PICES XIII S4-2020 Invited
Tagging of Pacific Pelagics: Using electronic tags to discover hot spots in the pelagic realm

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In an effort to understand and locate biological hot spots in the North Pacific Ocean, the Tagging of Pacific Pelagics (TOPP) program is using biologging technology to simultaneously map the location of marine vertebrates including sharks, tuna, albatrosses, seals and whales. Hot spots are regions of high biological activity where linkages occur between physical forcing, primary production, secondary consumers and top pelagic predators. Although it is generally accepted that these hot spots occur and are important, surprisingly little is known about these congregating spots for marine organisms in the open ocean. Our lack of understanding of the aggregating forces in the pelagic ocean ecosystem stems largely from limitations of available technology. Prior studies have focused on single species tracking and few have attempted to examine interactions among top pelagic species. TOPP is coupling electronic tagging data with satellite remote sensing technologies to simultaneously map the movements of diverse pelagic species and link their movements to oceanographic processes. To date we have tagged and tracked mako, salmon and white sharks, elephant seals, bluefin and yellowfin tuna, black-footed and Laysan albatross, California sea lions and leatherback sea turtles. Preliminary analysis indicates that frontal features associated with the North Pacific Transition zone and the California Current comprise a region of common habitat utilization for many of these species.

PICES XIII S4-2168 Invited
Persistent pelagic habitat in the Northeast Pacific

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We present analytical methods that define pelagic habitat in the Northeast Pacific based upon the density of steep temperature gradients, or fronts, and we quantify their spatial and temporal persistence over a single ENSO cycle (1996-1999) to benefit marine conservation and marine management strategies. We find less that than <1% of the Northeast Pacific ocean exhibits a persistent (> 8 mo/yr) concentration of temperature fronts (>.2 km/km^2) within and between years. The Baja California Frontal System (BCFS) is the largest concentration within federal waters, between 20 km and 300 km east of Baja California Sur. The BCFS appears more active under La Nina conditions, while the next largest persistent concentration, the high-seas North Pacific Transition Zone, appears more active under El Nino conditions. We demonstrate habitat functions associated with the BCFS for Blue Whales (*Balaenoptera musculus*), Swordfish (*Xiphias Gladius*), and Striped Marlin (*Tetrapturus audax*). Distinct residential periods were identified in telemetry data, punctuated by intermittent direct transits. In the Channel Islands, the Blue whales are foraging on krill, but off Baja they feast upon large concentrations of pelagic tuna crabs, *Pleuroncodes planipes*, known to occur within BCFS waters. Concentrations of density fronts aggregate prey, reducing foraging effort for a broad assemblage of species. We recommend more research, management, and protection for this pelagic "hot spot" off Baja California Sur.

PICES XIII S4-1983 Oral
Existence of hot spots of large sized baleen whale concentration in pelagic zone of the western North Pacific; its biological and oceanographical features

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Large-scale ecosystem studies on baleen whales and sperm whales have been conducted under the scientific permit since 1994 in pelagic zone of the western North Pacific. Based on cruises, we found a ”hot spot” in occurrence for large baleen whales, such as blue whale (*Balenoptera musclus*), fin whales (*B. physalus*), sei whales (*B. borealis*) and sometime right whales (*Eubalaena glacialis*) at around 44ºN-46ºN, 157ºE-160ºE. The area is well known as a traditional whaling ground. The present study investigates biological and oceanographic features for this “hot spot”. A number of characteristic features were found.

PICES XIII S4-2034 Invited
Recent advances in knowledge of cold water sharks in the North Pacific Ocean

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The endemic North Pacific shark species include: sleeper shark (*Somniosus pacificus*), salmon shark (*Lamna ditropis*), sixgill shark (*Hexanchus griseus*), and the dogfish shark (*Squalus acanthias*). This paper focuses on these sharks which occur from Washington State to the Arctic Ocean and are known to occur in the western part of the North Pacific Ocean. The sixgill shark has made a new appearance in Puget Sound and vicinity, Washington. Ecological hypotheses include that Puget Sound is a nursery ground. Primarily a deep benthic feeder, it comes near to, and below, the surface at night to feed. They appear to be rather localized and do not travel great distances. The sleeper shark is found more northerly than the sixgill shark but seems to occupy the same niche. The salmon shark carries out long-distance movements from Alaska to California (the oceanic transition zone), likely associated with reproduction. Capable of diving to great depths, it also actively feeds virtually at the surface. The species is endothermic, thus increasing the efficiency of muscular action. Movement was quantified via satellite pop-off tags. These three sharks are over two meters long at maturity. In contrast, the spiny dogfish is about a meter at maturity and is actively harvested. It occupies pelagic and benthic ecosystems. It is known to make long east-west and north-south migrations over the Pacific, but this feature does not appear to be a part of the normal life cycle.

PICES XIII S4-1793 Oral
Persistence of prey “hot spots” in southeast Alaska

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Marine foraging vertebrates face many constraints in finding patchily distributed prey in a three-dimensional water space. Particularly for vertebrates that cannot sample large areas (*e.g.*, seals and sea lions that sample the prey field by visually searching for fish), the relative costs of encountering high-density prey aggregations (“hot spots”) may be high unless the density of hot spots are high or persist through time. Should these hot spots persist, marine predators can use previous experience (long-term area-concentrated search methods) to minimize search costs and maximize foraging efficiency. We examined the quantity and location of pelagic forage fish species in southeast Alaska, including Pacific herring and walleye pollock, to determine (1) the density of prey hot spots over a 24-month period, (2) whether the location of these hot spots persisted over several months or across seasons. The density of hot spots varied across months and seasons. Large schools of Pacific herring were the most important

prey that determined the location and density of these hot spots. Perhaps more importantly, several hot spots persisted over time, although persistence was highest during the winter months, November-February. Large and medium sized schools of herring were consistently found in certain areas at relatively small (1 km) spatial scales. Ongoing work quantifying hot spot density and persistence on smaller time scales (days, weeks), will help further elucidate the relative 'costs' of finding prey, in addition to the rewards, and enhance our ability to link foraging behavior of marine foraging vertebrates with fitness ramifications.

PICES XIII S4-1942 Oral

Differences in large pelagic fish larvae and zooplankton volumes over and around a seamount in the Gulf of California

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To explore the influence of a seamount on the accumulation of plankton, we obtained data on hydrography and zooplankton in the vicinity of El Bajo Espiritu Santo (EBES) in the Gulf of California, Mexico. Hydrographic data consisted of conductivity-temperature-depth (CTD) profiles, underway velocity profiles, and underway surface temperature and salinity observations; measurements were carried out during June 20 to 22, 1999. Zooplankton was sampled by surface tows of a plankton net on four fine-scale grids located over and around the seamount. The circulation pattern showed a northwestward flow with magnitudes between 0.2 and 0.8 m s^{-1}. The influence of the relatively cooler and less saline waters from the Bay of La Paz was marked by a thermal front. The zooplankton volume distribution was linked to the sea surface temperature and salinity as the highest biomass was found over the seamount and to the west, within the cooler and less saline waters coming from the Bay of La Paz. Fish larvae of 39 taxa belonging to 26 families, 32 genera and 30 species were determined, with the grid over the seamount having the highest abundance and number of taxa. Large pelagic fish larvae of *Thunnus albacares, Euthynnus lineatus, Coryphaena hippurus and Auxis* sp. were recorded. The presence of several species with different habitat affinities appeared to reflect physical processes around the seamount which enhanced vertical mixing and induced re-circulations. These results indicate that the EBES seamount is an area of accumulation of zooplankton and retention of larval fishes.

PICES XIII S4-1885 Oral

Upper-trophic predator hot spots in the California Current system: A retrospective analysis of marine bird and mammal communities

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Marine mammals and birds are not distributed uniformly across the world's oceans. Instead, species distributions frequently mirror bathymetric domains, water mass distributions, and mesoscale hydrographic features. Nevertheless, relatively little is known about the mechanisms that restrict these upper-trophic marine predators to specific oceanic domains, and the extent to which species distributions are influenced by spatial habitat gradients and temporal oceanographic variability. Yet, thorough understanding of the patterns of biodiversity and species abundance is a necessary foundation for effective management and conservation of marine systems. We quantified the spatial and temporal patterns of marine bird and mammal distributions along a 1600-km stretch off the West Coast of North America, extending from Point Conception (34°N) to south of Vancouver Island (49°N), and from

the coast to 200 km offshore. More specifically, we analyzed a dataset of monthly marine bird and mammal sightings, collected along a series of standardized aerial survey lines in the 1980s (1980-83 and 1989-90) for the entire CCS. We found distinct bird – mammal communities associated with specific oceanic habitats, and identified several seasonal "hot spots" on the basis of upper-trophic predator concentrations (standing stocks) and community structure (species diversity). Our results suggest that, in spite of seasonal and interannual variability, there exist spatially-predictable upper-trophic predator communities in the California Current System. Moreover, these communities are associated with specific bathymetric and oceanographic habitats. In particular, this analysis highlights the ecological significance of productive continental shelf and slope regions, especially during the season of coastal upwelling (March – August).

PICES XIII S4-1947 Poster

Transport and migration of larval and juvenile fishes through oceanic fronts

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Aggregation of larvae and juvenile coastal pelagic fish, such as sardine, anchovy, and mackerels, are often observed around oceanic fronts in the Kuroshio-Oyashio Transition Region. This distribution expands eastward to the central North Pacific when stock abundance is high, corresponding to a spawning area over the Kuroshio. However, in periods of low abundance, the distribution shrinks around Japanese coastal waters, with a narrowing of the spawning area. As survival through the early life stages is responsible for the stock abundance of these species, both physical and biological characteristics of these distributions have been studied through hydrographic observations and net sampling. In this study, transport and migration processes are examined by a newly developed physical-biological coupled model for understanding the life history strategies of these fish. Physical characteristics of the oceanic fronts inhabited by the fish are compared to those of coastal fronts (*e.g.,* shelf break front). The impacts of hydrographic variation on patterns of transportare discussed, including primary/secondary production and migration behavior.

PICES XIII S4-2011 Invited

Configuration of migratory history based on analyses of stable isotopes and trace elements in otolith of the North Pacific chum salmon

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To understand the migratory history of chum salmon (*Oncorhynchus keta*) in the North Pacific Ocean, we conducted chemical analyses of otoliths. We obtained salmon otoliths from 4 places along the Asian and North American coasts during the 1997-1999 spawning seasons. Stable isotopes ($\delta^{18}O$ and $\delta^{13}C$) and trace elements (calcium, strontium, and zinc) were determined/compared with respect to region and life history. The $\delta^{18}O$ values of Asian salmon appeared higher than North American salmon, while the $\delta^{13}C$ isotope showed opposite patterns over three consecutive years. The high $\delta^{18}O$ and low $\delta^{13}C$ values of Asian salmon may represent a lower temperature and productivity of ocean habitat than North American salmon. Stable isotope values increased with age, showing a high correlation with salmon size. Such differences in stable isotope values indicate different migration routes and habitat distributions with respect to originations and life stages. Trace elements of otolith were examined by laser ablation inductively coupled plasma mass spectrometry (LA-ICPMS). Sr/Ca ratios, an indicator of salinity, were low during the freshwater stage, increased suddenly at a certain point, and oscillated periodically to a margin corresponding to the year-rings. These oscillations might reflect the movement of fish within salinity gradients between onshore/offshore or north/south migrations during their ocean life period. Zinc profiles also oscillated and

corresponded to the annual growth rings. However, the profiles of Sr and Zn oscillated oppositely after salmon migrated to saline water and the zinc uptake declined toward the rim of the otolith while strontium uptake increased.

PICES XIII S4-1951 Oral
Landmark for the spawning of Japanese eel

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Spawning areas for the Japanese eel (*Anguilla japonica*) are located in the North Equatorial Current (NEC), west of the Mariana Islands, 3000 kilometers from nursery rivers in East Asia. In 2002, we found that the larval distribution of Japanese eel was related to a salinity front, generated by two distinct water masses in the NEC. The salinity front moved southward during El Niño. Large numbers of smaller larvae (~ 10 d old) were collected just south of the salinity front during the 2002 El Niño event. El Niño events, represented by negative values of the Southern Oscillation Index (SOI), correspond with low catches of glass eel in Japan. According to analyses of carbon and nitrogen stable isotope ratios of leptocephali and particulate organic matter in seawater obtained during 2002 and 2004 surveys, the composition of larvae are different to the south and north of the NEC salinity front. We suggest that during their initial life stage leptocephali do not inhabit waters north of the salinity front, but do inhabit waters to the south to feed on particulate matter. Differences of the water properties represented by salinity are apparently related to spawning behavior. The NEC salinity front may function as the landmark for the spawning of Japanese eel.

PICES XIII S4-2105 Oral
Horizontal and vertical movements of juvenile bluefin tuna (*Thunnus orientalis*) in relation to seasons and oceanography in the eastern Pacific

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Juvenile Pacific bluefin tuna tagged with archival tags were released off Baja California in the eastern Pacific in the summers of 2002-2003. Thirty tags have been recovered with up to 677 days of time-series data on pressure, ambient and peritoneal temperature. Geolocations of tagged fish were calculated based on light-based longitude and sea surface temperature based latitude. Using this geolocation data in conjunction with oceanographic information, it was possible to examine the differences in horizontal and vertical movement patterns among seasons in relation to the oceanographic conditions. In summer, fish were found primarily in the Southern California Bight and along the continental shelf of Baja California. In these regions bluefin made use of the top of the water column undertaking frequent, brief forays to depths below the thermocline. In autumn bluefin migrated to the central California coast in the region of Monterey Bay where thermal fronts formed as the result of weakened equatorward wind stress. The timing of this movement towards the central California coast coincided with an increase in primary productivity in this region. An examination of peritoneal temperatures revealed that bluefin tuna fed frequently during this period along the frontal boundaries. In mid-winter, strong downwelling along the central California coast caused a decrease in the productivity in this region. At this time the bluefin returned to Southern California and Baja California continental shelf suggesting that prey species may have decreased in the central California region at this time. In addition to these latitudinal movements, several bluefin made trans-Pacific migrations along the transition zone to Japan during the winter. The migration involved movements to known seamounts including the Emperor Seamount and the Shatsky Rise.

PICES XIII S4-1913 Invited

How to discriminate the aggregated stocks of migratory species according to their origins: A simple and quick PCR method utilizing stock-specific single nucleotide polymorphisms

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Migratory fishes often intermix in the open ocean among stocks of different origins sometime during their life. The chum salmon (*Oncorhynchus keta*), an anadromous fish that distributes in the North Pacific is one of such examples? The fish reproduces in the river, migrates into the open ocean for growth and becomes intermixed. To study stock-specific migratory routes and other ecological characteristics, it will be necessary to develop a method discriminating each stock. Here, we present a simple polymerase chain reaction (PCR) method utilizing single nucleotide polymorphisms (SNPs) observed in the COIII-ND3-ND4L region of the mitochondrial DNA. From a 744 nucleotide-long sequence of the region, several stock-specific SNPs were observed (*e.g.*, positions 57, 70, 246, 303, 307, 534, 591) among 141 chum salmons of Korea, Japan, Canada, and the United States. Based on these SNPs, 20-25 nucleotide-long stock-specific PCR primers were designed in a way that the most 3'end nucleotide becomes identical to the SNPs and that the second to the 3'end mismatches the conserved nucleotide? With primer pairs designed as such, PCR amplified DNA distinctively among the Korea, Japan, Canada and the United States chum salmons: *e.g.* primer pairs of SF0 and SR1 for Korea and of SF1 and SR2 for America salmons. Because of its simplicity, this method would be useful for processing many specimens of aggregated stocks collected during any open ocean sampling cruise.

PICES XIII S4-2115 Poster

Pelagic habitat hot spots as revealed by replicate seabird surveys in the NE Pacific

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Identifying elevated oceanic productivity and upper trophic level predator aggregations (pelagic 'hot spots'), and quantifying spatio-temporal persistence of these hot spots at different scales is critical for effective marine conservation ranging from species to ecosystems. For seabird conservation, it has proven difficult to develop effective management programs based on empirically derived at-sea distributions, because of the nature of these distributions, and the enormous costs and support necessary for adequate spatio-temporal data collection. Developing models of seabird distributions at-sea using data from satellites may provide a cost effective approach for understanding and predicting seabird distributions at sea. Here we present data collected during seasonally and annually replicated Line P cruises (1996-2003), from the entrance of the Strait of Juan de Fuca (south-western British Columbia, Canada: 48.5° N, 124.4° W) to Ocean Station Papa (subarctic North Pacific Gyre, 50° N, 145° W). Consistent cruise timing among years and standardized at-sea survey techniques facilitated long-term comparisons across different oceanographic domains. We correlated the distribution and abundance of select seabird species with oceanic fronts as determined by concurrent remote sensing data for sea-surface temperature (SST: AVHRR), and Chlorophyll *a* (Sea -WiFS), as well as, testing for the presence of fronts and other discontinuities using ship-board data collected during the cruises (*i.e.* CTD and surface CUDLS). We discuss the persistence of identified seabird-pelagic hot spot associations at different spatio-temporal scales, in the context of species specific foraging tactics and life history strategies.

PICES XIII S4-1977 Invited
Stomach contents of toothed whales in relation to prey distribution in the North Pacific

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Stomach content analyses of toothed whales in the North Pacific have revealed details of their feeding ecology. Information on prey species composition, size of prey and diet composition by mass is available. Some dietary studies of toothed whales used data of fish composition and size spectrum obtained from trawled samples to discuss prey-predator overlap and prey selection. Baird's beaked whales (*Berardius bairdii*) in the western North Pacific off northern Honshu, Japan are distributed along the 1000 m isobath in summer. They feed primarily on demersal fish, especially rat-tails. In this area, potential prey species varies depending on the bottom depth. Prey species composition in the stomach contents resembles that net samples taken from waters 1000-1300 m deep. In summer, short-beaked common dolphin (*Delphinus delphis*) in the western North Pacific feed mainly on *Ceratoscopelus warmingi* which is distributed along a front of the Kuroshio Current facing the subarctic boundary. The prey species composition in the stomach contents and that net samples are nearly identical. Dall's porpoise (*Phocoenoides dalli*) is a widely distributed subarctic species, and feeds mainly on myctophids although prey species vary geographically. Comparison of stomach contents of Dall's porpoises and trawl samples show crude consistency. These examples suggest potential correlation between distributions of toothed whales and their prey. Prey availability may be a factor determining distribution pattern of toothed whales.

PICES XIII S4-2143 Oral
Hot spots for dining – A groundfish's view

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A look at over 20,000 stomachs from Pacific Ocean perch (1,417), Atka mackerel (2,236), Pacific cod (6,153), and Walleye pollock (11,179) tell a story of diverse feeding habits, with step-like gradients along a longitudinal track. The sample covers the area between 170˚E and 166˚W, for the period 1982-2000; most stomachs were collected during summer. Results show that areas with the highest prey diversity do not necessarily match those where stomachs were the fullest. The areas do not match among species either. For example, while prey diversity in POP seems to increase around Buldir and at Seguam Pass, the opposite trend is observed in Pollock. For Atka, higher diversity was observed around Buldir and Tanaga Pass. For Pacific cod, the areas of lowest diversity Amchitka, Seguam and Amukta Pass coincide with those where stomachs were the fullest. The longitudinal trends in the feeding habits show euphasiids made up 50-90% of the diets of walleye pollock, Atka mackerel and Pacific Ocean perch east of Samalga Pass. In contrast, euphasiids generally made up less than 50% of the diets of these fish west of Samalga Pass. Copepods and myctophids dominated the remaining portion of the diets to the west. For cod, pollock were more common as prey items towards the east, while Atka mackerels prevailed towards the west. These changes in the diversity and availability of ingested preys by groundfish provide evidence for biogeographic boundaries such as Samalga Pass, and other potential ones further west, around Buldir Island.

PICES XIII S4-2046 Oral
Identifying biological hot spots within the northern California Current

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Understanding how marine animals utilize their environments and identifying important habitats is crucial for our continued understanding of oceanic ecosystems. This information will yield better-informed management decisions and have implications for the design of marine reserves. The goal of the present study is to identify biologically rich areas within the northern California Current and elucidate patterns of habitat use by species occurring within the areas. Sampling was conducted during June and August of 2000 and 2002 as part of the GLOBEC mesoscale surveys. Stations were sampled along both regular transects and also in areas of special biological interest extending from Newport, Oregon in the north to Crescent City, California in the south. At each station a CTD cast, surface zooplankton tow and pelagic nekton trawl were made and a chlorophyll sample collected. Given the high degree of spatial and temporal variability in the northern California Current, the goals of the study are to 1) identify regions of high levels of phytoplankton and surface zooplankton productivity, 2) identify regions of persistent high levels of surface zooplankton and nekton biodiversity, 3) identify dominant members and the structure of the nektonic communities within these regions, and 4) examine the habitat characteristics associated within these areas. To accomplish these objectives, the spatial distributions and abundances are examined using geostatistical analyses and GIS. Results will be presented.

PICES XIII S4-1897 Poster
Seamounts as hot spots of pelagic fish diversity in the Eastern Pacific Ocean

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Migratory pelagic fishes aggregate at seamounts because of greater opportunities to feed or because topographic features provide landmarks during migration. Such aggregation of diverse species reflects the potential of seamounts as vital marine protected areas and emphasizes our need to understand the role they play among Pacific fish populations. We integrate fisheries observation, underwater visual census, ultrasonic tagging, and diet analyses to examine how pelagic fish utilize seamounts in the southern Gulf of California. Fisheries catch data has been used to track species' seasonal migrations into the Gulf and arrival at seamount hot spots, while visual census has delineated distinct winter and summer fish assemblages at seamounts due to fluctuating sea temperatures. To further determine residence patterns at seamounts, twenty-three *Thunnus albacares* were ultrasonically tagged at Espiritu Santo Seamount in 1998. Two ultrasonic monitoring stations recorded tagged tunas swimming within their range of reception, and showed tunas stayed at this seamount for time periods ranging from 0 to 18 months. Monitors were redeployed in 2002 to investigate the residence of multiple species across trophic levels, and five *Caranx caballus*, five *Seriola lalandi*, and two *Sphyrna lewini* were tagged. Records of these species have shown short-term residence patterns that are currently being analyzed. We also use stable isotopes and gut contents to determine trophic structure and interactions among diverse pelagic species at seamounts and depict how resource utilization at seamounts compares with open ocean areas. Using these techniques, we have developed an effective method for analyzing ecological processes among pelagic fishes in complex seamount ecosystems.

PICES XIII S4-1815 Poster
Transport of fodder plankton in low-frequency waves and eddies: Favorable conditions for fishing grounds formation

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The distribution of plankton in dynamic systems is important both for fundamental biology and fisheries. Plankton distribution may confer information on of the relative value of fishing grounds. The process of plankton concentration in eddies and low-frequency waves is particularly interesting, as these features dominate formations on a synoptic scale. However, the role of eddies and waves in aggregating plankton is not clear.

Plankton is transported by currents; this process can be described as "transport of a passive impurity". Thus, on the one hand, cyclones have favorable conditions for primary production generation (due to upwelling of nutrients-rich deep water), but on the other hand, this new production is carrying out on periphery of these dynamic systems because of divergence of currents. In opposite, plankton concentrates in anticyclones due to convergence of currents.

In gradient-eddy waves, the divergence mode is replaced by the mode of convergence with period equal to the period of a wave. Therefore, waves may confer more favorable conditions for realization of trophic connections and, accordingly, more favorable conditions for formation of commercial fish concentrations.

We used analytical models of low-frequency waves and eddies (Belonenko *et al.*, 1998) to describe plankton distribution in dynamic formations. A simple analytical solution was not possible for distribution of plankton biomass in the case of moving bell-shaped vortex-like disturbance. However, numerical estimations allow to us to conclude that plankton concentrates on the back slope of low-frequency waves, in the rear part of a moving anticyclonic eddies, and in the forward part of a moving cyclonic eddy. These dynamic formations are well identified on satellite altimetery maps. The application of determining plankton and fish concentrations with altimetry maps is discussed.

PICES XIII S4-1989 Oral
Using GIS to locate pelagic hot spots for bluefin tuna

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Using sample data from a previous study on the relationship between bluefin tuna and sea surface temperature (SST) fronts, we used model output to document previously unknown good-habitat areas in the Gulf of Maine, Northwest Atlantic Ocean. To locate these ephemeral habitat envelopes, we used the relationship between tuna presence and the following environmental variables: SST, distance to SST fronts, kernel-smoothed density of SST fronts, bottom depth, and slope. To quantify this relationship between bluefin tuna presence and oceanographic features in the Gulf of Maine, we fit a Generalized Linear Model (GLM) to the data using a logit link to our presence-absence data set grouped together across all years. The full model was run through a stepwise selection procedure using Bayes Information Criteria as the penalty criteria. Using raster processing with the GIS, we mapped spatially explicit raster cells that satisfy conditions of the GLM. Once located, we used GIS to further document the persistence of these features by calculating the ratio of how many times a cell was a habitat cell to how many times it was an absence cell. Using the output, we explore events at multiple spatial and temporal scales, and note how the method is scale and location independent. Though the results are specific to the Gulf of Maine, the techniques can be easily applied to other pelagic systems.

PICES XIII S4-2097 Invited
An oceanographic basis for identifying biological hot spots

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Marine predators, including large pelagic fish, marine mammals, sea birds, and fishing vessels, recognize that fish and other organisms congregate at ocean fronts and other features. Thus biological hot spots in the ocean are likely created by physical processes and have distinct physical signatures. Until recently, however, our understanding of the relationship between physical ocean structure and the distribution and behavior of large pelagics was largely limited to anecdotal reports and opportunistic sampling. The technologies of biologging and remote sensing now provide continuous basin-wide coverage of ocean conditions, and specifically the physical characteristics of the hot spots that animals frequent. Instrumented tags allow for animals to be tracked spatially and temporally, and provide a high-resolution record of their environment. Changes in their behavior can be correlated to changes in physical conditions, thus giving clues about the oceanographic basis for hot spots. Animal tracks can be mapped upon images from multiple satellites that provide information on ocean structure, circulation, and production, which collectively define the attributes of biological hot spots. Our approach is to identify candidate hot spots based on the physical attributes of the areas where tagged animals aggregate or change behavior, then conduct a hot spot "census" of satellite fields. The results of this analysis will be compared for different species (*e.g.*, tuna, elephant seals) to differentiate the preferred pelagic habitats and hot spots of each species.

PICES XIII S4-2058 Oral
Foraging destinations of short-tailed albatrosses (*Phoebastria albatrus*) in the Northwest Pacific Ocean, Gulf of Alaska, and Bering Sea

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We used satellite transmitters and oceanographic remote sensing data to determine the distribution, movement patterns, and characteristics of foraging areas of short-tailed albatrosses during May to November 2002 and 2003. Transmitters were deployed on birds immediately prior to their final departure from the breeding colony at Torishima (n = 11), or after capture at-sea in the Aleutian Islands (n = 3), and thus represent non-central-place foraging trips. Tracking durations ranged from 51 to 138 days for a total of 7,400 location fixes after filtering (131 – 954 locations per bird). Albatrosses ranged along much of the North Pacific rim above 30 degrees north latitude and most often remained over continental shelf break and slope regions at a median depth of 2030 m. High use areas in the western Pacific basin included productive waters of the Kuroshio and Oyashio current regions off Japan, and the Kurile Islands, Russia. In the Aleutian Islands, birds most often occurred within straits, particularly along the western part of the chain (*e.g.*, Near Strait, Buldir and Seguam Passes), and in the Bering Sea, they occupied waters along the northern continental shelf break (200 m depth) and the Kamchatka Currrent region. These results indicate that non-breeding short-tailed albatrosses concentrate their activities in oceanic areas characterized by specific bathymetric and hydrographic features.

PICES XIII S4-2060 Poster

Wing loading and prevailing winds: Their relative importance to the at-sea distribution of four species of Pacific albatrosses

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The four species of albatrosses that inhabit the Central and North Pacific Ocean exhibit markedly different distributions at-sea. The short-tailed albatross (*Phoebastria albatrus*) nests in the northwest Pacific within close proximity (< 500 km) to the continental margin and productive feeding grounds of the Kuroshio Current region. The waved albatross (*Phoebastria irrorata*) in the equatorial, eastern Pacific, travels moderate distances (< 1,500 km) from its nesting area in the Galápagos Islands to the adjacent feeding grounds within the Humboldt Current region. In contrast, the Laysan albatross (LAAL, *Phoebastria immutabilis*) and black-footed albatross (BFAL, *Phoebastria nigripes*) travel over large expanses of open ocean (> 3,000 km) when foraging along continental shelf regions of the California Current and Alaska Current systems. In addition to differences in proximity to continental margins, these four albatrosses also differ morphometrically, with the two smallest species nesting furthest from productive coastal regions, indicating potential adaptive significance to body size and flight energetics. We obtained measurements of body and wing morphologies pertinent to flight performance and calculated power curves and glide polars based on equations of mechanical flight. Preliminary results indicate that wing loading (body mass/wing surface area) varies up to 30% among species, resulting in up to 20% differences in minimum sink and best glide velocities (the two smallest and furthest ranging albatrosses, LAAL and BFAL, being most similar in all measures). We hypothesize that these differences in flight mechanics may be important in navigating prevailing wind systems within the respective foraging ranges of the four albatross species.

PICES XIII S4-1787 Oral

Seasonal frequency of pelagic fish species in some micro-regions of the southwestern Okhotsk Sea

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The frequency of eight pelagic fish species in three micro-regions of the southwest Okhotsk Sea was considered. I conducted investigations in a zone of deep water near southeast Sakhalin from July – early November, 1999. The maximal frequency was observed for walleye pollock (*Theragra chalcogramma*), minimal – for Pacific lancetfish (*Alepisaurus ferox*). Large concentrations of Japanese anchovy (*Engraulis japonicus*) and saury (*Cololabis saira*) were observed in August and September. On the whole, seasonal peaks of different pelagic fishes were found. Characteristics of species catches and biological parameters of fishes are presented, as well as data of the seasonal occurrence of marine mammals and seabirds and water surface temperature in the study area. The highest frequency and maximum duration of pelagic fish species occurrence were observed in the northwest micro-region, an area characterized by higher biological productivity in general.

PICES XIII S4-1797 Poster
Zone of "hot spots" of the surface temperature for the NW Pacific

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The NW Pacific is a unique and specific area for investigating complex thermodynamic processes. A major component – ocean surface temperature is a key parameter for models and experimental studies. The main objective is to study the peculiarities of thermodynamic structures in the region. We used regional data archives of the Meteorological Agency of Japan for the period 1960-1985 to evaluate thermodynamic processes. Our focus is an analysis of the ocean surface temperature anomalies as the major characteristics predetermining the dynamics of the temperature background in the NW Pacific.

On the basis of the archived data, the following quantitative characteristics were calculated: the ratio of the area of positive anomalies of the ocean surface temperature to the total area of the region - S_{+a} %; the ratio of the area of the most heated waters (>3^0C) to the total area of the region - $S_{a>3}$ %; maximums of the temperature anomalies (extremums) - T^0_{am}. As a result, it is ascertained a quasi-stationary zone of the most heated waters located in the band of 36^0-46^0 N to the east of 140^0 E. That confirms a stationary state of the main source of the exceeding heat energy in the considered study area.

Consequently, the NW Pacific is a region of the increased temperature background and considerable energy where the temperature of the ocean surface is the main indicator of its thermodynamic processes.

PICES XIII S4-2071 Oral
The effects of ENSO events on California chinook salmon (*Oncorhynchus tshawytscha*) as revealed by scale increment analysis

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We correlate the strength of El Niño - Southern Oscillation (ENSO) events, regional upwelling, and sea surface temperatures to growth patterns in scales from returning ocean-type chinook salmon, *Oncorhynchus tshawytscha*, from California, U.S.A. waters collected over a more than 20 year period. Additionally, to determine the effects of environmental variation on early growth we examined increment patterns from a collection of scales from estuarine resident juveniles collected over 15 years. The impact of ENSO events at larger and regional scales is apparent on the growth patterns during estuarine residence and while at sea with obvious reductions in growth occurring during ENSO years. The effects of the ENSO event of 1982/83 were particularly dramatic. These negative impacts affect fish of any given age and may have a bearing on early mortality, return size, and age at maturation. Our approach of examining the effects of large and regional scale events across years, and hence distribution, is an essential step for proper adaptive management.

PICES XIII S4-2073 Oral
Chlorophyll hot spots in the oligotrophic North Pacific Subtropical Gyre

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Satellite observations of sea surface chlorophyll show that large blooms of phytoplankton sometimes develop in late summer in the oligotrophic North Pacific Subtropical Gyre near 30°N and between 130°-160°W. These blooms have been observed by multiple ocean color satellite (CZCS, OCTS, SeaWiFS and MODIS). The blooms do not occur every year; they have been observed in nine of the fifteen years of available ocean color data. The largest

blooms covered more than 350,000 km^2 and lasted as long as 4 months. They are distinct from the surface seasonal cycle of chlorophyll in both timing and amplitude. The blooms are not associated with either SSH or SST anomalies indicative of changes in subsurface structure, nor do they appear to be forced by nutrient fertilization from dust deposition or rainfall. These blooms are compared with phytoplankton blooms that have been previously observed in this region by *in situ* studies, and the potential causes for them are discussed.

PICES XIII S4-2206 Poster
Backscatter variability within a Haida Eddy

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Haida Eddies are known to carry productive coastal waters into the HNLP area of the North Pacific and Gulf of Alaska. Satellite images of surface chlorophyll levels often show distinct annular banding of pigment content along sea surface height contours, especially as the eddies are forming. A set of transect lines through a recently-formed 2004 Haida Eddy also shows evidence of a similar banding in the acoustic backscatter data, probably due to zooplankton biomass density variations. This observation is investigated over the width of the eddy for both spatial and depth variations, and in addition to the satellite imagery, is compared to geostrophic and ADCP-derived current estimates, and to net tow estimates of zooplankton abundance.

PICES XIII S4-1940 Oral
Detection of high productive area of albacore fishing ground and migration route using multi-sensor satellite remote sensing

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We linked remotely sensed data from multi-sensor satellite images of sea surface temperature (SST, TRMM/TMI), sea surface chlorophyll concentration (SSC, SeaWiFS) and sea surface height anomalies (SSHA, AVISO grid data) with fisheries catch to analyze dynamics of albacore. We investigate albacore fishing ground formation, migration routes, and impacts of El Niño 1998 and La Niña 1999 on albacore fisheries in the northwestern North Pacific. We observed that fishing grounds tended to form near the anticyclonic eddy and fronts around the Shutsky Rise, an area known as a "hot spot" in November 1998 and 2000. In November 1999, when the eddy formation around the area appeared to be weak, the fishing grounds shifted to frontal regions near the Kuroshio Extension (KE). These fronts were indicated by the confluence of two contour lines of 20°C SST and 0.3 mg m^{-3} SSC. The north-south migration route of the fish seems to be associated with the dynamics of these isotherms, particularly in winter (November-March). It is likely that the formation of the fishing grounds and migration route for albacore were strongly related to eddies and front formation. During the first half of 1999 (a strong La Niña period), formation of fishing ground appears more developed than during El Niño period (the first half of 1998) near the meeting of the contours where fronts were likely formed well particularly near the southern edge of KE (31-34ºN and 160-175ºE). As a result, CPUE was higher during La Niña than El Niño period.