PICES XIII FIS_P-1814 Poster
Modeling analysis for multispecies fisheries

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Multispecies fisheries create a challenge to rationally achieve catches of individual species. The TINRO-Centre developed an approach to analyze and forecast multispecies fisheries using mathematical models. Total allowable catch (TAC) is defined for every species separately, but the fisheries forecasts involve combined species. Here, we describe the mathematical models used for analysis of multispecies fisheries. The first model estimates the Real Catch (RC) as opposed to TAC. Also, we can use this model to analyze the dynamics of the community. The TAC for a species is the assigned catch for this species, whereas RC is calculated on the basis of data on actual multispecies catches. A comparison of RC with TAC allows estimation of the effect of the illegal catches. The problem associated with realization of the TAC is solved in the second model. We calculate the TAC based on catch volume and estimates of RC. This is an optimization procedure in mathematical sense. We look for TAC and RC to agree as closely as possible. This approach can be applied to a defined ocean region for which information about specific composition of catch is available. Data must be averaged over several years.

PICES XIII FIS_P-1820 Poster
Effect of the artisanal shrimp fishery on the ichthyofauna in a subtropical coastal lagoon in the Gulf of California

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The likely effects of the artisanal shrimp fishery on the fish fauna in the Santa Maria la Reforma coastal lagoon, Mexico, were assessed. Twenty-nine stations were sampled for shrimp and fin fish monthly for 6 months, from December 2001 to May 2002, from small boats fitted with outboard engines and the three fishing methods used by the shrimp fishery in the area: a small otter trawl, a gillnet, and a cast net trawl. Each sampling period lasted five days. In total, 11,368 individuals were caught comprising 173 fish species. The species most represented in terms of numbers and biomass included the commercially important species *Eucinostomus entomelas, Sphoeroides annulatus, Urotrygon chilensis* and *Diapterus peruvianus.* The highest abundance and biomass, as determined with the log- normal-based estimator, was caught with the otter trawl. The mean total length of the fish captured was 17.5 cm, but most of the fish were between 14 and 23 cm. The fishing methods in the shrimp fishery that are likely to have the greatest effect on the fish fauna are the otter trawl and the gill net, since in this study they were the methods that caught the highest abundance, biomass and diversity of fish as well as a high quantity of small individuals. These two fishing methods caught fish fauna from the bottom and from the water column, and were the methods that showed the lowest ratio of shrimp biomass to fish biomass caught. The otter trawl caught up to 15.0 kg of fish per kg of shrimp, and the gill net caught up to 69 kg of fish per kg of shrimp.

PICES XIII FIS_P-2107 Oral
Differential food habits as a mechanism for seasonal and geographic variation in juvenile walleye pollock condition in the western Gulf of Alaska

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A large amount of scientific interest exists for walleye pollock, *Theragra chalcogramma*, due to their commercial and ecological importance in the North Pacific Ocean. In temperate waters, over-winter nutritional stress can be a significant source of mortality for juvenile fish, particularly in the first year of life prior to substantial accumulation of energy reserves. In this study, diets of juvenile walleye pollock from the 2000 year class were examined

seasonally in relation to body condition (weight-at-length and whole body energy density). Pollock diets consisted primarily of euphausiids, copepods, larvaceans, larval crabs, and cumaceans, varying by season and area. During the winter, mean stomach fullness decreased and euphausiids were compositionally less important as prey. These dietary changes coincided with decreases in length-specific weight and whole body energy content from fall (2000) to winter (2000/01), suggesting that nutritional stress contributed to decreased condition. Geographically, pollock off of eastern Kodiak Island tended to be more robust with higher energy densities than fish near the Semidi and Shumagin Islands, corresponding with larger amounts of energy-rich prey, such as copepods and euphausiids, in their diets. Seasonal variation in juvenile pollock diet and condition exists, but its effect on nutritional stress, and perhaps fish survival, during winter might be tempered by geographic variation in prey resources.

PICES XIII FIS_P-1976 Oral
Pollock fishery and total allowable catch in the Bering Sea

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The walleye pollock, *Theragra chalcogramma,* is one of the most important fished species in the world. Maximum catch in the Bering Sea exceeded 4 million tons in 1988. The main fishing grounds are located in the southeastern Bering Sea and in the Navarin area. Average catch for these two areas was 0.8 million tons and 0.5 million tons, respectively, during 1979-2003.

The fishery management system is based on annually estimated Total Allowable Catch (TAC), which depends on fishable stock biomass and exploitation rate (US and Russian Federation EEZ). Stock assessment research involves several different methods: ichthyoplankton surveys (western area, KamchatNIRO), acoustic and trawl surveys (all areas), and modeling approaches (all areas). In the Donut Hole the pollock fishery is regulated by the Convention on the Conservation and Management of Pollock Resources in the Central Bering Sea. Since 1993, fishing has been prohibited in this area.

Knowledge of pollock stock structure and intermixing is still largely incomplete. Practical approaches are necessary to study this problem. Data from ichthyoplankton surveys in the Bering Sea reveal two ecological spawning groups (winter and spring). Six spawning grounds (Bogoslof-1, Pribylof-2, Aleutian-1, Kommander-1, Navarin-1) are located beyond the shelf area in February-March. Eggs and larvae from these areas usually drift to the outer shelf. Spring spawning is associated with the middle shelf zone. Eggs in early stages of development are concentrated in 14 relative separated aggregations (Unimak-1, Bristol-1, Pribylof-2, St.Mattew-1, Anadyr-1, Navarin-2, Dezhnyov-1, Olyutorskyi-1, Karaginskyi-1, Ozernoy-1, Kommander-1, Aleutian-1). On the other hand, genetic methods have identified only 3-5 stock units.

A second problem concerns the precision of stock assessment methods. The power of each method should be tested. There is a need to optimize methods for analysis of stock assessment. A third problem concerns the magnitude of the exploitation rate. How should the fishery be managed, when stock biomass reaches high or low levels?

PICES XIII FIS_P-1776 Poster
New data on walleye pollock spawning in waters of the Commander's Islands Preserve

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The off-shore waters around the Commander's Islands have been characterized as highly abundant of a number of fishery objects (walleye pollock, pacific cod, shortspine thornyhead, Atka makrel, Commander's squid, ect.). High biological production of the waters caused forming large rookeries of northern fur seal and sea-lion, and aggregations of sea otter and colonial marine birds. Since 1975, fishery restricted thirty-mile zone had been set

around the islands. In 1993, there was created National Commander's Marine Preserve in order to protect biological diversity, genetic fond of flora and fauna.

Walleye pollock population has been suggested to inhabit the waters around the Commanders, although the data concerning the population are rather scarce. Last studies of Commanders walleye pollock relate to 1988-1989; on assigning the area to be a preserve the studies of walleye pollock have been stopped.

In 2001, ichthyoplankton and hydrological surveys have been carried out around the islands which indicated large-scale spawning of walleye pollock occurring around the Commanders. The obtained data allow to estimate conditions and features of spawning of the Commanders' walleye pollock. It has been found that spawning takes place in April-May at the shelf area between Bering Island and Medny Island in the warm Pacific Ocean waters and cold Bering Sea waters mixturing zone. Results of egg abundance estimation indicate current growing Commanders' walleye pollock abundance it being compared to that in 1980.

PICES XIII FIS_P-2190 Poster

Study on dynamic of fisheries resources and protection countermeasures in adjacent waters of Jiuduansha

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Adjacent water of Jiuduansha is a part of Changjiang (Yangtze River) estuarine area, where is a traditional fishing ground with high productivity. A great number of runoff with containing abundant nutrients from upper-steam of Changjiang goes down to Estuary of Yangtze River each year. It provides living nutrient basis for abundant fisheries resources. More than 100 species of fishes were recorded. On other hand, it is a habitat of many crustaceans such as shrimps and crabs. Up to now, some key species of economic fishes and crabs have been monitoring since 1997. They are *Coilia nasus* Temminek et Schlegel (long-tailed anchovy), *Coilia mystus* Linnaeus (estuary tapertail anchovy), *Hemisalanx prograthus* Regan (noodlefish), *Tenualosa reevesii* Richardson (Hilsa herring), *Eriocheir sinensis* H. Milnin Edwards (Chinese Mitten-handed crab), *Anguilla japonica* Temminck etschlegal (Japanese eel), *Acipenser Sinensis* Gray (Chinese sturgeon) *etc.*

PICES XIII FIS_P-1800 Poster

Composition and changeability of the fish community of the central seamounts of the Kyushu-Palau Ridge and some oceanographic features (Part II)

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Chaotic processes usually occur in excited oscillating systems (Nikolis G., Prigogin I., 1990; Shuster G., 1998) and they are produced by the interaction of a different range oscillations and their mixing. During last thirty years investigations showed that chaotic systems are common and may predominate in different processes of nature and society (Eremin, 2004).

As marine ecosystems are multi-component aggregations in which nonlinear phenomena are a typical, their chaotic processes are also typical as determinate processes. When energy of a system is increasing, chaotic processes occur. Chaotic and determinate structures can exist together. Seamount ecosystems provide a good example of the existence of both.

However, cycles estimated for the baroclinic layer do not reveal all oscillations above seamount summits. Near seamounts significant changes in current velocity are observed (Darnitsky, 1980; Gamsahurdia, 1990).

V.N. Zyryanov (2003) theoretically proved that, in the two-layered water column above seamounts, lens-shaped eddies should occur due to baroclinicity and velocity shift coorative processes (BVSCP), which do not penetrate the surface layer unlike usual eddies. Consequently, they can be investigated only by sounding the water column above seamount summits. Oceanographic surveys represent lens-shaped eddies as an increase of deep-water tracer concentration. Tracers are biogenic elements in intermediate layers with a lens-shaped distribution.

The layer of minimal salinity (500-600 m horizon) is influenced strongly by subsurface dynamics caused by the occurrence of summits at these depths. This is the reason for higher frequency oscillations of thermohaline features and other characteristics that affect different components of ecosystem. Thus, we cannot assess other stochastic processes in intermediate layers. As a result, the behavior of ecosystem components is more complicated in the vicinity of seamounts.

Some chaos induced in seamount ecosystems by fluctuations at different scales can have positive effects. For instance, theoretically, these ecosystems are insensitive to damage by anthropogenic influences. Nonetheless, cases of adverse effects of harvest on such seamount ecosystems, such as the Hawaiian and Emperor Ridges.

PICES XIII FIS_P-2170 Poster
Trophic relations of chum (*Oncorhynchus keta)* and pink salmon (*O. gorbuscha*) in the western Bering Sea

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The feeding ecology of chum (*Oncorhynchus keta*) and pink salmon (*O. gorbuscha*) in the western part of the Bering Sea was investigated during summer of 1993, 1995, and 2003. In the course of these long-term investigations it was established that diets of chum and pink salmon are very flexible. Salmon fed on diverse prey such as fishes, squids and plankton. Depending on conditions in each specific region, they can easily switch from one prey to another. Chum salmon diet varies significantly with body size. Smaller (< 40 cm) fish prey mainly on amphipods, whereas larger (>40 cm) fish prey mainly on jellyfish, ctenophores and fish. Diet compositions of larger chum salmon were quite similar in 1993 and 1995, but differed in 2003 when tunicates were one of the main prey items. Fishes, squids and euphausiids dominated the diet of pink salmon, occurring in over 50% of the stomachs that contained food. In summer 2003, pink salmon consumed many decapods in this region. These observed differences in diet composition of chum and pink salmon are statistically significant.

PICES XIII FIS_P-1822 Oral
Temperature-dependent stock-recruitment model for walleye pollock around Hokkaido, Japan

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Around Hokkaido, Japan, there are four walleye pollock populations including the Japanese Pacific population (JPP) and the north Japan Sea population (JSP). It is known that the stock fluctuations of JPP and JSP are mainly caused by recruits of strong year classes. To clarify the mechanism determining recruitment, we investigated the relationship between recruitment (R), spawning stock biomass (SSB) and sea surface temperature (SST) for JPP and JSP. First, we assumed three different types of stock-recruitment models (SRM): no relation model ($R=\alpha$), density-independent model ($R=\alpha SSB$) and Ricker model ($R=\alpha SSB\exp(-\beta SSB)$), where α and β are coefficients. Then, we correlated the residuals from these SRMs (log transformed) with monthly SST during the pelagic phase. In JPP, the residuals from all SRMs showed a high positive correlation with SST in February and a negative correlation with that in April. On the other hand, the residuals from all SRMs for JSP represented a strong negative correlation with SST in February and a positive correlation with that in summer. Finally, we developed the temperature-dependent SRM (TDSRM) by incorporating these SSTs as a predictor variable: no relation TDSRM ($R=\alpha\exp(\gamma SST)$), density-independent TDSRM ($R=\alpha SSB\exp(\gamma SST)$) and Ricker TDSRM ($R=\alpha SSB\exp(-\beta SSB+\gamma SST)$), where γ is a

coefficient. The model comparison using AIC indicated that the optimal model for JPP is no relation TDSRM with SST in February and April, and that for JSP is density-independent TDSRM including SST in February. These findings suggest that the recruitments of JPP and JSP are affected by environmental factors rather than density dependent factors.

PICES XIII FIS_P-1922 Poster

Estimation of catch efficiency of salmon gillnets, distance traveled by salmon, and salmon density in the Bering Sea

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Gillnets are one of the major fishing gears used for salmon fisheries both in offshore and coastal waters. Catch efficiency of a gillnet is defined as the proportion of the number of fish caught to the number of fish in the effective fishing area. The effective fishing area is defined as a product of the length of gillnet and the distance traveled by the fish during the time between set and haul of the gillnet. Fish density is defined as the number of fish per unit area in the effective fishing area. The catch efficiency of a salmon gillnet, the distance traveled by the fish, and the fish density were estimated based on the catch data of three gillnets set in parallel configuration in the Bering Sea in June-July, 1985-1987. The average catch efficiency was 0.60 for sockeye, 0.54 for chum and 0.81 for pink salmon. The average distance traveled was 5.9 km for sockeye, 5.1 km for chum and 16.2 km for pink salmon. The average density of fish was 5.1 fish/km^2 for sockeye, 50.3 fish/km^2 for chum and 16.5 fish/km^2 for pink salmon. Differences in these estimates are discussed based on the biological features of each species.

PICES XIII FIS_P-2025 Poster

Prediction of Pacific saury fishing grounds based on physical variability derived from daily satellite remote sensing data

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This study investigates the influence of the Oyashio front on saury fishing grounds and estimates daily saury fishing grounds in the northwestern North Pacific using daily satellite remote sensing data. Saury fishing grounds were defined as vessel fishing positions estimated from nighttime images of the Defense Meteorological Satellite Program (DMSP) /Operational Linescan System (OLS). The SST gradient, the Oyashio front and warm core rings were identified by NOAA/AVHRR MCSST data and TOPEX/ERS-2 altimeter maps. The distances between saury fishing grounds and the Oyashio front were calculated in order to investigate effects of the Oyashio front on saury fishing grounds. Calculated distances show large fluctuations, for example, the maximum distance was 60 km in 2001 and 130 km in 2002. A major finding of this study was that the spatial and temporal variability of saury fishing grounds were strongly affected by variability of both these distances and the SST gradient. This suggests that it is the presence of these physical features that may effect the formation of saury fishing grounds. Our study contributes to understanding the role of the Oyashio front in saury southward migration and prediction of daily saury fishing grounds.

PICES XIII FIS_P-2152 Poster
Status of Far Eastern Pacific salmon stocks during recent years (1971-2002)

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Official statistical data on catch, adult escapement and average body weight have been examined by principal spawning areas in the Russian Far East for each of five commercial species of Pacific salmon: pink, chum, sockeye, coho and chinook salmon. Stock abundance dynamics have been analyzed, and results of hatchery production in some regions and features of commercial use of the species have been considered.

PICES XIII FIS_P-2021 Poster
The variations in distribution, catch, and biology of skipjack tuna (*Katsuwonus pelamis*) induced by climate variability

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The distribution and catch of skipjack tuna was investigated to reveal the relationship between tuna populations and ocean conditions affected by climate patterns such as El Niño. Catch and effort data on skipjack tuna in the Western Central Pacific Ocean during a specific period was grouped by geographic area (5°×5° for SPC data, and 1°×1° for NFRDI data), and some biological information was collected from the Korean purse seine fisheries starting in 1993. The examination of GSI indicated that there was no clear seasonal periodicity intra-annually, though the changing patterns of males and females generally matched. The change in main fishing grounds was calculated to detect the effects of El Niño. The main fishing ground was formed near 176°W in 1997, moving to 163°E in 1998, reflecting the effect of the 1997/98 ENSO event. Higher catches in 1995 and 1998 were reported after strong El Niño events with a time lag of about 12 months, and relatively high values of condition factor also appeared in 1994-95 and 1997-98. Length frequency information, from SPC and NFRDI data, will give clues towards understanding growth processes given a time lag, and the result might be applied to predict the future biomass of skipjack tuna.

PICES XIII FIS_P-1896 Poster
Effect of the Kuroshio frontal eddy on the recruitment of jack mackerel larvae and juveniles in the Bungo Channel, Shikoku, Japan

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Bungo Channel, located between Kyushu and Shikoku, is a representative semi-enclosed coastal sea in southern Japan. With the exception of a few river discharges into the channel, its marine environments are mainly influenced by oceanic disturbances. A prominent phenomenon, named as *"kyucho"*, is most influential among these disturbances; a *kyucho*, which means a sudden strong current in Japanese, is an intrusion of warm water from the Pacific. It has been observed through long-term monitoring of water temperature in the Bungo Channel; the *kyucho* occurs when a cyclonic frontal eddy derived from the Kuroshio frontal wave is propagated from southwest of Shikoku between spring and neap tide. Time series of sea surface temperature images also demonstrate that the cyclonic frontal eddies make the Kuroshio warm waters intrude along the east coast of the Bungo Channel as the Kuroshio axis approaches the cape of Ashizuri southwest of Shikoku. Size-frequency distributions of daily jack mackerel (*Trachurus japonicus*) landings from 1985 to 2001 indicated recruits (which start to appear in April) became the target of jack mackerel catches until September along with existing local populations within the Bungo Channel. Furthermore, individuals with the smallest body length appear earlier in the southern region than in the

central region of the Bungo Channel. Coincidence of the appearance of the individuals with the *kyucho* support the hypothesis that the recruitment in April is largely derived from offshore.

PICES XIII FIS_P-1836 Poster
Changes in the composition of demersal fish communities on the western Kamchatka shelf under the influence of fishing

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Until "Rybolovstvo" was applied in 1996 it was nearly impossible to monitor changes in demersal fish communities and to assess fishing intensity by area. We analyzed data on fishing intensity on the western Kamchatka shelf over 1997 to 2003 and data from trawl surveys from 1996 to 2003. We document persistent growth of fishing intensity from 1997 to 2003. In 1996, the dominant demersal fish species on the shelf of western Kamchatka were flounders (73%), followed by Pacific cod and saffron cod (16.6%), and sculpins (7.6%). The primary flatfish species was yellowfin sole, the most abundant (about 50%) sculpins were the great sculpin, and banded and yellow Irish lords. Fish stock assessments in 2003 revealed a decrease in the biomass of flounders (39.7% of the demersal fish community on the shelf of western Kamchatka); the dominant flatfish had become Bering flounder. Also, the new dominant sculpin was purple gray sculpin. We suggest that increased fishing intensity caused these changes in the composition in the demersal fish communities on the shelf of western Kamchatka within the period of observation.

PICES XIII FIS_P-2103 Poster
The stock assessment and fishery of walleye pollock in the Sea of Okhotsk off West Kamchatka

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Stock assessment surveys of walleye pollock were conducted on their spawning grounds off West Kamchatka in 1996-2001. A rapid decline of biomass occurred in 1996-1998. By 1999, the decline still continued but at a slower rate. In 2000, biomass began to increase and the increase developed further in 2001-2003. During the period of investigation, there were significant changes in the environment, fish community structure, and biological condition of the pollock stock. In 1996, pollock constituted about 97% of trawl catches by weight, but by 1997, the percentage of pollock fell to 72%. In the next two years, there was an increase in percentage of pollock. In 1996-1999, the catches consisted mainly of pollock of older age groups. In 2000, the age composition shifted due to the predominance of fish from the 1995 year class and younger. Rather large concentrations of young fish were estimated in 2001. This rise of biomass was associated with the appearance of a large 1997 year class. In 1996-1997, the maximum number of pollock was observed in March during the period of mass spawning. In subsequent years, the largest concentrations were observed in April. Also, significant changes occurred in bathymetric distribution. The future status of this pollock stock depends on whether pollock juveniles and adults can be conserved under intense exploitation.

PICES XIII FIS_P-1937 Oral

Predictability of future recruitment by parametric and non-parametric models: Case study of Gulf of Alaska walleye pollock

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Prediction of future recruitment is a critical task in fisheries science, providing probabilistic projections of fish populations and reference information for management decisions. The difficulty of the task lies in the inherent high variability of recruitment, lack of theoretical development, inadequate length of time series, and inability to meet the required assumptions. Recruitment of stocks can be modeled as a function of environmental variables using parametric and non-parametric statistical methods. A benefit of using parametric methods is the ability to test statistically the significance of variables, while non-parametric methods can cope with the non-linearity of data and be free from rigid statistical assumptions that often don't pertain to fisheries data. This study examines the utility of several different parametric and non-parametric methods for recruitment prediction. Parametric methods tested are multiple regression and generalized Ricker models; nonparametric methods are generalized additive models (GAM) and artificial neural networks (ANN). Data from the Gulf of Alaska walleye pollock (*Theragra chalcogramma*), which span 1961-2001, are used for the analysis. Variables examined consist of recruitment and spawning biomass as well as various environmental indices, including sea surface temperature, wind mixing, precipitation, and Pacific Decadal Oscillation. The first segment (35 observations) of each data series was used to construct the various parametric and non-parametric models, and the last segment (6 observations) was reserved to test the predictive capability of the constructed models. This study demonstrates that combining the merits of both modeling approaches would improve recruitment modeling and prediction.

PICES XIII FIS_P-2013 Poster

Influence of commercial fishing on the stock conditions of Pacific herring from the northern part of the Okhotsk Sea

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After the sharp decline in the biomass of Pacific herring (*Clupea pallasi*) in the Sea of Okhotsk to a low of 1.2 million tons in 1998, biomass increased owing to strong 1996-1997 year-classes of the Okhotsk and Gijiginsko-Kamchatsk herring populations. By 2001, the total biomass of herring exceeded 2 million tons; 0.5 million tons of this biomass was attributable to the Gijiginsko-Kamchatsk population. Based on data collected during a research survey in 2003, total herring biomass in the northern part of the Sea of Okhotsk was estimated to be about 3 million tons. Surveys conducted in 2001-2003 indicated that the herring in the Sea of Okhotsk are mainly comprised of fish from Gijiginsko-Kamchatsk population, which has almost no commercial fishery, and by fishes from the western portion of the Okhotsk population. Owing to heavy commercial fishing and poor year classes in recent years, the eastern portion of the Okhotsk population has declined and contributes a diminishing portion of the overall herring abundance in the region compared to earlier years. In our view, during the next few years (*e.g.*, 2004-2006) it is necessary to establish an allocation of the total allowable catch of Okhotsk herring in the fall-winter period into two components: east and west of 147° E longitude. This split should be allocated in such a way to shift effort from the east to the west with a goal to reduce fishing mortality and promote recovery of the eastern group of Okhotsk herring.

PICES XIII FIS_P-1950 Poster
Density dependent growth of sockeye salmon in the ocean

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It has been demonstrated earlier that in the Kvichak River, Bristol Bay, Alaska the average length of each major age class of sockeye salmon decreases 20 mm or more during peak years of abundance in the 5-year cycle. The same changes in average length occur also in the sockeye salmon in the adjacent streams, the Egegik and Ugashik Rivers. These studies are being expanded to include other streams like the Wood River in the Nushagak Bay and the Togiak River. If no changes are found in the average length of the important age classes in these rivers, density dependent growth must take place in coastal waters on the return migration. Otherwise, density dependent growth occurs during the entire ocean residence on the High Seas of the North Pacific Ocean and the Bering Sea. The average size of the most recent five-year Kvichak sockeye salmon cycle is the lowest in the past nine cycles and is less than 40% of the average cycle, and thus, the density dependent effect on growth to other stocks is not expected to occur.

PICES XIII FIS_P-1879 Poster
Acoustic methods for monitoring and ecosystem studies in the Bering and Okhotsk Seas

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The TINRO-Center conducts annual echo integration-trawl surveys of pollock and other fishes in the Bering and Okhotsk Seas with Simrad EK-500 scientific echo sounders. Powerful post-processing software and information technologies are keys to efficient extraction of information from the echosounder data and to increase the precision and reliability of survey results. The system for registration and processing of acoustic data, FAMAS (Fishery Acoustic Monitoring and Analyses System), has been used. FAMAS facilitates: visualization and accumulation of acoustic data in real time; secondary processing and analysis of acoustic images; organization and maintenance of a database of acoustic and biological measurements; and estimation of large zooplankton with a two-frequency algorithm. Processing of acoustic data is combined with the information from the biological database to provide estimates of biomass and numbers at length and age. FAMAS algorithms allow echosign assignment in mixed species situations and provide for characterization of spatial features throughout the survey area and water column. Annual echo integration-trawl surveys can be used to estimate current stock status and distribution of pollock and other fishes in the northwestern Bering Sea and Okhotsk Sea. Estimates were derived of abundance and biomass of pollock, spatial distribution, and interannual variability of these parameters in the northwestern Bering Sea and Okhotsk Sea in 1997-2003. Annual age composition, distribution and biomass of pollock in the northwestern Bering Sea vary significantly. Annual variability increased over time, especially since 1998 in association with a climate shift in the Bering Sea region. Also, spatial distribution and abundance of age-0 pollock, capelin and Arctic cod are presented. In 2003, experimental research was conducted to explore potential applications of acoustic technology to estimate salmon abundance during both phases of their migration in the Sea of Okhotsk and western Bering Sea, including Pacific waters of Kamchatka. Acoustic sounding data were collected on the vertical and horizontal distributions of salmon in upper epipelagic waters. Daily and seasonal differences in vertical distribution of salmon, associated with thermal structure of the water column, were identified. To investigate large zooplankton, a two-frequency algorithm was used to obtain information on spatial distribution and daily vertical migrations in the western Bering Sea. Our experience in the use of acoustic technology in ecosystem research of the North Pacific and marginal seas demonstrates that acoustic methods offer many advantages, in particular a continuity of echosign registration and an opportunity to estimate the vertical distribution of hydrobionts. These successes indicate that it may fruitful to pursue future development and application of these methods to study “hot spots” of biological activity in the North Pacific.

PICES XIII FIS_P-1853 Poster

The distribution and prevalence of Bacterial Kidney Disease (*Renibacterium salmoninarum*) in juvenile chinook and coho salmon in the Northeast Pacific Ocean

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In the summers of 2000 and 2002, we sampled juvenile salmon in the Northeast Pacific (Northern California Current) from northern Washington to central Oregon ("northern study area" NSA) and from southern Oregon to northern California ("southern study area", SSA) as part of an effort to better understand factors affecting juvenile salmon health and condition. Bacterial Kidney Disease (BKD: caused by *Renibacterium salmoninarum*) is a focus because the infection is known to be widespread in fresh water, the disease is typically chronic (spawning females pass the bacterium to their offspring), and mortality in hatchery and naturally reproducing salmon populations can be high. Using DNA amplification (PCR) to detect the pathogen in juvenile Chinook (*Oncorhynchus tshawytscha*) and coho salmon (*O. kisutch*), we determined that the prevalence of infection is consistently higher in the northern study region (54.3% compared to 4.4% in 2000) and that infection prevalence in both areas varies annually as well as spatially (28.1% were infected in the NSA in 2002, compared to 15.7% in the SSA). In both these years, the percentage of infected fish tended to decline from early summer to fall, suggesting that increased mortality may be occurring in salt water. Infection prevalences were similar for Juvenile coho and subyearling and yearling Chinook. The spatial discrepancy in infection by this common pathogen suggests that salmon populations in these areas are partially segregated, which has been confirmed by genetic analysis (allozymes), although no physical barrier separates these regions.

PICES XIII FIS_P-1823 Oral

Recruitment process of the Japanese jack mackerel in the East China Sea (ECS) - Spawning ground and larval transport into fishing grounds

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The Japanese jack mackerel (*Trachurus japonicus*) is one of the most exploited fishery resources in southern Japan, especially for large- and medium-sized purse seine fisheries. The shelf-break regions of the ECS are considered to be their primary spawning ground during winter to spring. To understand the mechanisms of year-to-year variation in jack mackerel recruitment, it is necessary to examine: (1) the population's primary spawning ground and season in the ECS, (2) larval transport into the nursery ground, and (3) jack mackerels' survival during early life stages. Based on catches of just-hatched larvae (< 3 mm notochord length), the principal spawning ground for jack mackerel is formed in the southern ECS south of 28°N; peak spawning occurred in February–March. In April, juveniles (10–30 mm standard length) were abundant off the west coast of Kyushu Island and the central ECS, north of 28°N where larvae of < 3 mm NL were rarely collected. Current systems, such as the Kuroshio and its branches, transport a large number of the eggs and larvae spawned and hatched in the southern ECS northeastward into the jack mackerels' nursery and fishing grounds off southern Japan. The relationship between abundance of small larvae (< 3 mm NL) in February–March and juveniles in April during 2001–2004 suggests that larval survival fluctuates highly from year to year. Relationships to wind and current features, and larval prey condition in the ECS are also discussed.

PICES XIII FIS_P-1995 Oral

Interannual changes in Pacific hake (*Merluccius productus*) growth in response to oceanographic conditions

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Annual as well as decadal changes in oceanographic conditions have been shown to affect the growth of various fish stocks in the Northeast Pacific Ocean. Understanding past environmental variations and their effects on growth can provide information to accurately estimate annual changes in biomass for improved management decision-making. We used sagitta otoliths of Pacific hake, *Merluccius productus,* and measurements of age and year specific annuli to construct a time series of annual growth. A general linear model (GLM) was first used to assess the variation among growth increments due to age, sex, the area where sample specimens were obtained and potential interactions. While there is a statistically significant difference between sexes, this is extremely small relative to other factors. Year was then added to the model and a strong age-year interaction was found. Previously documented differences among areas and between sexes validated the use of otolith growth increments as proxies for somatic growth. Further analysis suggested that young (age 1-2), intermediates (age 3-4) and adults (ages 5 and older) showed distinct annual growth trajectories. The least-square mean annual trend for each age group was found to respond significantly to environmental factors. A non-linear growth-at-age trend function was fit to the growth increment data and the residuals were then transformed to minimize heteroscedasticity. Using these two methods, the year-to-year variability was related to various time series of oceanographic conditions. The results from the two methods are presented and differences are discussed. These results indicate that annual growth-at-age in Pacific hake is not constant but can be influenced by environmental and/or oceanographic conditions. Forty-eight, 81 and 75 percent of the year-to-year variation in the least-square mean annual increment respectively for the three age groups can be explained by two or three environmental variables. Annual changes in growth can be used as benchmarks to help determine the age of the fish; records of environmental variables can provide pre-survey assessment of biomass as well as hind cast possible historic growth trends of the population.

PICES XIII FIS_P-1805 Poster

Environmental impact of interannual variability of Okhotsk Sea pollock abundance

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The pollock stock in the Sea of Okhotsk is one of the biggest in the North Pacific. Annual catches reached 1.5-2.0 million t in periods of high abundance. Multiyear studies have shown that the interannual variability of pollock abundance in the Sea of Okhotsk depends of natural biological causes. Physical oceanographic conditions – ice distribution, storm activity, temperature, salinity, current direction, eddy formation, and scale of egg and larval drift – have no direct influence on early life stage survival. Physical conditions only determine plankton community structure and general ecosystem functioning. Feeding conditions could influence the quality of pollock gonads and quite possibly on the survival of eggs and larvae. Feeding conditions were favorable in 1984- 1987 and unfavorable in 1997-1998. The length and age of spawning pollock also have no influence on year-classes strength.

Pollock larvae inhabit the mid-water column for a protracted length of time and the period of initiation of active feeding is most critical to larval survival. As rule, large pollock year-classes do not occur when plankton, especially copepods, are low or when predatory species predominate the plankton community, regardless of whether parental stocks are abundant and other oceanographic conditions are favorable. Successful copepod and euphausiid reproduction in the pollock spawning area provides for good larval survival and strong year-classes.

Pollock larvae predominate the ichthyoplankton community in the Okhotsk Sea, so they do not compete for food with other species. Growth rate of pollock larvae is significantly lower and mortality is higher in areas of very high concentrations due to density dependence. As a result, there is no relationship between pollock spawning stock abundance and year-class strength.

PICES XIII FIS_P-1953 Poster

Variability in sex ratio of the northern Okhotsk Sea walleye pollock spawning stock in 1997-2002

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Walleye pollock spawning stock dynamics in the northern Okhotsk Sea in 1997-2002 was provided by alternating cohorts with different productivity, which resulted in significant variability in sex ratio. Strong 1995 and 1997 year-classes that entered the spawning stock, and strong 1988 and 1989 year-classes that left the stock caused the observed pattern of variability. In the first case, earlier maturation of males compared to females led to a sharp, significant increase in their share among sexually mature fish. In the second case, rather abundant large individuals, mostly females, exited the stock. This coupled to low abundance of recruits entering the stock at that same time, also resulted in increased share of males among spawners, though this increase was somewhat lower than in the first case. When the whole Okhotsk Sea area is considered, females outnumbered males in 1997 only, with estimated shares of 59.9% and 40.1%, respectively. Such a pattern was attributable to prevailing number of females in the 1988 and 1989 cohorts, and also to small year-classes entering the spawning stock in the early 1990s. In 1998-2000, when the stock stabilized at a low level, large-sized females from the 1988 and 1989 year classes were eliminated from the stock, and pollock from the 1994-1996 year-classes, already significantly depleted by commercial fishing, began entering the spawning stock. As a result, the percentage of males increased to 54.0-55.5%, and females declined to 44.7-46.0%. In 2001-2002, numerous first maturing males of the strong 1997 year class began entering the spawning stock, resulting in an increased share of males to 63.1-65.4%, and decreased share of females to 34.6-36.9%. Significant interannual variability in the sex ratio of spawners should be taken into account when estimating reproductive potential of the northern Okhotsk Sea pollock.

PICES XIII FIS_P-1873 Oral

Maturation of walleye pollock, *Theragra chalcogramma,* in the eastern Bering Sea in relation to temporal and spatial factors

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Walleye pollock, *Theragra chalcogramma*, are both ecologically and commercially important as the most numerous fish species and support the most valuable fishery in the eastern Bering Sea (EBS). Size at maturity is a critical parameter in the stock assessment to set annual total allowable catch. Pollock maturity has not been examined in the EBS since 1976, and possible interannual and geographic variation has never been considered. Our goal is to estimate correct maturity schedules for EBS pollock. Maturity data, fish lengths and macroscopic maturity stages were collected by Pollock Conservation Cooperative personnel aboard pollock trawlers during winter 2002 and 2003 across the EBS from a total of 10,197 pollock. Similar data were collected by NMFS scientists during hydroacoustic surveys from 1989 – 2002. Histological analysis of ovary tissue confirmed appropriateness of macroscopic staging. However, some pollock classified macroscopically as "developing" may mature in either the current or following spawning seasons. Therefore, our analysis was performed with two alternative assumptions: fish classified as "developing" were either considered immature or mature. Maturity rates were estimated with a logistic regression, and spatial and temporal patterns were identified using GIS. Geographic variability exists; fish mature at the smallest lengths north of the Pribilof Islands, perhaps due to cross-shelf differences in water temperature. Size at maturity varies interannually, as well. Possible links to climate indices, sea temperature, and

variability in age class structure were investigated. Our results should improve the accuracy of future stock assessments.

PICES XIII FIS_P-1809 Oral
Environmental differentiation of pollock reproduction in the Bering Sea

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Biological phenomena leading to wide spatial separation of pollock spawning grounds, coupled to high biodiversity, may favor reproductive success, consistent recruitment, and promote a stable role of pollock in the ecosystem of the eastern Bering Sea. These features contrast with the western Bering Sea where the spatial distribution of pollock spawning grounds and ecological biodiversity are much less.

There are three distinct types of pollock spawning groups in the Bering Sea: (1) continental shelf (eastern and western Bering Sea shelf), (2) shelf along island coastlines (Pribilof Islands, Amak Is., and Commander Is.) and (3) deep water (Bogoslof Is. and Samalga and Kanaga Pass areas).

Ecological conditions over continental shelves vary very significantly on annual time scales, and associated pollock reproductive success and recruit abundances also experience short-term interannual variability. Coastal ecosystems associated with islands are spatially very limited, and therefore these areas are acceptable for reproduction by the oldest pollock only. Ecological conditions in deep water are much more stable. Deep areas are driven by long-term variability of regional physical oceanography of the North Pacific; therefore reproduction and recruitment of older pollock to deep waters also experience long-term variability.

Shelf and deep-water basin spawning pollock are quite independent in the Bering Sea ecosystem. They differ by duration of life, period and location of spawning, and age of first maturity. “Basin” pollock spawn by the end of winter and early spring in deep water (450-500 m) off the Aleutian Islands, their duration of life is 15-20 years, age of first maturity is 6 years, and they recruit to the shelf. “Shelf” pollock spawn in middle spring on the shelf, duration of life is 7-8 years, and age at first maturity is 3-4 years.

This differentiation of spawning pollock into separate groups has a specific role to support high abundance of pollock in the Bering Sea ecosystem. The shelf pollock spawning group may provide stable population abundance at average levels over the long term. High spawning activity over the shelf and in deep water could provide for periods of maximum abundance of pollock in the Bering Sea. The group that spawns on the coastal shelf off islands could serve as a reproductive reserve for periods of catastrophically low survival during early stages development of pollock on shelf and deep water spawning areas.

Winter habits of the Bering Sea pollock are stable interannually and are determined by specific oceanographic conditions (*e.g.*, relatively high temperature, intrusions of water from the Pacific Ocean, minimum ice cover). There are three main types of winter pollock concentrations: (1) winter concentrations consisting of several spawning groups of pollock; (2) those consisting of only one spawning group; and (3) concentrations consisting of immature pollock.

PICES XIII FIS_P-1959 Poster

Video analysis of the schooling behavior of Japanese surfsmelt (*Hypomesus japonicus*) under light and dark conditions using a mathematical model

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The schooling behavior of captive Japanese surfsmelt (*Hypomesus japonicus*) under light (80 lx) and dark (< 0.01 lx) conditions was observed. The fish were divided into an experimental group in which the lateral line sensory system of each fish was disabled and a control group in which the lateral lines were not altered. The two-dimensional motion of individuals during 20-min observation periods was digitized and processed, and the schooling behavior was analyzed quantitatively using the mathematical model of Sannomiya *et al.* (1996). The frequency distribution of the nearest neighbor distance in both groups was unimodal in the light and multimodal in the dark. The schooling behavior of the control group in the light was dominated by both propulsive and schooling forces, whereas the schooling behavior of this group in the dark and of the experimental group was dominated by only propulsive force. These results suggest that Japanese surfsmelt depend on vision when aggregating in a non-parallel orientation to other fish, and on both vision and their lateral line when schooling in a parallel orientation to other fish.

PICES XIII FIS_P-1857 Oral

Interannual variation in growth of larval and early juvenile Japanese anchovy in the Kuroshio-Oyashio transition region

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Since the 1990s, the distribution range of Japanese anchovy *Engraulis japonicus* has expanded from coastal waters to the eastern offshore waters off northern Japan, the Kuroshio-Oyashio transition region, with the increase in population abundance. This study aimed to examine effects of environmental conditions on early growth of *E. japonicus* in the transition region during 1997-2002. Late larvae and early juveniles were distributed in waters characterized by 15-19°C SST and 10-1000 mg dry weight m^{-2} in available copepod density. The recent growth rates (G) for 10 days before capture of late larvae and early juveniles were considered to be regulated more strongly by SST than copepod density in waters < 17°C, and more strongly by copepod density than SST in the waters < 100 mg DW m^{-2}. Annual mean G in the southwestern waters ranged from 0.7 to 0.8 mm d^{-1}, resulting from relatively high SST (> 17°C) and copepod density (> 100 mg DW m^{-2}), while those in the northern and eastern waters ranged from 0.4 to 0.8 mm d^{-1} and were variable among survey years, resulting from decreases of SST to 15-16°C and food availability to 50-100 mg DW m^{-2}. Interannual variability in the growth and survival rates during early life stages in *E. japonicus* seems to be higher in the northern and eastern waters than in the southwestern waters in the Kuroshio-Oyashio transition region. Comparisons of larval growth and survival rates between Japanese anchovy and Japanese sardine in the transition region will be discussed.

PICES XIII FIS_P-1957 Oral
Geographical variations in carbon and nitrogen stable isotope ratios of Japanese anchovy *Engraulis japonicus*

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Japanese anchovy *Engraulis japonicus* is widely distributed around Japan from inshore to offshore. Carbon and nitrogen stable isotope ratios of animals reflect the isotope ratios of prey species and therefore are used for the study of trophic relationship. We present results of the carbon and nitrogen isotope ratios of Japanese anchovy collected around Japan, including Sagami Bay, Wakasa Bay, Tsushima Strait, Kuroshio Extension area and Kuroshio-Oyashio Transition area. Adult anchovies collected from Sagami Bay, inshore habitat, showed the highest values ($\delta^{13}C$ = -15.2 ‰, $\delta^{15}N$ = 14.2 ‰ in average), and those from Kuroshio Extension and Kuroshio-Oyashio Transition areas, offshore habitat, showed the lowest values ($\delta^{13}C$ = -19.4 ‰, $\delta^{15}N$ = 8.7 ‰). Anchovies from the other areas showed intermediate values. Similar trends were found in the ratio values for larvae. In fact, larvae from Sagami Bay showed higher values than those from Kuroshio Extension and Kuroshio-Oyashio Transition areas. Such geographical variations in carbon isotope ratios may be due to the difference of the carbon source of primary production, since the inshore ecosystem is expected to be influenced more by the benthic primary production than the offshore ecosystem, where the source of primary production is expected to be mainly pelagic phytoplankton. On the other hand, the variations of nitrogen isotope ratios might be due to differences in oceanographic conditions rather than trophic level of prey items, since the anchovy stomach contents which were composed of copepods and the other crustaceans did not differ among regions.

PICES XIII FIS_P-1813 Oral
Impacts of global change on fisheries resources of a coastal ecosystem

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Both environmental and human factors affect marine resources in ocean and coastal ecosystems. Recent decades have seen more frequent and stronger climate variations and changes. Understanding the functioning of the marine ecosystem and how it responds to global change is also essential for effective management of living marine resources, such as fisheries, which have sustained human communities for centuries. Understanding the environment and its impact on ecosystem variations may lead to the sustainable management and development of fisheries in coastal ecosystems.

This report will focus on the impacts of global change on the fisheries resources of a coastal ecosystem. It will deal with the physical oceanographic and climate variations that induce changes in marine ecosystems. The relationship between living resources abundance and ocean and climate dynamics, climate-induced change in small pelagic fish productivity in Chinese waters, and the control mechanisms of decadal-scale variation of ecosystem productivity are the essential scientific issues to be addressed by Chinese scientists. Decadal-scale variations of ecosystem productivity in the Bohai Sea are described using survey data from 1959-60, 1992-93 and 1998-99. Indices of primary production, zooplankton biomass and fish productivity are used to describe the ecosystem productivity at different trophic levels. The results indicate that substantial variation in ecosystem productivity is one of the important characteristics of coastal ecosystem dynamics.

PICES XIII FIS_P-1924 Oral

Analysis of fish bycatch from the commercial shrimp fleet in the Southeast Gulf of California

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According to FAO, during the year 2000, the world demand for fishing resources was $1x10^8$ tons. This great demand could be fulfilled with incidental fishing. Every year approximately 3 to 5 x 10^6 tons of fish are discarded world-wide. The goals of this work were the identification of fish stocks of economic importance from bycatch data, the description of historical changes in their abundance, and finally to look for mechanisms that might account for their observed patterns of abundance. The study area was the coast of Sinaloa, which is in the Southeast Gulf of California. Samples came from shrimp surveys undertaken to evaluate shrimp stocks. In total, 203 species from 52 families were found. From these, 17 species represented almost 50% of the total. The main species in terms of abundance were *Orthopristis chalceus* which accounted for 8.49%, and *Selene peruviana* which accounted for 5.75%. In terms of biomass, the main species were *Synodus scituliceps* and *Pomadasys panamensis* which accounted for 8.15 % and 5.28% respectively. The diversity results for the study area were high, the Shannon index of diversity was 4.170. The annual catches from 1993 to 2003 showed that the fish bycatch could be used as a source of fish resources in this area. The fleet discarded an estimated 146,049 tons of fish in 2003. The species composition of discards did not differ a lot in the different zones. A possible explanation for the discards is the small size of the species in the catch, but there is a considerable amount of discard. Hence there is a need for regular economic use for these catches.

PICES XIII FIS_P-2088 Poster

The preliminary estimation of abundance of some fishes in adjacent waters of the Commander Islands by results of bottom long-line catching in 1995-1997

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Data on species composition and frequency of fishes in the catches of bottom auto long-line system Mustad was collected within the 30-mile conservation zone of the Komandorskiy Reserve in 1996 and in adjacent waters on the continental slope in 1995, 1997. 29 species of fishes relating to 13 families are registered in catches within the limits of the conservation zone in 1996 on depths from 35 to 680 m. The families of the rockfishes Sebastidae (7 species), flatfishes Pleuronectidae (6) and sculpins Cottidae (4) were submitted at the most miscellaneous. Among commercial species the highest frequency of occurrence was marked for Pacific cod *Gadus macrocephalus* – 98,5 %, halibut *Hippoglossus stenolepis* – 69,5 %, rock greenling *Hexagrammos lagocephalus* – 43,6 %, for different species of rockfishes: rougheye rockfish *Sebastes aleutianus* (28,3 %), Pacific ocean perch *S. alutus* (21,9 %), shortraker rockfish *S. borealis* (22,8 %), and also shortspine thornyhead *Sebastolobus alascanus* (24,8 %). In 1995 and 1997, Pacific cod was the base of longline catches on depths of 100-300 m – 87 and 43 % on biomass accordingly. The calculation of abundance and biomass of some species was conducted by the "spline surface approximating" method. The average abundance (thousand fishes) and biomass (tons) were estimated: for Pacific cod – 3550 (9574), for halibut – 38 (166), for shortraker rockfish – 34 (49), for shortspine thornyhead – 2479 (3633) in this region for 1995-1997. Based this data the large reduction of the stock of rockfishes (especially of shortspine thornyhead) is judged as the result of the poaching. Some actions for protection of marine biota of the Komandorskiy Reserve are offered.

PICES XIII FIS_P-1831 Poster

Growth and morphological development of sagittal otolith of jack mackerel *Trachurus japonicus* in larval and early juvenile stages

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Daily periodicity of growth increment formation in sagittal otoliths of jack mackerel *Trachurus japonicus* was confirmed by marking otoliths with alizarin compelxone (ALC). Analysis of otoliths of known-age juveniles confirmed that the first increment was formed on the 3rd day after hatching, associated with first feeding. A total of 198 specimens, ranging from 2.6 to 49.2 mm body length (notochord length or standard length) and from 7 to 78 days in age, were collected in the East China Sea and Tosa Bay; data were analyzed to examine the association between otolith morphological development and ontogenetic development. The relationship between body length (L) and otolith radius (R) was significantly expressed by a linear function of L=2.65+0.0425R (N=198, r^2=0.99, p<0.00001), indicating that somatic growth history can be reconstructed from otolith growth pattern. The otolith was primarily spherical in the preflexion larval stage and became elongated with the notochord flexion. The first secondary primordium (SP) was formed at about 25 days of age when fish were in the middle postflexion stage, which was associated with metamorphosis. By about 42 days of age, juveniles attained an adult-like morphology of sagittal otolith with the primary growth zone (PGZ) enclosed by the marginal growth zone (MGZ) except in the anterior rostrum area. These results indicate that age, growth and developmental stages were recorded in sagittal otolith of jack mackerel during larval and early juvenile stages. Thus, future work can use these records to study early life ecology of this species.

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Hatch-date dependent difference in growth and development of jack mackerel *Trachurus japonicus* during early life stages recorded in otolith microstructure

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Jack mackerel spawn in both the East China Sea (ECS) and the coastal waters of southern Japan from January to June. We hypothesized that growth and development of jack mackerel during early life stages varied with hatch-dates. We tested this hypothesis by comparing sagittal otolith microstructure of jack mackerel juveniles. A total of 308 juveniles sampled from Fukagawa Bay in southern Sea of Japan during June and September 2002 were analyzed. They were hatched from 16 January to 30 May 2002. Age of the first secondary primordium (SP) formation ranged from 19 to 54 days with a mean (±SD) of 30.4±6.1. Numbers of SP in an otolith ranged from 2 to 15 with a mean (±SD) of 6.1±1.7. Age of the first SP formation, number of SP, and increment width varied with hatch dates. A general pattern was that late-hatched fish were younger at age of the first SP formation, larger in number of SP, and wider in increment width during late larval and early juvenile stages than early-hatched fish. As increment width is a linear function of somatic growth and formation of the first SP is associated with metamorphosis in jack mackerel, variations in otolith microstructure indicated that growth rate was higher as inferred by wider increments, and developmental rate was higher as inferred by younger age of the first SP formation, for late-hatched fish than early-hatched fish. Influences of these seasonal variations in growth and development on recruitment of jack mackerel population were discussed.

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Current Status of Ecosystem-based fisheries management in Korea

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It is suggested that ecosystem-based management (EBM) be defined as "a strategic approach to managing human activities that seeks to ensure the coexistence of healthy, fully functioning ecosystems and human communities". Based on the elements of EBM, initiatives with the spirit of EBM have been established in 14 Acts and 15 Presidential and Ministerial Orders in Korea. One of the major EBM initiatives in Korean is the "Basic Act of Ocean and Fisheries Development". Most of the Korean Acts with the spirit of EBM are more focused on the elements of the maintenance of biodiversity and protection from the effects of pollution and habitat degradation, rather than sustainability of yields and socio-economic benefits. Current main actions for the ecosystem-based fisheries management (EBFM) in Korea are precautionary TAC-based fishery management, closed fishing season/areas, fish size- and sex-controls, fishing gear restrictions, and marine protected areas (MPA). The Korean government is currently developing a comprehensive ecosystem-based marine ranching program. This program will eventually be designed for the enhancement and efficient management of fisheries resources. We present how the spirit of EBM is developing in Korean fisheries management to achieve operational objectives, and introduce some examples of how the comprehensive ecosystem-based management in Korea can prevent significant and potentially irreversible changes in marine ecosystems caused by fishing.