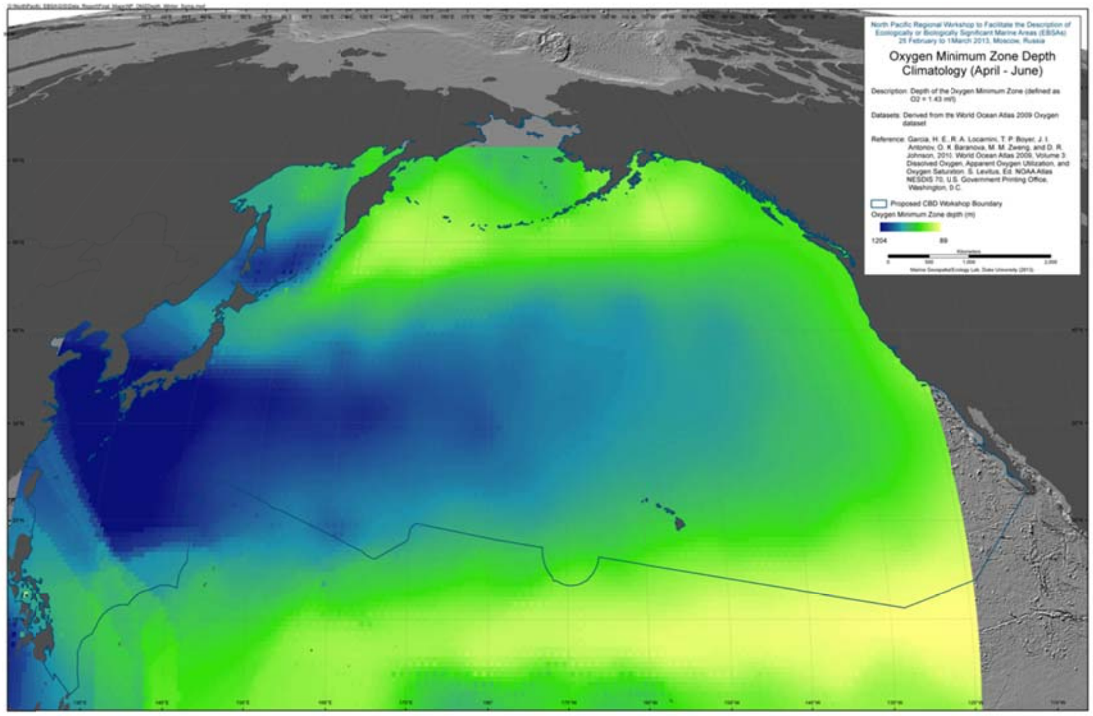

Figure 4.12-2 Oxygen Minimum Zone Depth Climatology (April - June)

4.12.3 Oxygen Minimum Zone Depth Climatology (July - September)

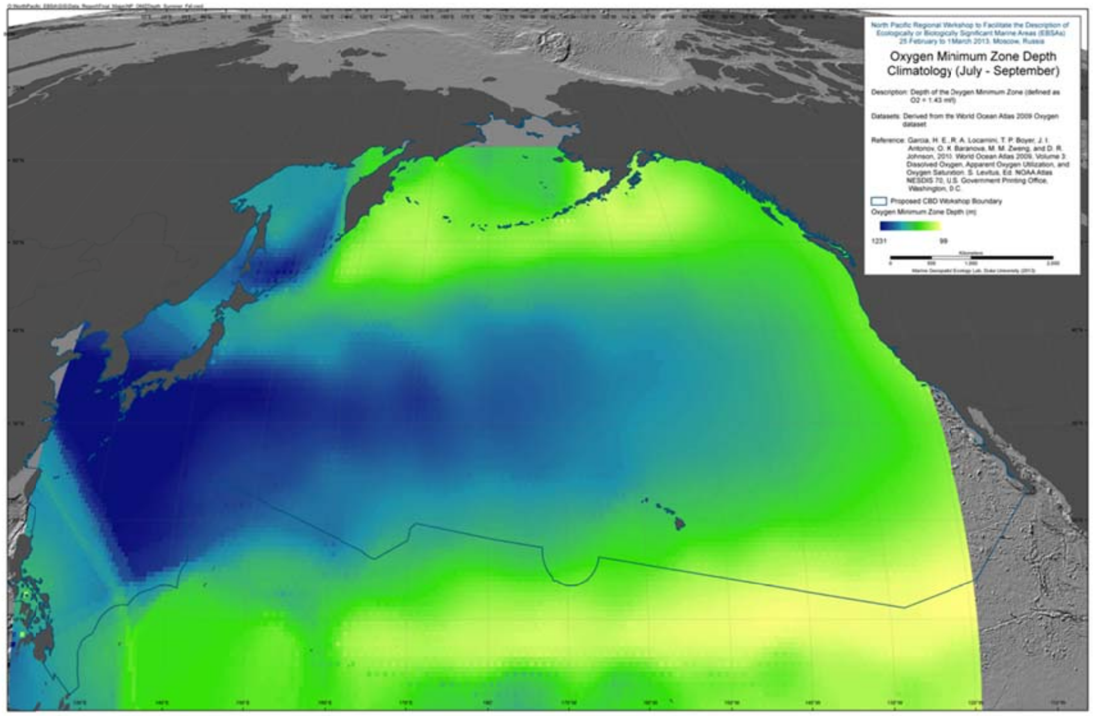

Figure 4.12-3 Oxygen Minimum Zone Depth Climatology (July - September)

4.12.4 Oxygen Minimum Zone Depth Climatology (October - December)

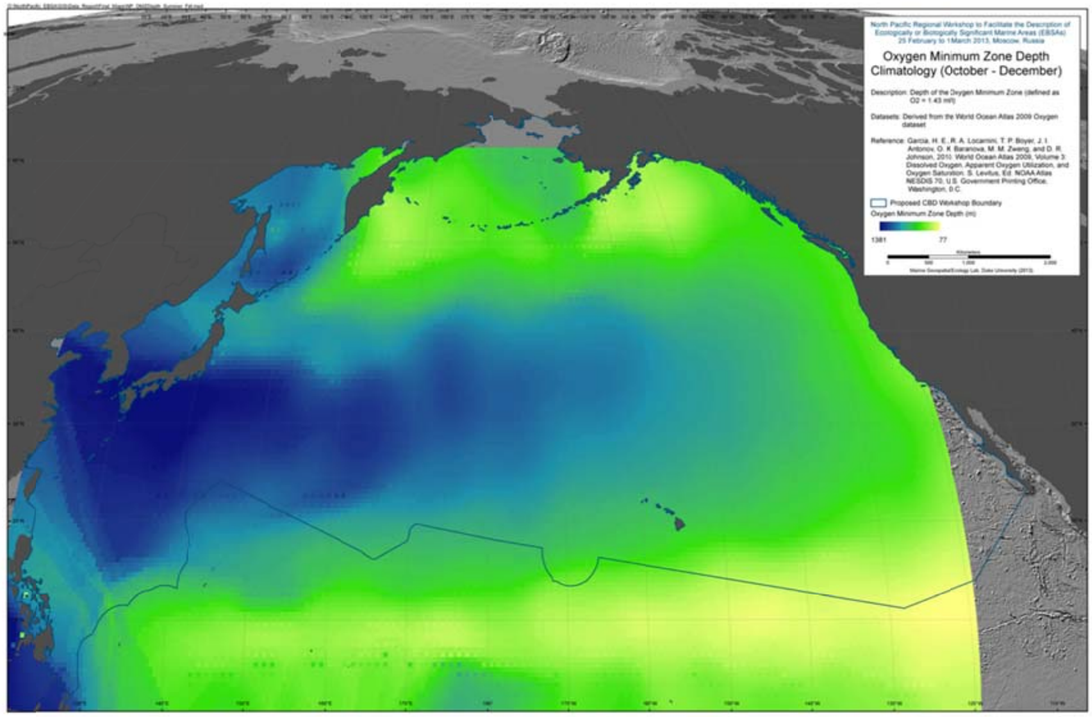

Figure 4.12-4 Oxygen Minimum Zone Depth Climatology (October - December)

4.13 Sea Surface Height

The Archiving, Validation and Interpretation of Satellite Oceanographic data (AVISO) group publishes various products derived from satellite altimetry data, including estimates of sea surface height (SSH), geostrophic currents, wind speed modulus, and significant wave height. To maximize accuracy and spatial and temporal resolution and extent, AVISO merges observations from multiple satellites, including Topex/Poseidon, Jason-1, Jason-2, GFO, ERS-1, ERS-2, and EnviSat. Most Aviso products are one of these "merged" datasets, although a few products are based on observations from a single satellite.
(source: http://code.nicholas.duke.edu/projects/mget)

For this effort a cumulative climatology was created from AVISO Global DT-Ref Merged MADT SSH data, from 1993-2011, using the “Create Climatological Rasters for Aviso SSH” tool in the Marine Geospatial Ecology Tools (MGET) for ArcGIS (Roberts et al., 2010).

Reference:

Roberts, J.J., B.D. Best, D.C. Dunn, E.A. Treml, and P.N. Halpin (2010). Marine Geospatial Ecology Tools: An integrated framework for ecological geoprocessing with ArcGIS, Python, R, MATLAB, and C++. Environmental Modelling & Software 25: 1197-1207.

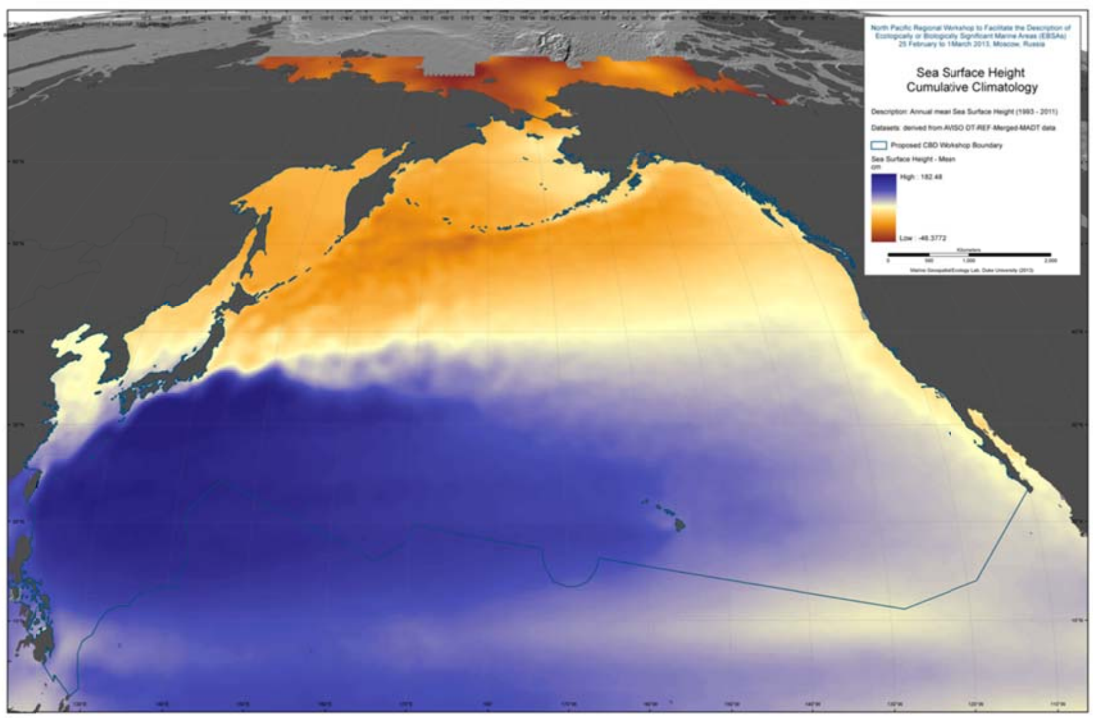

Figure 4.13-1 Sea Surface Height - Cumulative Climatology

4.14 Mesoscale Eddy Density

Dudley B. Chelton and Michael G. Schlax maintain a database of trajectories of mesoscale eddies for the 18-year period October 1992 - January 2011. The eddies are based on the SSH fields in Version 3 of the AVISO Reference Series. Only eddies with lifetimes of 4 weeks or longer are retained; the trajectories are available at 7-day time steps. (source: http://cioss.coas.oregonstate.edu/eddies/)

A density raster of eddy centroids was created from the Chelton database (http://cioss.coas.oregonstate.edu/eddies/). First, the NetCDF file was converted to a SpatiaLite database using the MGET tool "Convert Mesoscale Eddies NetCDF to SpatiaLite". Next, the "Extract Mesoscale Eddy Centroids from SpatiaLite" and "Extract Mesoscale Eddy Tracklines from SpatiaLite" tools were run specifying the date range (1993 - 2010) and the region of interest. For the tracks, only eddies that persisted at least 17 weeks were selected. By joining the centroids and tracks features, we obtained all centroids for eddies that persisted at least 17 weeks. The density raster was created from the Point Density ArcMap tool using 0.5 degree cell size and 0.5 x 0. 5 rectangular window.

References:

Chelton, D.B., M.G. Schlax, and R.M. Samelson (2011). Global observations of nonlinear mesoscale eddies. Progress in Oceanography 91: 167-216.

Roberts, J.J., B.D. Best, D.C. Dunn, E.A. Treml, and P.N. Halpin (2010). Marine Geospatial Ecology Tools: An integrated framework for ecological geoprocessing with ArcGIS, Python, R, MATLAB, and C++. Environmental Modelling & Software 25: 1197-1207.

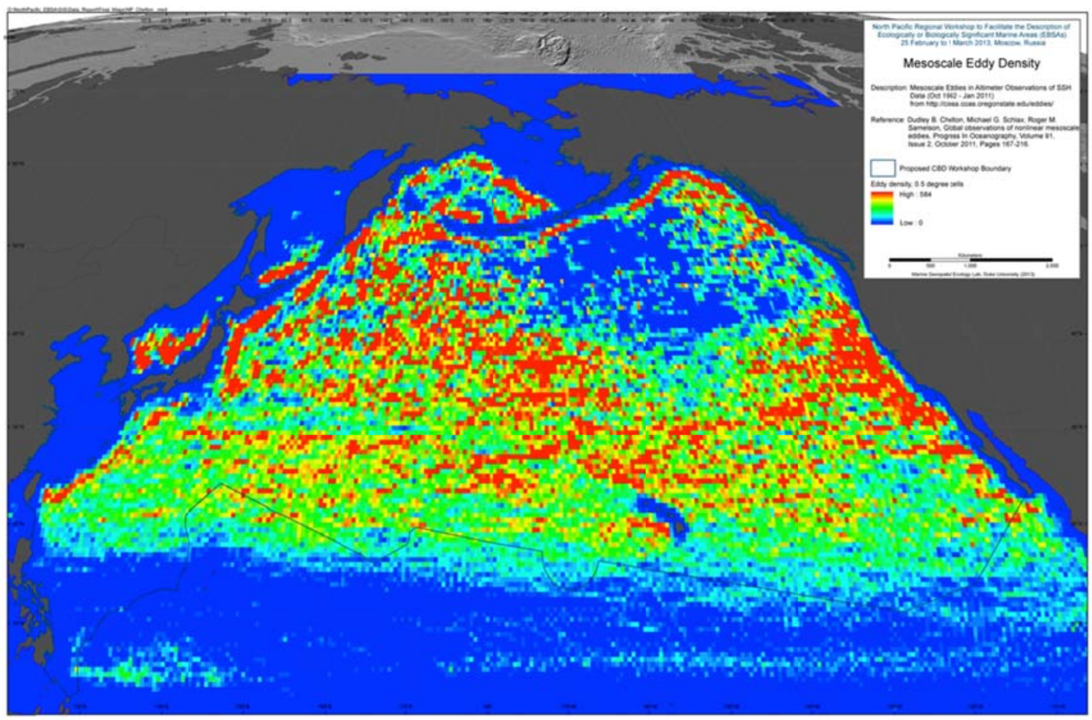

Figure 4.14-1 Mesoscale Eddy Density

4.15 Eddy Kinetic Energy

Locations where shear between water masses is high can generate productivity due to mixing. One measure of this mixing is estimated using Eddy Kinetic Energy (EKE). EKE was calculated from the velocity maps based on sea surface height from The Archiving, Validation and Interpretation of Satellite Oceanographic data (AVISO). Using the U and V components from the currents data, EKE is defined as $0.5*(U^2 + V^2)$ and was calculated using AVISO data from 1993-2011, inclusive.

For this effort, a cumulative EKE climatology (1993-2011) was created using the Global DT-Upd Merged Mean Sea Level Anomaly data product in the "Create Climatological Rasters for Aviso Geostrophic Currents Product" tool in the Marine Geospatial Ecology Tools (MGET) for ArcGIS (Roberts et al., 2010).

Reference:

Roberts, J.J., B.D. Best, D.C. Dunn, E.A. Treml, and P.N. Halpin (2010). Marine Geospatial Ecology Tools: An integrated framework for ecological geoprocessing with ArcGIS, Python, R, MATLAB, and C++. Environmental Modelling & Software 25: 1197-1207.

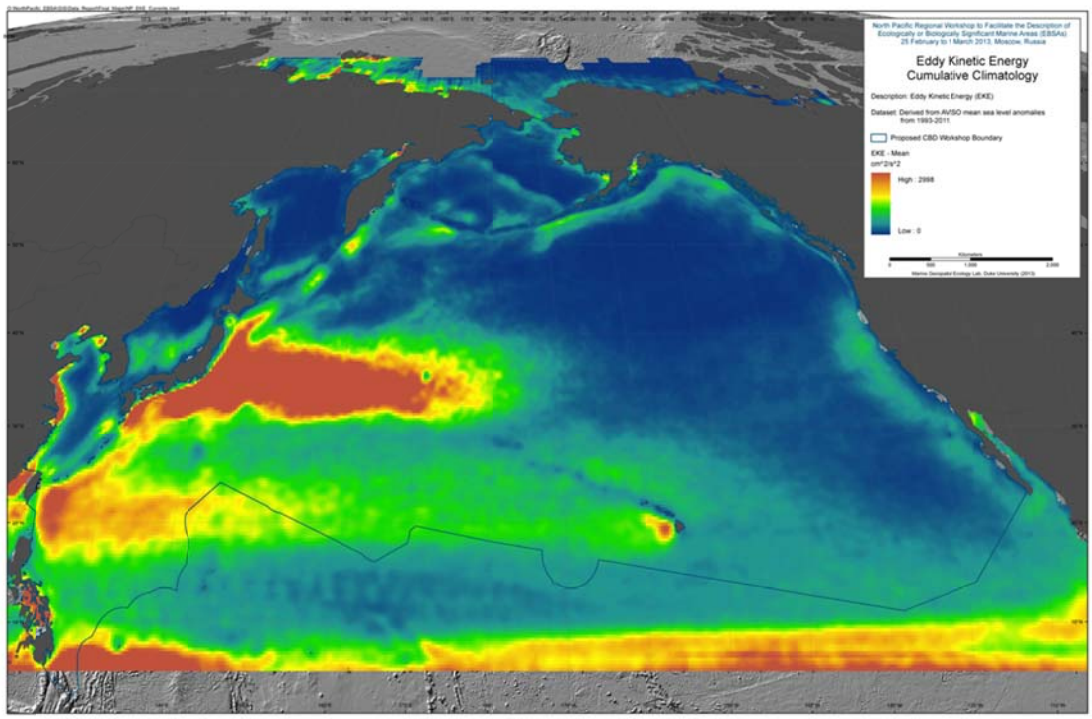

Figure 4.15-1 Eddy Kinetic Energy - Cumulative Climatology

4.16 Drifter Climatology of Near-Surface Currents

Satellite-tracked SVP drifting buoys (Sybrandy and Niiler, 1991; Niiler, 2001) provide observations of near-surface circulation at unprecedented resolution. In September 2005, the Global Drifter Array became the first fully realized component of the Global Ocean Observing System when it reached an array size of 1250 drifters. A drifter is composed of a surface float which includes a transmitter to relay data, a thermometer which reads temperature a few centimeters below the air/sea interface, and a submergence sensor used to detect when/if the drogue is lost. The surface float is tethered to a subsurface float which minimizes rectification of surface wave motion (Niiler *et al.*, 1987; Niiler *et al.*, 1995). This in turn is tethered to a holey sock drogue, centered at 15 m depth. The drifter follows the flow integrated over the drogue depth, although some slip with respect to this motion is associated with direct wind forcing (Niiler and Paduan, 1995). This slip is greatly enhanced in drifters which have lost their drogues (Pazan and Niiler, 2000). Drifter velocities are derived from finite differencing their raw position fixes. These velocities, and the concurrent SST measurements, are archived at AOML's Drifting Buoy Data Assembly Center where the data are quality controlled and interpolated to 1/4-day intervals (Hansen and Herman, 1989; Hansen and Poulain, 1996).

Reference:
Lumpkin, R. and Z. Garraffo, 2005: *Evaluating the Decomposition of Tropical Atlantic Drifter Observations*. J. Atmos. Oceanic Techn. I 22, 1403-1415.

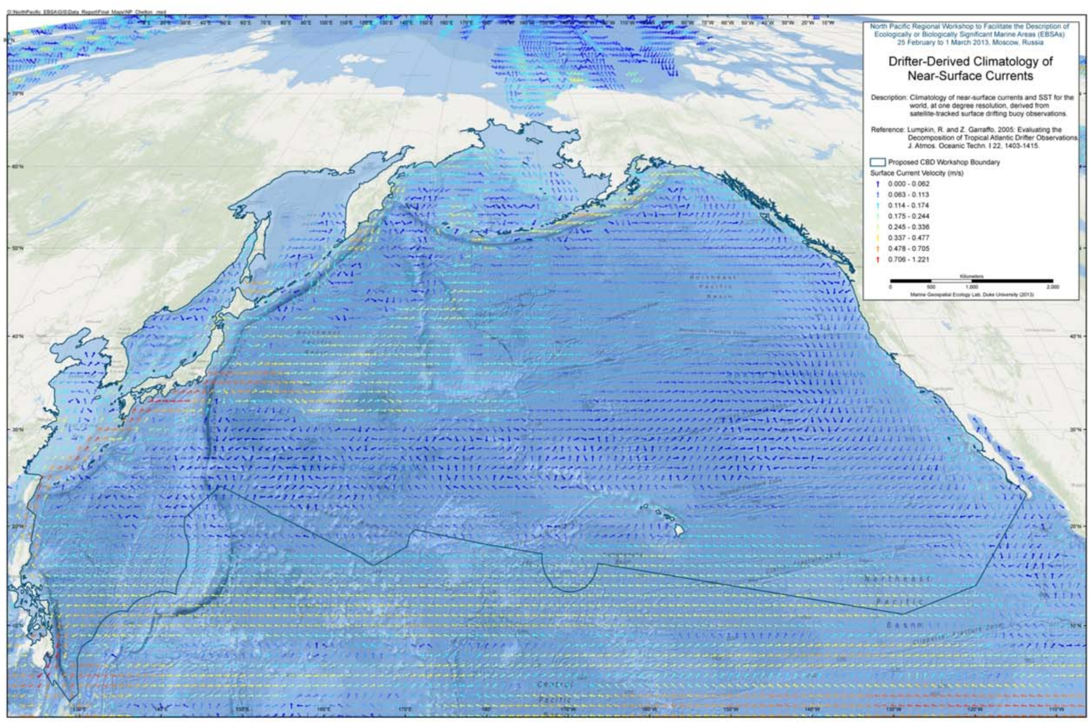

Figure 4.16-1 Drifter-Derived Climatology of Near-Surface Currents

4.17 Surface Current Velocity

The Archiving, Validation and Interpretation of Satellite Oceanographic data (AVISO) group publishes various products derived from satellite altimetry data, including estimates of sea surface height (SSH), geostrophic currents, wind speed modulus, and significant wave height. To maximize accuracy and spatial and temporal resolution and extent, AVISO merges observations from multiple satellites, including Topex/Poseidon, Jason-1, Jason-2, GFO, ERS-1, ERS-2, and EnviSat. Most Aviso products are one of these "merged" datasets, although a few products are based on observations from a single satellite.
(source: http://code.nicholas.duke.edu/projects/mget)

For this effort, cumulative climatologies (1993 - 2011) for ocean current velocity were created using the “Create Climatological Rasters for Aviso Geostrophic Currents Product” tool with the Global DT-Upd Merged MSLA product and “mag” (for magnitude) geophysical parameter selected in the Marine Geospatial Ecology Tools (MGET) for ArcGIS (Roberts et al., 2010).

References:

Bonjean, F. and Lagerloef, G.S.E. (2002) Diagnostic Model and Analysis of the Surface Currents in the Tropical Pacific Ocean. J. Physical Oceano. 32(10):2938-2954.

Roberts, J.J., B.D. Best, D.C. Dunn, E.A. Treml, and P.N. Halpin (2010). Marine Geospatial Ecology Tools: An integrated framework for ecological geoprocessing with ArcGIS, Python, R, MATLAB, and C++. Environmental Modelling & Software 25: 1197-1207.

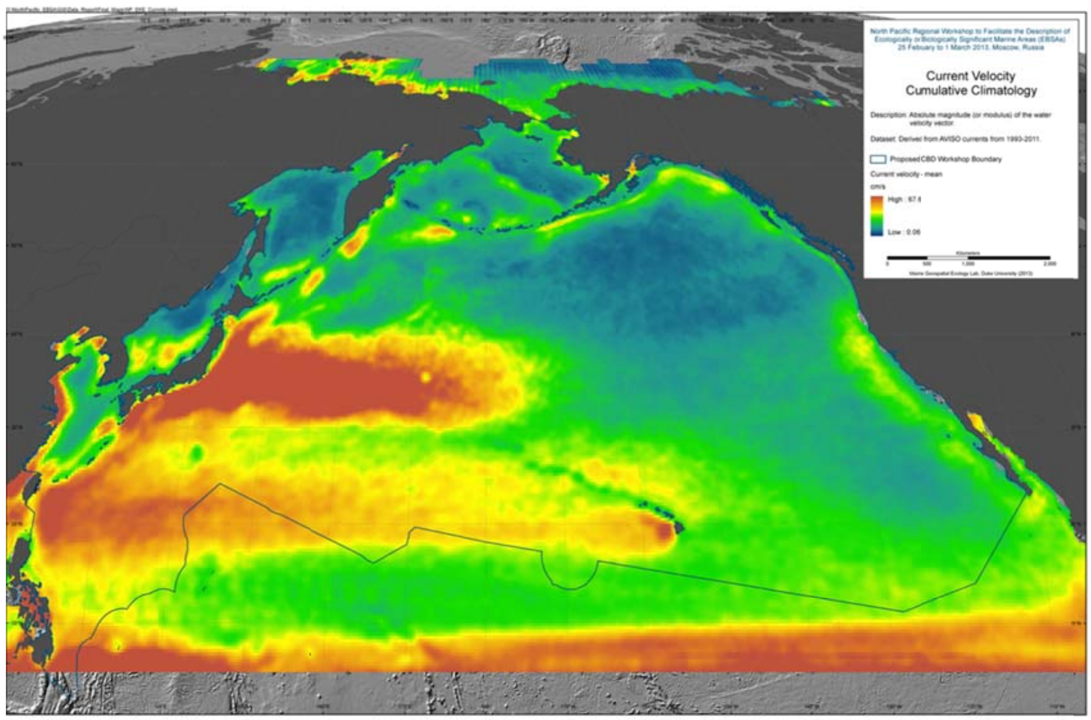

Figure 4.17-1 Surface Current Velocity - Cumulative Climatology

5 Additional Data Reports

Data reports from several ongoing scientific research programs and planning processes were suggested for the review of workshop attendees.

5.1 North Pacific Marine Science Organization (PICES)

The North Pacific Marine Science Organization (PICES), an intergovernmental scientific organization, was established in 1992 to promote and coordinate marine research in the northern North Pacific and adjacent seas. Its present members are Canada, Japan, People's Republic of China, Republic of Korea, the Russian Federation, and the United States of America.

PICES scientific and technical reports: http://www.pices.int/default.aspx

Latest North Pacific Ecosystem Status Report:
The PICES report on marine ecosystems is intended to periodically review and summarize the status and trends of the marine ecosystems in the North Pacific, and to consider the factors that are causing or are expected to cause change in the near future. The first report, begun in mid-2002 and completed about 18 months later, served as a pilot project for what might be possible. This report was based largely on geographic locations and subjects for which time series data or information are readily available. The report also identified locations and subjects where data were collected but are not yet available. http://www.pices.int/projects/npesr/default.aspx

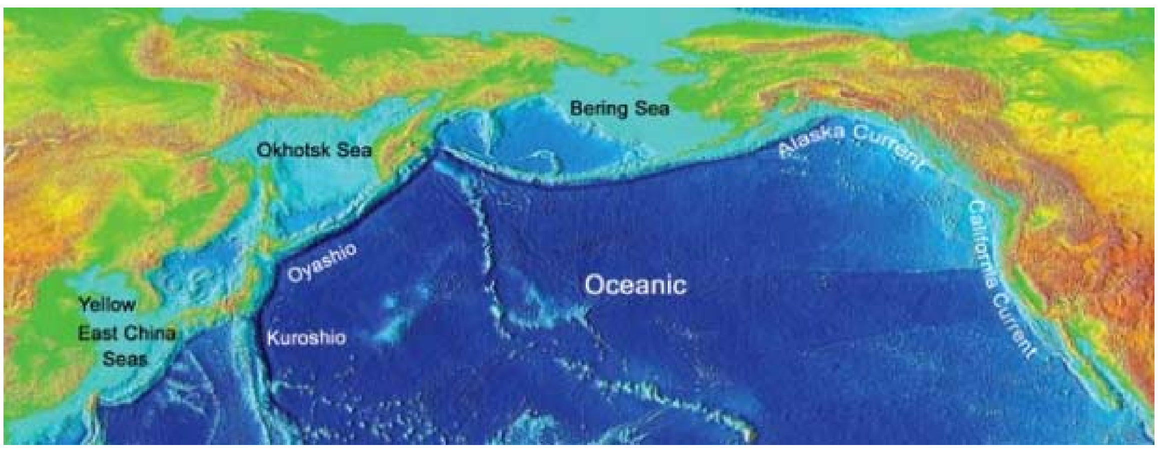

Figure 5.1-1 Regional organization of the chapters of the PICES report on Marine Ecosystems of the North Pacific Ocean

[Figure S-1 from PICES North Pacific Ecosystem Status Report "Marine Ecosystems of the North Pacific Ocean 2003-2008" (2010)]

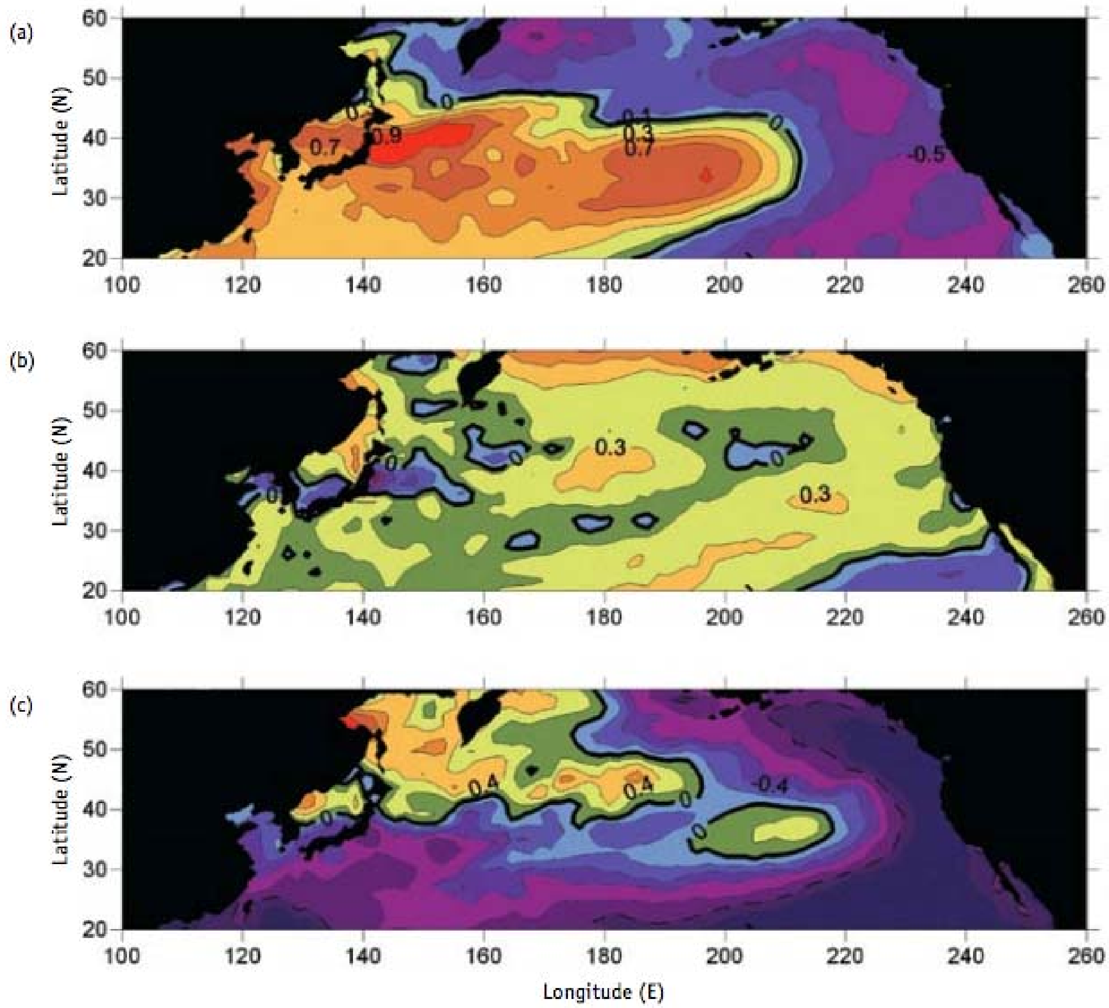

Figure 5.1-2 Average SST anomalies within the periods: (a- upper panel) May 1998-August 2002, (b- middle panel) September 2002-September 2007, and (c- lower panel) October 2007-December 2008 (end of focus period).

[Figure S-6 from PICES North Pacific Ecosystem Status Report "Marine Ecosystems of the North Pacific Ocean 2003-2008" (2010)]

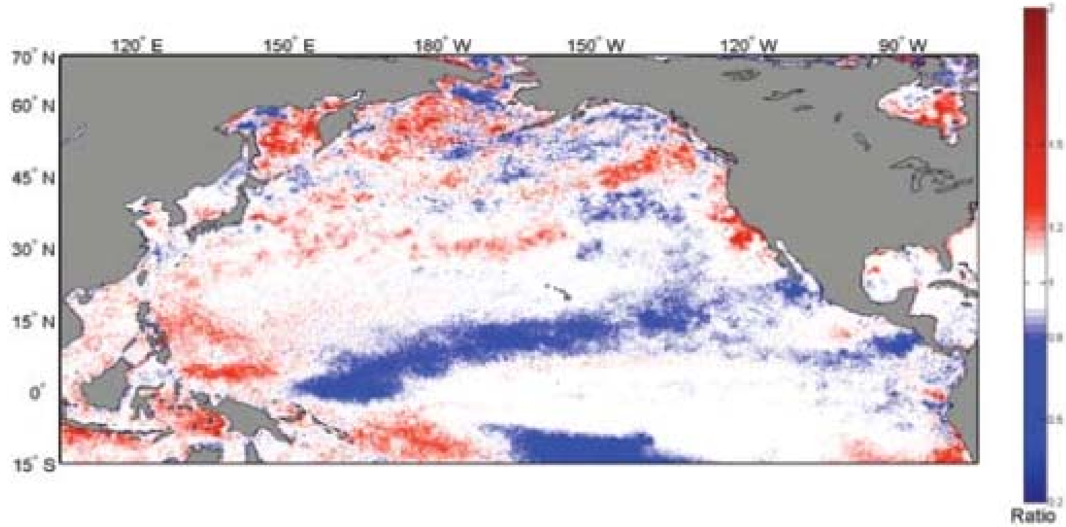

Figure 5.1-3 Ratio of mean chlorophyll A between 1998-2002 (denominator) and 2003-2007 periods.

[Figure S-20 from PICES North Pacific Ecosystem Status Report "Marine Ecosystems of the North Pacific Ocean 2003-2008" (2010)]

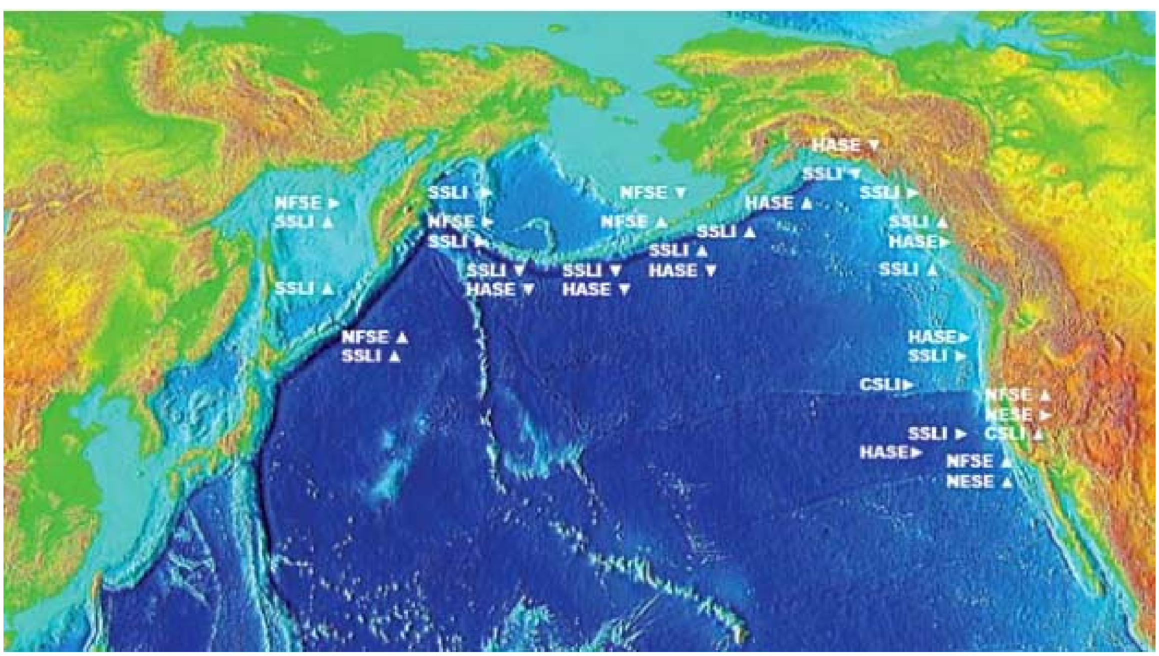

Figure 5.1-4 Abundance trends for pinnipeds in the North Pacific Ocean

Trends are indicated by ▲ (upward), ► (without trend), and ▼ (downward). Species codes are: CSLI=California sea lion, HASE= harbour seal, NESE=northern elephant seal, NFSE=northern fur seal, and SSLI=Steller sea lion. [Figure S-34 from PICES North Pacific Ecosystem Status Report "Marine Ecosystems of the North Pacific Ocean 2003-2008" (2010)]

5.2 Identification of Arctic marine areas of heightened ecological significance

Identification of Arctic marine areas of heightened ecological significance: A follow-up project to Recommendation IIC of the Arctic Marine Shipping Assessment, 2009

The Arctic Marine Shipping Assessment (AMSA) 2009 Report reviewed environmental impacts and threats from current and future Arctic marine shipping. AMSA Recommendation IIC called for the Arctic states to identify areas of heightened ecological and cultural significance in light of changing climate conditions and increasing multiple marine uses, and, where appropriate, to encourage implementation of measures to protect these areas from the impacts of Arctic marine shipping. An AMSA IIC project was established with Norway, Canada, Denmark/Greenland, and the United States of America as lead countries, and with assistance from AMAP, CAFF and SDWG. A group of core-drafters were selected to carry out the work of identifying and describing the areas of heightened significance. The present report includes the identified areas of heightened ecological significance. The areas of heightened cultural significance have been identified in a different process and are reported as a separate part of the final AMSA IIC report.

Areas of heightened ecological significance have been identified for each of the 16 Large Marine Ecosystems (LMEs) within the Arctic area. Three different approaches have been used to identify the areas. Areas identified as vulnerable areas in the AMAP Assessment of oil and gas activities in the Arctic (OGA) have been used as a basis for the identified AMSA IIC areas in 12 LMEs (located in the Northeast Atlantic sector, in the Russian Arctic, Bering and Chukchi seas, and the Central Arctic Ocean). Canada and Denmark/Greenland have had separate national processes to identify areas of heightened ecological significance for their waters (5 LMEs, from the Beaufort Sea to the Greenland Sea).

A PDF of this draft report will be available for review by the participants of the workshop.

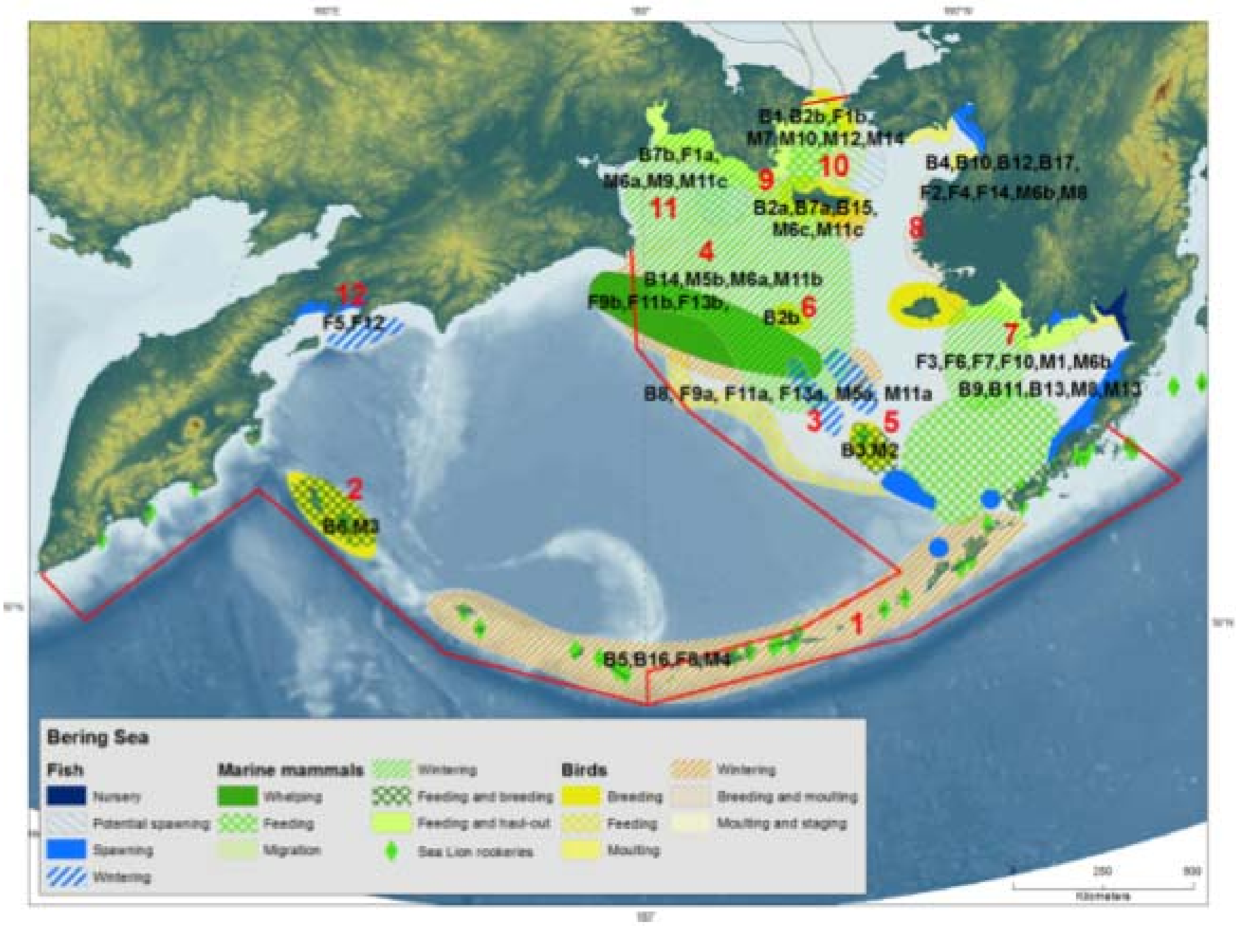

Figure 5.2-1 Areas of heightened ecological significance in the Bering Sea LME

[Figure 10 from "Identification of Arctic marine areas of heightened ecological significance: A follow-up project to Recommendation IIC of the Arctic Marine Shipping Assessment, 2009"]

5.3 Whale and Dolphin Conservation Society

The Whale and Dolphin Conservation Society (WDCS) has been involved with several relevant projects in the North Pacific, the Far East Russia Orca Project and Russian Cetacean Habitat Project. WDCS and colleagues have been engaged in killer whale and other cetacean studies mostly in the nearshore waters of Kamchatka and the Commander Islands over the last decade. In the last few years the research has expanded to include more data on Baird's beaked whales and humpback whales. Several resulting papers/reports were suggested for review by workshop attendees.

For copies of any of the following, contact erich.hoyt@me.com.

Papers available in PDF:

Filatova, O.A., I.D. Fedutin, M.M. Nagaylik, A.M. Burdin and E. Hoyt. 2009. Usage of monophonic and biphonic calls by free-ranging resident killer whales (*Orcinus orca*) in Kamchatka, Russian Far East. *Acta Ethologica,* 12(1):37-44

Nagaylik, M.M., Filatova, O.A., Ivkovich, T.V., Burdin, A.M. and Hoyt, E. 2010. Area usage by killer whales (*Orcinus orca)* in Avacha Gulf of Kamchatka. *Zoologicheskii* Zhurnal *(Russian Journal of Zoology*), 89(4):484-494. (ЗООЛОГИЧЕСКИЙ ЖУРНАЛ, том 89, No 4, с. 484–494) In Russian with English abstract.

Burdin A.M., Hoyt E., Filatova O.A., Ivkovich T., Tarasyan K. and Sato H. 2007. Status of killer whales, *Orcinus orca,* in Eastern Kamchatka, Russia, based on photo-identification and acoustic studies. Preliminary results. IWC Scientific Committee (SC/59/SM4).

Filatova O.A., Fedutin I.D., Burdin A.M. and Hoyt E. 2007. The structure of the discrete call repertoire of killer whales *Orcinus orca* from Southeast Kamchatka. *Bioacoustics* 16(3):261-280.

Filatova, O.A., I.D. Fedutin, T.V. Ivkovich, M.M. Nagailik, A.M. Burdin and E. Hoyt. 2009. The function of multi-pod aggregations of fish-eating killer whales (*Orcinus orca*) in Kamchatka, Far East Russia. *Journal of Ethology* 27(3):333-341

Ivkovich, T., Filatova, O.A., Burdin, A.M., Sato, H., Hoyt, E. 2010. The social organization of resident-type killer whales (*Orcinus orca*) in Avacha Gulf, Northwest Pacific, as revealed through association patterns and acoustic similarity. *Mammalian Biology* 75:198-210

Fedutin I.D., Filatova O.A., Mamaev E.G., Chekalski E.I., Burdin A.M., Hoyt E. 2012. The results of long-term monitoring and first evidence of stable social associations in Baird's beaked whales (*Berardius bairdii*) in the waters of the Commander Islands, Russian Far East. IWC Scientific Committee, 11pp (SC64/SM5)

Filatova, O.A., Witteveen, B.H., Goncharov, A.A., Tiunov, A.V., Goncharova, M.I., Burdin, A.M., Hoyt, E. In press for 2012. Humpback whale diet on the shelf and oceanic feeding grounds in the western North Pacific inferred from stable isotope analysis. *Marine Mammal Science*. [ISSN: 1748-7692]

Filatova, O. A., Deecke, V.B., Ford, J.K.B., Matkin, C.O., Barrett-Lennard, L.G., Guzeev, M.A., Burdin, A.M., Hoyt, E. 2012. Call diversity in the North Pacific killer whale populations: implications for dialect evolution and population history, *Animal Behaviour* 83, pp595-603

Report available in PDF:

Williams, R., K. Kaschner, E. Hoyt, R. R. Reeves and E. Ashe. 2011 *Mapping Large-scale Spatial Patterns in Cetacean Density: Preliminary work to inform systematic conservation planning and MPA network design in the northeastern Pacific,* Report from the WDCS Critical Habitat/ MPA Programme, Whale and Dolphin Conservation Society, Chippenham, UK, 53pp [ISBN: 978-1-901386-24-0]

Books available in PDF:

Burdin, A, Hoyt, E, Sato, H and O. Filatova. 2006. The Killer Whales of Eastern Kamchatka. Alaska SeaLife Centre, Seward, Alaska, 157pp.

Burdin, A.M., Filatova, O.A., Hoyt, E. 2009. Морские млекопитающие России. (Marine Mammals of Russia). Kirov Regional Printing House, plc, Kirov, 208pp

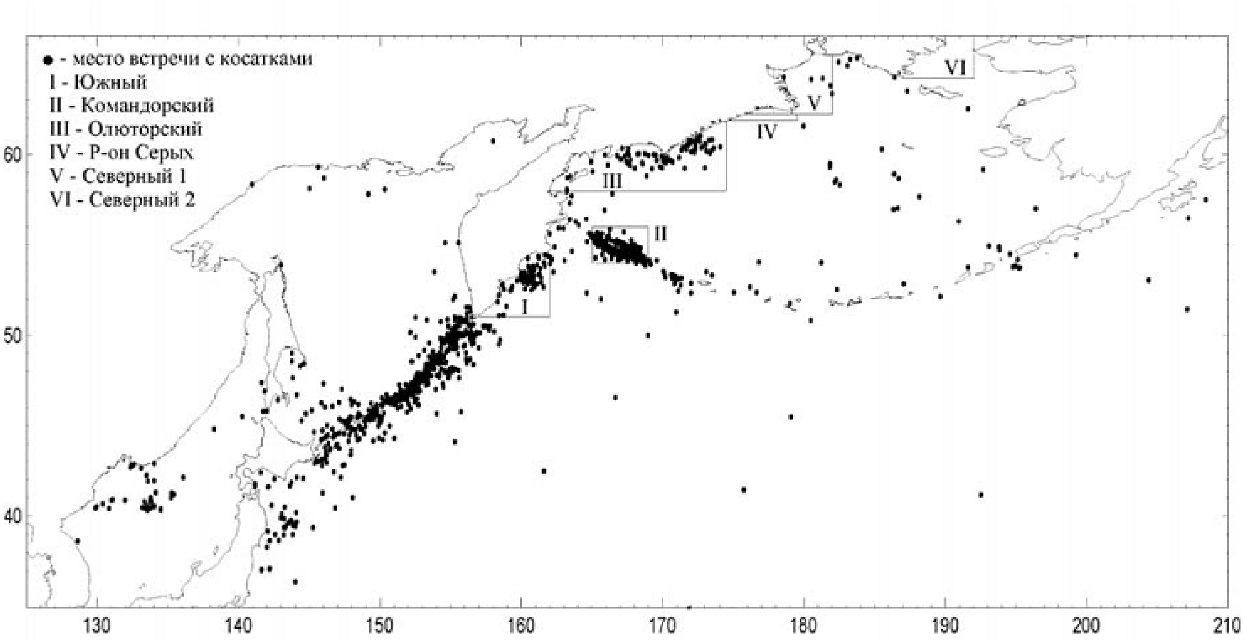

Figure 5.3-1 The distribution of killer whales in 1935-1988 in harvest regions

[Figure from Perlov A.S., Shvetsov E.P. (2004) *Distribution and abundance dynamics of Killer Whale (Orcinus orca) in the northwest part of the Northern Pacific in 1935-1988.*]

5.4 IUCN/NRDC Workshop to Identify EBSAs in the Arctic Marine Environment

The International Union for the Conservation of Nature (IUCN) and the Natural Resources Defense Council (NRDC) have undertaken a project to explore ways of advancing implementation of ecosystem- based management in the Arctic marine environment through invited expert workshops.

The first workshop, held in Washington, D.C. on 16-18 June, 2010, explored possible means to advance policy decisions on ecosystem-based marine management in the Arctic region. Twenty-nine legal and policy experts from around the region participated in the June workshop. The report and recommendations of the June policy workshop can be found here: http://cmsdata.iucn.org/downloads/arctic_workshop_report_final.pdf.

The second workshop, the subject of this report, was held at the Scripps Institution of Oceanography in La Jolla, California on 2-4 November, 2010. The La Jolla workshop utilized criteria developed under auspices of the Convention on Biological Diversity to identify ecologically significant and vulnerable marine areas that should be considered for enhanced protection in any new ecosystem-based management arrangements. A list of participants, the meeting agenda and other relevant documents are attached as appendices to this report.

See http://docs.nrdc.org/oceans/files/oce_11042501a.pdf

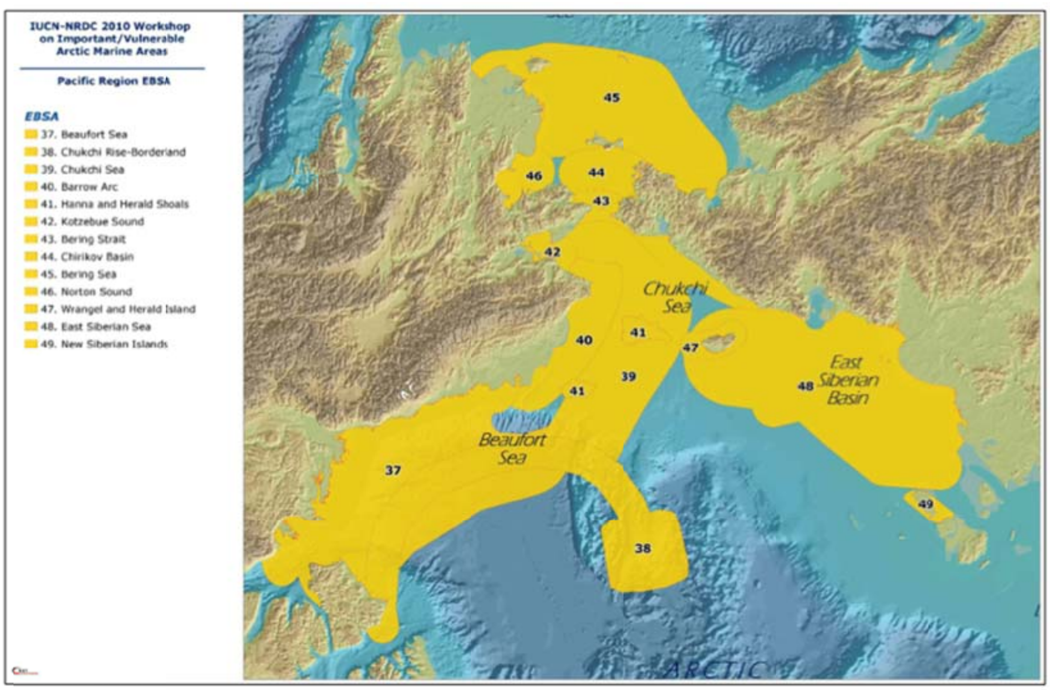

Figure 5.4-1 Pacific region EBSAs as proposed at the IUCN/NRDC Workshop to Identify EBSAs in the Arctic Marine Environment

5.5 Evaluation of proposed ecologically and biologically significant areas in marine waters of British Columbia

Canada's Oceans Act provides the legislative framework for an integrated ecosystem approach to management in Canadian oceans, particularly in areas considered ecologically or biologically significant. DFO has developed general guidance for the identification of ecologically or biologically significant areas. The criteria for defining such areas include uniqueness, aggregation, fitness consequences, resilience, and naturalness. This science advisory process identifies proposed ecologically and biologically significant areas (EBSAs) in Canadian Pacific marine waters, specifically in the Strait of Georgia, along the west coast of Vancouver Island (southern shelf ecoregion), and in the Pacific North Coast Integrated Management Area (PNCIMA, northern shelf ecoregion).

EVALUATION OF PROPOSED ECOLOGICALLY AND BIOLOGICALLY SIGNIFICANT AREAS IN MARINE WATERS OF BRITISH COLUMBIA, Canadian Science Advisory Secretariat, Science Advisory Report 2012/075
See http://www.dfo-mpo.gc.ca/csas-sccs/Publications/SAR-AS/2012/2012_075-eng.html

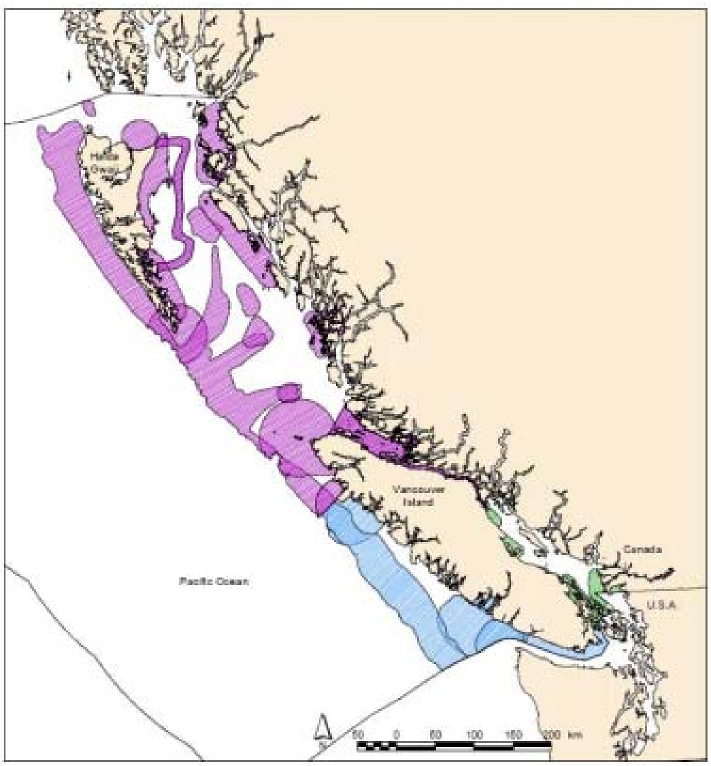

Figure 5.5-1 Proposed ecologically and biologically significant areas (EBSAs) in Canadian Pacific marine waters

[Purple shading represents those EBSAs in the Northern shelf ecoregion, blue in the Southern shelf ecoregion, and green in the Strait of Georgia ecoregion. Figure 1 from Canadian Science Advisory Secretariat, Science Advisory Report 2012/075"]

5.6 US NOAA publications on Seamounts and Living Marine Resources

NOAA recommended several publications and workshop reports for use by workshop participants. These publications cover a range of topics around seamounts in the North Pacific and the living marine resource associated with them. Electronic copies of these documents will be available at the workshop.

References:

Wilson CD, Boehlert GW (2004) *Interaction of ocean currents and resident micronekton at a seamount in the central North Pacific*. Journal of Marine Systems 50:39–60.

Uchida, R.N., S. Hayasi, G.W. Boehlert, Eds. (1984) "*ENVIRONMENT AND RESOURCES OF SEAMOUNTS IN THE NORTH PACIFIC". PROCEEDINGS OF A WORKSHOA MARCH 21-23, 1984. SHIMIZU, JAPAN.* NOAA Tech Report NMFS 43.

Hughes, S.E. (1981) *Initial U.S. Exploration of Nine Gulf of Alaska Seamounts and Their Associated Fish and Shellfish Resources.* Marine Fisheries Review, 43, 26-33
(online at http://spo.nmfs.noaa.gov/mfr431/mfr4314.pdf)

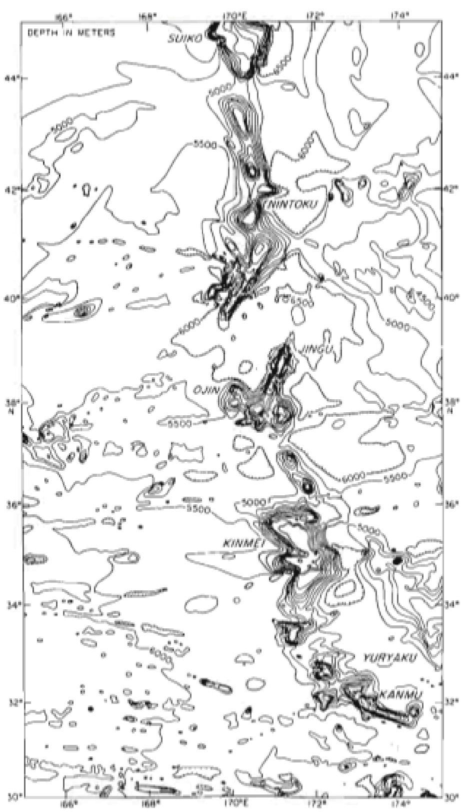

Figure 5.6-1 Map showing topography of the Emperor Seamount region

[Figure 5 from Roden 1984, included in Uchida et. al. 1984]

5.7 Publications on Marine Protected Areas in North-East Asia from the NEASPEC Secretariat

The North-East Asian Subregional Programme for Environmental Cooperation (NEASPEC) Secretariat recommended several relevant publications for use by the workshop participants. These include a review paper on marine protected areas in North-East Asia, prepared by the NEASPEC secretariat to propose launching a Northeast Asia MPA Network. This paper together with other background documents are available from the NEASPEC website.

Review paper:
Subregional Cooperation for Strengthening Marine Protected Areas in North-East Asia. NEASPEC SECRETARIAT. NOVEMBER 2012.
(http://www.neaspec.org/documents/som17/SOM17_Marine%20environment_Annex.pdf)

SOM document:
http://www.neaspec.org/documents/som17/5.%20SOM17_Marine%20environment.pdf

Figure 5.7-1 Special Marine Protected Ares (SMPA) in China (2009)

[Figure 2 from NEASPEC 2012]

Figure 5.7-2 MPAs in Japan (2010)

[Figure 3 from NEASPEC 2012]

Figure 5.7-3 MPAs in Republic of Korea

[Figure 4 from NEASPEC 2012]

Figure 5.7-4 Marine and Coastal Protect Areas (MCPA)s in the Russian Federation

[Figure 5 from NEASPEC 2012]

5.8 Data and Information on Protected Areas and Marine Biodiversity from the Northwest Pacific Action Plan's Data and Information Network Regional Activity Centre (NOWPAP DINRAC)

The Northwest Pacific Action Plan's Data and Information Network Regional Activity Centre (NOWPAP DINRAC) identified several recent reports of interest to workshop attendees. These reports address data and information on marine reserves and protected areas and marine and coastal biodiversity in the NOWPAP region.

Regional and National Reports on Marine and Coastal Biodiversity Data and Information in the Northwest Pacific Region (NOWPAP DINRAC, September 2007)
http://dinrac.nowpap.org/documents/NOWPAP_DINRAC_National_Reports_Marine_Biodiversity.pdf

Regional Overview and National Reports on Marine and Coastal Nature Reserves in the Northwest Pacific Region (NOWPAP DINRAC, September 2007)
http://dinrac.nowpap.org/documents/NOWPAP_DINRAC_National_Reports_Nature_Reserves.pdf

Summary on Marine and Coastal Protected Areas in NOWPAP Region (NOWPAP DINRAC, March 2010)
http://dinrac.nowpap.org/documents/NOWPAP_DINRAC_Summary_on_MPAs_in_NOWPAP.pdf

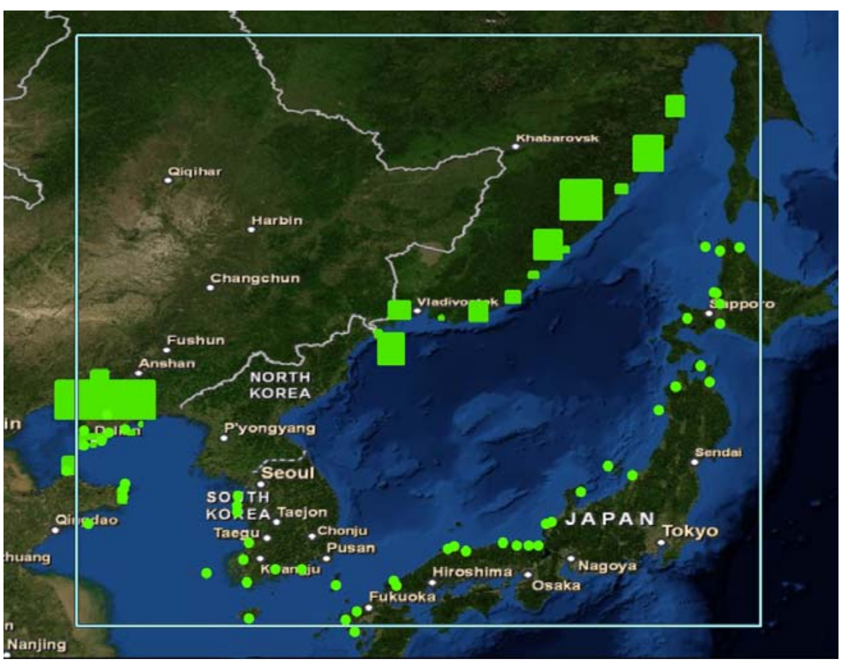

Figure 5.8-1 Locations of MPAs in NOWPAP Region

[Map 1 from NOWPAP DINRAC 2010]

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