Annex 15

Seminar Report: Impacts of Climate Change on Tuna and Tuna-like Species

14th Meeting of the
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In the North Pacific Ocean

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Below are a list of the seminar presentations and their abstracts. General discussion surrounding the seminar is captured after the abstracts.

*Presenter

Changes in the fish species composition in the coastal zones of the Kuroshio Current and China Coastal Current during periods of climate change: Observations from the set-net fishery

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Abstract
Changes in fish distribution and migration patterns have occurred in mid- and high-latitude oceans world-wide in response to climate change. Since the 1980s, the sea surface temperature (SST) of the southern East China Sea has increased significantly, particularly in winter. The mechanisms behind these changes in migratory fish assemblages are difficult to elucidate from general capture fisheries databases. This study collected a long-term data set of set-net catches, reported from the remote Tung-Ao Bay in northeastern Taiwan to analyze catch composition. Both the total number of species and the Shannon–Wiener index(H) showed an increasing trend, while the cumulative percentages of the top 10 captured fish species decreased annually. These results indicated that in the coastal zone at the front of Kuroshio Current (KC)and China Coastal Current (CCC), increased SST caused fluctuations in the presence of cold-water and warm-water fishes and in the timing of fishing seasons. Additionally, results based on multi-dimensional scaling (MDS) and cluster analyses showed that the study period could be divided into two clusters,1993–1997 and 1998–2011, with an 80% similarity value. The boundary of these clusters was consistent with changes in SST. A species composition change analysis of these clusters showed that clustering was associated with changes in the intensities of the CCC and KC, especially in winter seasons. A northward expansion of low-latitude fish species was observed in Tung-Ao Bay, similar to expansion of high-latitude fish species into Polar region.

Effects of climate variability on the distribution and fishing conditions of yellowfin tuna (*Thunnusalbacares*) in the Indian Ocean

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Abstract

Variations in the abundance and distribution of pelagic tuna populations have been associated with large-scale climate indices such as the Southern Oscillation Index in the Pacific Ocean and the North Atlantic Oscillation in the Atlantic Ocean. Similarly to the Pacific and Atlantic, variability in the distribution and catch rates of tuna species have also been observed in association with the Indian Ocean Dipole (IOD), a basin-scale pattern of sea surface and subsurface temperatures that affect climate in the Indian Ocean. The environmental processes associated with the IOD that drive variability in tuna populations, however, are largely unexplored. To better understand these processes, we investigated longline catch rates of yellowfin tuna and their distributions in the western Indian Ocean in relation to IOD events, sea surface water temperatures (SST) and estimates of net primary productivity (NPP). Catch per unit effort (CPUE) was observed to be negatively correlated to the IOD with a periodicity centred around 4 years. During positive IOD events, SSTs were relatively higher, NPP was lower, CPUE decreased and catch distributions were restricted to the northern and western margins of the western Indian Ocean. During negative IOD events, lower SSTs and higher NPP were associated with increasing CPUE, particularly in the Arabian Sea and seas surrounding Madagascar, and catches expanded into central regions of the western Indian Ocean. These findings provide preliminary insights into some of the key environmental features driving the distribution of yellowfin tuna in the western Indian Ocean and associated variability in fisheries catches.

Spatial and Temporal Distributions of Pacific saury Associated with Environmental Factors in the Northwestern Pacific Ocean

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A 5-year(2006–2010)fishery datacoupled with multi-sensor satellite images had been examined to determine the pelagic habitat characterizationof Pacific saury in the Northwestern Pacific Ocean (NWPO). The results showed thatthe monthly average CPUEs (metric tons/day/boat) ranged from 10.8 of early fishing season (June to August) to 23.1 of the highest CPUE in October.The totally average CPUE is 15.3. Its major fishing grounds located within $37-48^{o}$N latitude and $145-165^{o}$E longitude.The monthly mean centers of gravitiesof fishing grounds had a remarkable latitudinal movement. In addition,Pacific saury's habitat preferences were also determined using the empiricalcumulative distributionfunction. As a result, the high CPUEs corresponded to areas where sea surface temperature (SST) ranged from $14-16^{o}$C, Chlorophyll-*a*concentrations ranged from 0.4–0.6 mg m^{-3} and net primary productions ranged from 600–800 mg C m^{-2} day^{-1}. Then, local areas within the NWPO with similar satellite-derived oceanographic parameterswere assumed to be potential habitat zonesof Pacific saury.

Moreover, possible changes in potential habitat zones of Pacific saury were estimated under four scenarios of SST increase due to climate change. Results revealed an obvious poleward shift of potential saury habitats under the influence of SST increase. Based on these SST preferences in concert with the corresponding fish distributions, monthly potential saury habitats were predicted. Possible changes in potential saury habitats were estimated under 4 scenarios: the present years and with 1, 2, and 4 °C rises in SST due to climate change. Results showed an obvious poleward shift of potential saury habitats during the influence of increases in SSTs. The southernmost boundary of potential saury habitat located at 40.24°N latitude at the present time shifted to 46.15°N latitude under the scenario of a 4 °C rise in SSTs.

Consequently, above mentioned results can improve our understanding of the variability in the spatial distribution of saury habitats, and can form the basis for fishery management and fishing forecasts in the future.

Ensemble-based analysis of climate change effects on the habitat of striped marlin (*Kajikia audax*) in the North Pacific Ocean

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Striped marlin is a highly migratory species distributed throughout the North Pacific Ocean, which shows considerable variation in spatial distribution as a consequence of habitat preference. This species may therefore shift its range in response to future changes in the marine environment driven by climate change. It is important to understand the factors determining the distribution of striped marlin and the influence of climate change on these factors, to develop effective fisheries management policies given the economic importance of the species and the impact of fishing. We examined the spatial patterns and habitat preferences of striped marlin using generalized additive models fitted to data from longline fisheries. Future distributions were predicted using an ensemble analysis, which represents the uncertainty due to several global climate models and greenhouse gas emission scenarios. The increase in water temperature driven by climate change is predicted to lead to a northward displacement of striped marlin in the North Pacific Ocean. Use of a simple predictor of water temperature to describe future distribution, as in several previous studies, may not be robust, which emphasizes that variables other than sea surface temperatures from bioclimatic models are needed to understand future changes in the distribution of large pelagic species.

Preliminary comparisons between spatiotemporal fluctuations in larval distributions and environmental conditions from 2011 to 2013 in waters of spawning grounds of Pacific bluefin tuna

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A number of research surveys to analyze the geographical distribution of Pacific bluefin tuna (PBF) larvae have been carried out for more than a half of century by Japanese scientists. These surveys could be categorized into three generations. The first generation of surveys (1956-1989) was focused on understanding horizontal extent of larval distribution in the northwestern Pacific Ocean, clearly illustrating two geographically-isolated spawning grounds, that is, the Nansei area and the Sea of Japan, and indicating month-to-month changes of occurrence of PBF larvae. The second one (2007-2010) was concentrated in development of basic strategy for larval sampling in waters of the major spawning ground around the Nansei Islands. Adaptive sampling trials adjusting to oceanographic conditions succeeded to converge the survey area using specific oceanographic and geographic features for future researches and also year-to-year fluctuation in amounts of larval catches was detected. The most recent surveys (2011-), the third generation, have been continuing to reevaluate spatiotemporal extent of larval distribution around Japanese waters including the two spawning grounds and to identify spawning spots and their surrounding environments. Possible spawning spots were estimated from all of each sample of PBF larvae using backward calculation on an oceanographic numerical model, though much less larval collections in the Sea of Japan may provide rough estimates of the spots in the area.

Although a whole picture of larval distribution of PBF have been represented steadily, larval demography and/or abundance induced from fluctuations observed in the amounts of larval catches have never been investigated because of lack of detailed examinations regarding relationships between the year-to-year fluctuations and oceanographic conditions. It should be a key approach to detect correlation of fluctuations between larval catches and environmental conditions, in order to understand mechanisms of interactions between wild PBF reproduction and environments. In this presentation, we introduce an example of year-to-year fluctuation in the amounts of PBF larval catches observed in the Nansei area which appears to be connected with oceanographic conditions. We compare the amounts of larvae sampled in the middle of May to both geographic distributions and a time series of anomaly of sea surface temperature simply, and then discuss a possible trigger to influence the opening of the spawning periods. Additionally fluctuation of food web environments for the larvae observed in the Sea of Japan is also introduced. These findings are expected to help us to understand larval demography of PBF in the near future.

Discussion
It was recommended that the authors of these studies consider the some relationship of the presented research to stock assessment applications in the future. It would be good to use indicators for biodiversity, habitat quality, and socioeconomic benefit in the prediction of Indian Ocean Dipole events, for example, to be used as an early indicator of success or failure prior to the fishing season. N. Suzuki's research was discussed. It was noted that satellite imagery can provide another view of bluefin early life history survival based on predator-prey relations. More sampling is probably needed to understand how temperature anomalies affect early life history of bluefin tuna. Although there is

no definitive answer, the reason for two widely-separated spawning areas, in the Sea of Japan and Nansei area, might be the relatively shallow depths in waters between the Korean peninsula and Southern Japan, which separates the two spawning areas. [Applicability to other species]
The ISC Chair thanked the presenters for their presentations and noted that that the research is consistent with the intent of the emerging PICES-ISC collaboration.