ISC4/2004/_7

Interim Scientific Committee for Tuna and Tuna-like Species
in the North Pacific Ocean

Report of the Swordfish Working Group [1]

January 29 and 31, 2004
Honolulu, Hawai`i

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[1] A report adopted at the Fourth Meeting of the Interim Scientific Committee for Tuna and Tuna-like Species in the North Pacific Ocean (ISC), January 29 and 31, 2004, Honolulu, Hawaii

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1.0 INTRODUCTION

A meeting of the Swordfish Working Group (SWO-WG) of the Interim Scientific Committee for Tuna and Tuna-like Species in the North Pacific Ocean was convened at the Ala Moana Hotel in Honolulu, Hawaii, on January 29 and 31, 2004. The purpose of the meeting was to review information concerning swordfish resources in the North Pacific, including fishery statistics, the status of swordfish stocks, and progress in biological and oceanographic research in support of stock assessment. Robert Humphreys, chairman of the SWO-WG, welcomed participants (Attachment 1) and appointed Pierre Kleiber and Bruce Mundy as rapporteurs. Working papers were distributed (Attachment 2) and the meeting agenda was adopted (Attachment 3).

2.0 REVIEW OF FISHERIES

Reports were presented describing fisheries of the United States, Japan, Chinese Taipei, and Mexico that catch swordfish in the North Pacific. These fisheries account for a large percentage of the annual swordfish catch in the North Pacific. Canada reported that they do not have a fishery for swordfish in the North Pacific. No report for the Republic of Korea was presented.

2.1 United States

Russell Ito presented a status report on U.S. fisheries for swordfish in the North Pacific (ISC/SWO-WG/04/01). The United States is a major swordfish harvesting and consuming nation. U.S. fisheries in the North Pacific harvested 1,901 t of swordfish in 2002, approximately 49% of the total domestic swordfish production. U.S. swordfish fisheries in the North Pacific are characterized by three distinct gear types (harpoon, drift gill net, and longline), and each has exhibited periods of increase, peak, and decline in effort and catch.

Harpoon fishing for swordfish is the oldest of the three, with a long history that dates back to the early 1900’s. The harpoon fishery reached a record high of 309 vessels that caught 1,699 t of swordfish in 1978. The participation and catch by this fishery has subsided since then. There were 29 active harpoon vessels that caught 90 t of swordfish in 2002 (Table 1).

The California drift gill net fishery, which targets shortfin mako sharks and common thresher shark, as well as swordfish, began in 1980, then expanded and replaced the harpoon fishery as the dominant swordfish fishery on the U.S. West Coast after only one year from its inception. The number of drift gill net vessels and swordfish catch grew rapidly and peaked at 220 vessels catching 2,368 t of swordfish in 1985. Fleet participation and catch has decreased since then to only 29 vessels that caught 302 t of swordfish in 2002.

Although the longline fishery has a history of fishing in Hawaii from the early 1900's, swordfish-directed longline fishing began only in 1988 and grew rapidly (Table 1). The number of Hawaii-based longline vessels peaked in 1991 at 141 vessels with 115 vessels targeting swordfish. Swordfish catch peaked at 5,909 t in 1993. Beginning in 1999, restrictions were placed on Hawaii-based longline fishery to reduce sea turtle interactions. Regulations were also passed in mid-2001 prohibiting the Hawaii-based longline fishery from deploying shallow-set "swordfish style" longline gear. The Hawaii-based longline fleet was allowed to set their gear "deep" and targets tunas. Swordfish catches by the Hawaii-based longline fishery dropped off by 2,729 t in 2001 as a result of the prohibition. There were 100 Hawaii-based longline vessls that caught 204 t of swordfish in 2002.

The California-based longline fishery began in 1991 when 3 vessels based in San Pedro fished waters outside the U.S. EEZ. The California-based longline fishery grew in the late 1990's peaking at 44 vessels with a catch of 1,908 t in 2000. The growth was a result of the migration of vessels that had targeted swordfish in Hawaii to California. These vessels continued to target swordfish although this style of longlining was prohibited for the Hawaii-based longline fishery. The California-based longline fleet was the largest U.S. fishery for swordfish in 2001 and 2002. There were 21 vessels that caught 1,302 t of swordfish in 2002.

2.2 Japan

Kotaro Yokawa provided an update on Japan's swordfish catch and fisheries in the North Pacific (north of 10°N and west of 130°W). The primary methods used by Japan to catch swordfish in the North Pacific are longline, harpoon, and drift gill net. Longline fisheries are conducted by three fleets: coastal, offshore, and distant-water. Harpoon and drift gill net fisheries operate in coastal waters within Japan's 200 mile EEZ. Swordfish are targeted in the harpoon fishery and, to some extent, the drift gill net and offshore longline fisheries. In the distant-water longline fishery swordfish are caught incidentally. Minor catches of swordfish are also reported in set net and troll fisheries. The catch from offshore and distant water fisheries has declined in recent years. During the most recent 5-yr period (1998-2002), the combined swordfish catch by the offshore and distant-water fisheries in the North Pacific ranged from 5,404 mt in 1998 to 4,753 mt in 2002 (Table 1). During the 1997-2001 period, annual catches of swordfish in the coastal longline fishery declined from 1,213 mt in 1997 to 899 mt in 2001. Since 1993, the number of driftnet vessels has increased inside of Japan's EEZ. The catch in the driftnet fishery has increased from 365 mt in 1997 to 732 mt in 2001 (peak catch of 808 mt in 2000). The annual catch of the harpoon fishery declined to 230 mt in 2001, the lowest annual catch since 1991.

2.3 Chinese Taipei

Dr. S. C. Chou presented an update of information about fisheries of Chinese Taipei that catch swordfish in the North Pacific Ocean. Swordfish are caught in the longline and harpoon fisheries of Chinese Taipei. The catch of swordfish in the distant-water and offshore longline fleets which operate in both the North and South Pacific region have little impact on the harpoon fishery which operates in coastal waters east of Taiwan, along the edge of the Kuroshio current. The distant-water longline fleet is comprised of vessels larger than 100 gross registered tons (GRT) and have been operating since 1963. Annual catches of swordfish have fluctuated before 1998, and showed an increasing trend from 1998 to 2002. In 2002, 1,572 t of swordfish were caught by Chinese Taipei in the North Pacific region by the distant-water longline fleet. Two groups of vessels operate in the offshore longline fishery. Vessels of 20-50 GRT, based in domestic fishing ports, take short trips (7-10 days) in the general vicinity of their home port and land their catch there. Vessels of 50-70 GRT are based in fishing ports of western Pacific island nations. The annual catch of swordfish in the offshore longline fishery, while fluctuating, has been higher than 1,000 t since 1986. The trend of the catch landed in domestic ports during last 5 years has increased from about 1,900 t to 4,200 t, which may or may not include catches from the Indian Ocean.

2.4 Mexico

Pedro Ulloa presented an overview of the fisheries that presently catch swordfish. Both longline and gillnet vessels catch swordfish. There are 34 vessels that fish for swordfish and other species seasonally and just 12-15 search for swordfish as the target species. The base port is in Ensenada, Baja California, and San Carlos in Baja California Sur. All the commercial fleet is restricted from fishing inside 50 miles because this area is reserved for sport fishing activities. A study made on the placement of observers on longline vessels was developed between 1998 to 2000. Results of this study show that the length-size composition for the capture with a mode of 210 cm eye-to-fork length (EFL). Gillnet vessels are regearing for longline fishing.

3.0 FISHERY STATISTICS

Swordfish catch statistics from Japan, Chinese Taipei, and the United States for fisheries in the North Pacific were updated and presented in Table 1. The table does not reflect the total catch of swordfish in the North Pacific, as data were unavailable from other fleets operating in the region; only statistics presented at the SWO-WG meeting are included. There is a need to complete the catch table by incorporating data from other countries whose vessels catch swordfish in the North Pacific. The SWO-WG strongly recommends that all ISC data contributors ensure that their respective data correspondents submit available category I through III data to the ISC Database Administrator in accordance with established ISC protocols. Compilation of a comprehensive and up-to-date catch table is a recommended task of the SWO-WG work plan (Attachment 4).

4.0 PROGRESS IN BIOLOGY, ECOLOGY, AND OCEANOGRAPHY

4.1 Age and Growth

Robert Humphreys presented recent results on the age and growth of juvenile swordfish in Hawaii based on otolith increment enumeration (ISC/04/SWO-WG/02). The two objectives of this study were to determine the early growth rate of swordfish and to corroborate the size-at-age 1 (365 days) results to a concurrent age and growth study based on second anal fin ray sections. The size range of specimens (n=49) utilized in this study ranged from early larvae 3.7 cm to larger juveniles 133.0 cm lower jaw fork length (LJFL) ; all collected from central North Pacific waters in and adjacent to the Hawaiian Archipelago. An acid-etching preparation technique was developed to expose the entire series of sagittal otolith increments from core to tip of rostrum. Processed otoliths were examined under SEM and a series of overlapping digital photos were taken from the core region to the tip of the rostrum. Increment counts were made directly from these photos using image analysis software. The estimated size at 365 days (age 1) was 96 cm EFL (111 cm LJFL) based on a power function fit to the data. This is very close to current estimates of age 1 fish from Hawaii based on anal fin ray cross-sections. Backcalculated birthdates of aged swordfish indicates that 90% of birthdates correspond to the known April through October spawning period in Hawaii based on larval captures. Direct validation of the presumed daily periodicity of increment deposition on the otolith has not been conducted.

Humphreys also presented recent data on regional growth differences between western Pacific versus central and eastern Pacific swordfish (ISC/04/SWO-WG/02). A preliminary comparison of otolith increment based age estimates between Hawaii and Taiwan (study by Chi-Lu Sun) indicates that Hawaii fish are approximately 8 cm larger at age for ages 9-11 months old. Age and growth estimates from Taiwan published recently by Chi-Lu Sun and based on presumed annual rings found within anal fin spine cross-sections were compared with preliminary data from the eastern Australia (Jock Young, CSIRO). Growth curves were similar for both the faster growing females and the more slow growing males. Very recent preliminary growth results from Chile (Francisco Cerna, IFOP) indicates that both females and males realized much higher growth rates (lengths (LJFL) at age for Chile fish >25 cm at age 5 and beyond versus western Pacific) than either study revealed for western Pacific fish. The Australia and Chile studies remain preliminary, although such interesting differences in growth between the western and eastern Pacific will need to be carefully examined for this and other related life history parameters, such as female age/length at 50% maturity.

4.2 Movement

Suzy Kohin presented swordfish movement related data that has been that has been obtained through the Southwest Fisheries Science Center's (SWFSC) Billfish Research Program. This program conducts research in support of conservation and management of billfish resources in the Pacific Ocean. One project overseen by the Program is an annual International Billfish Angling Survey which is distributed to US anglers to gather data on distribution of catch and effort of recreational billfish fishing. The Angling Survey has provided a 33 year time series of recreational catch and effort by species in the Pacific and Indian Oceans, particularly in areas where the effort is highest (i.e. Hawaii, southern California and Baja California). The Center also sponsors a billfish tagging program. As of December 2003, 521 broadbill swordfish have been tagged by recreational and US commercial fishers through the program, 18 of which have been recaptured. Six swordfish tagged within the southern California Bight were recaptured within 35 days less than 30 nm from the tagging sites. Several swordfish tagged north of Hawaii by US longline vessels moved west and were caught by other commercial vessels. One swordfish tagged northeast of Hawaii moved east and was recovered near San Clemente Island, California. A third program is the analysis of historical catch records of southern California recreational angling clubs. Swordfish appear in the club catch records in the early 1900's and combined club records indicate a decline in the average whole weight of swordfish caught recreationally in southern California. The nature of the recreational fishery for swordfish where individuals may take different amounts of time to assure good tagging practices and obtain accurate measurements, and where reporting is not required, means that the data are not necessarily reliable for estimates of mortality, growth or population abundances. However, the cooperative efforts with the recreational anglers will enable researchers to continue to have access to billfish for both conventional and electronic tagging efforts in order to gain information on migration, and to access recreational catch and effort data which may be utilized in improved stock assessment models.

Michael Musyl presented current findings on the horizontal and vertical movements of swordfish recorded by PSAT tags (ISC/04/SWO-WG/02). In March-April 2001, NMFS Honolulu scientists conducted the first PSAT tagging of swordfish in the vicinity of Hawaii. These tags are capable of recording vertical and horizontal movements by recording pressure (depth), geolocation (based on changing light levels), and ambient temperature. PSAT tags release and transmit data to a satellite when its pre-programmed pop-off date is reached. PSAT tags also release and transmit data if no pressure change is recorded for four consecutive days (tag has presumably been "shed" and is free-floating) or if the tag reaches a depth of 1200 m (the fish has presumably died and sunk through this depth). Twenty-eight swordfish have been PSAT tagged through the year 2003. Nine of 28 PSAT tags reported their data earlier than their pre-programmed release dates. Data from these 9 tags represent in aggregate 527 days at liberty (range, 5-190 days, avg. 59 days). Two types of vertical movement behavior have been recorded: 1) deep oscillating behavior with dives down to 700 m and, 2) basking behavior, moving downward only to 200 m maximum. Because of deep crepuscular dive patterns, estimates of geolocations (from changes in ambient light-levels to calculate dawn/dusk) were not possible in a majority of cases. However, incorporation of SST into Kalman filter algorithms, whereby satellite-derived SST measurements are matched to those given by the PSAT, may help geoposition the tag. The premature shedding of PSATs is common for billfish. The cause(s) of this "early-release" problem with PSATs has not been identified but a new "speargun" head may promote better retention by increasing surface area of the tag anchor. Repetitive dives to 700m may help explain the high non-reporting rate (i.e. tags weaken and fail over time due to pressure breech). Until these problem(s) can be rectified, the potential of PSATs to provide new insights into long term horizontal movement patterns and possible stock separation in swordfish remains limited.

4.3 Stock Structure

Michael Hinton presented a comprehensive review of all population genetics studies conducted on swordfish sampled from the Pacific Ocean (ISC/04/SWO-WG/03). The most recently published genetic analysis by Ward, Reeb and Block (2001) interpret the population structure of swordfish as a sideways horseshoe pattern across the Pacific with the opened end aligned with the western North and South Pacific (representing the most genetically separated regions), with contiguous west to east populations extending separately across each hemisphere. The bend of the horseshoe pattern occurs along the eastern Pacific linking northern and southern hemisphere populations. This study, however, may have erroneously used an Australian outgroup sample that actually combined Pacific and Indian Ocean specimens and may have ultimately confused the analysis. In general, most studies show no difference between the eastern tropical Pacific and Hawaii although one allozyme study and a current study conducted by Jaime Alvarado-Bremer (Texas A&M University) indicate differences exist. Compared to Atlantic studies, the stock structure signal in the Pacific is not as pronounced. The current study of Alvarado-Bremer recently received to complete the analysis of all samples; this study has sufficient samples from distant locations to resolve stock structure if it exists.

Robert Humphreys presented results of a meristic analysis of juvenile swordfish collected from the equator to the subtropical transition zone along the central North Pacific (ISC/04/SWO-WG/02). The objective of this study was to examine total dorsal and anal fin element counts as a possible phenotypic difference that might stock-specific nursery environments. The study examined a total of 214 young-of-year (YOY) juvenile specimens (47-99 cm EFL). We assumed that these YOY juveniles remained latitudinally adjacent to their natal sites. Juvenile specimens were obtained as by-catch from Hawaii based tuna longline vessels. Meristic data were grouped geographically within latitudinal bands (0-7^{o} N, n=29; 13-16^{o} N, n=38; 20-22^{o} N, n=39; and 28-34^{o} N, n=34, and all specimens combined, 0-37^{o} N, n=214) to represent areas associated with the equator, North Equatorial Current, main Hawaiian Islands, the Subtropical Transition Zone, and the entire central North Pacific, respectively. The distribution and mean values for both dorsal and anal fin elements showed no significant differences among these latitudinal groupings, even when the two most distant sample groups were compared. A comparison with published meristic counts for total dorsal and anal fin elements in the Atlantic (Potthoff and Kelley, 1982) revealed that the meristic distributions and means for the Atlantic specimens were indistinguishable from those of the central North Pacific. Results suggest that these meristics offer little future promise as a natural marker of natal or nursery site origin.

Humphreys also reported on a collaborative study with Steve Campana (Bedford Institute of Oceanography, Nova Scotia, Canada) to analyze the elemental composition of swordfish otoliths (ISC/04/SWO-WG/02). The objective was to analyze the trace element composition of YOY juveniles as a preliminary test to ascertain the value of otolith elemental fingerprints for determining swordfish nursery ground origin in the central Pacific. The existence of geographically distinct elemental fingerprints could serve as natural markers embedded in the juvenile portion of adult otoliths. Juvenile swordfish specimens were collected within a narrow swath of longitude (160 -165^{o}W); latitudinal sites within this swath included equatorial waters (0 -1^{o}N, n=12), waters immediately south of Hawaii (17^{o}N, n=2), west of the main Hawaiian Islands (22^{o}N, n=7)), and in temperate waters north of Hawaii (31^{o}N, n=2). Detection of otolith trace element concentrations was determined using isotope dilution-inductively coupled plasma mass spectrometry (ID-ICPMS); assays were conducted at the National Research Council Laboratory in Ottawa, Canada. Concentrations of Mg, Zn, and Pb displayed similar levels of concentrations among these latitudinal sites. The concentrations of Sr and Ba, however, varied significantly with greater latitudinal separation. The concentration of Sr declined with increasing latitude while Ba concentrations showed a reverse trend. Using discriminant analysis, Sr and Ba concentrations significantly differed between the two larger samples (0-1^{o}N and 22^{o}N latitude sites). These results point out the potential promise rather than the direct application of the geographic variation in the otolith elemental fingerprint. Additional YOY juveniles collected from sites outside the central North Pacific (western Pacific off Japan, and French Polynesia) will be included in future tests to assess whether distinct otolith elemental fingerprints exist for juveniles associated with these distant nursery areas.

4.4 Feeding Habits

Kotaro Yokawa presented preliminary results on the seasonal change in the diet of swordfish (ISC/04/SWO-WG/09). A total of 194 stomach samples were obtained from swordfish captured by Japanese offshore longliners fishing in subtropical and transition zone waters from 11 March to 23 September 2001 and 2002 in the western North Pacific. Sampling localities generally shifted northward in time due to the seasonal summer migration of swordfish. Each prey item recovered was measured and identified to the lowest possible taxonomic level. Swordfish fed mainly on cephalopods and fishes from spring to early autumn. Among the cephalopod prey, neon flying squid was the most common but its importance in the diet decreased with the seasons. Alternately, transitional and subarctic squids accounted for nearly 40% of the total number of cephalopod prey in May-September. Pacific pomfret was the most dominant fish prey, comprising 54% of the total number of fish prey in March-April, but its importance declined abruptly to less than 10% thereafter. In transition zone waters, myctophids accounted for over 50% in May-September. Results indicate that the diet of swordfish shifted from subtropical components in March-April to transitional components in May-September. The prey size spectrum of swordfish shifts to a smaller size range from spring to summer in accordance with the northward migration of the large-sized prey species, neon flying squid and Pacific pomfret, into subarctic waters.

5.0 STATUS OF STOCKS

Hirokazu Saito presented an analysis of the long term trend in abundance index for swordfish derived from Japanese longline fishery statistics for 1956-2002 (ISC/04/SWO-WG/04). In this analysis, area stratification of the west and central North Pacific (north of 10° N and west of 130° W) was divided into five regions. Two datasets (1956-1975 and 1975-2002) were analyzed and the abundance time series connected in the year 1975. Gear configuration (number of hooks between floats, NHF) was classified into five classes. The GLM analysis was conducted independently for the two dataset time series. The highest catch rates were found when the NHF was 3-4 with a negative correlation found between NHF and standardized CPUE. The declining trend in the abundance index of the northwest areas (particularly Area 2) appears distinct from trends displayed in Area 4 (central North Pacific) and Area 5 (eastern North Pacific). Overall, the standardized CPUE trends in each of the five areas displayed large fluctuations over the time series.

Kotaro Yokawa described initial efforts to estimate effective fishing effort of swordfish caught by longliners in the west and central North Pacific (north of 10° N and west of 130° W) (ISC/04/SWO-WG/05). Japanese longline data in the northwest and central North Pacific provides a good example for testing the adequacy of the habitat model used, because this is the only region where large scale shallow longline sets continue. General trends in CPUEs calculated by effective effort were quite similar to those calculated by the nominal effort. These results are not unrealistic because swordfish is one of the major target species in the area investigated. Estimated abundance indices showed a continuous declining trend since the mid-1980s. The lack of information about the number of hooks between floats (NHF) in the database prior to 1975 is the largest problem in the estimation of effective effort. This may require an analysis of data by individual sets in order to identify target species. Collection of further information about input parameters, such as underwater movement of gear and the vertical distribution pattern of swordfish and its CPUE, should increase the reliability of the model.

Yokawa also presented a comparison of three abundance indices estimated by different methods (two by GLM and one by the habitat model) to explore actual stock status of swordfish in the northwest and central Pacific (ISC/04/SWO-WG/06). In the main swordfish fishing grounds north of 10° N, these three indices suggest different stock levels before the 1970s and a similar downward trend since the mid-1980s. The relative values of the three indices in 2000 – 2002 are about 40 – 50% of those in the second half of the 1980s. This trend indicates that the current status of swordfish in the north Pacific should be closely monitored until reliable stock assessment conducted. Further information and study to improve reliability of the abundance index also be necessary. The difference observed among the index trends in the northwest, northeast, southwest, and southeast regions may indicate the presence of more than one stock in the northwest and central Pacific.

Pierre Kleiber presented an updated MFCL analysis of swordfish in the west and central North Pacific (north of 10° N and west of 130° W) using catch, effort, and size sample data from Japanese longline, Hawaii longline, and high seas Japanese driftnet (ISC/04/SWO-WG/07). Problems were encountered in the data, and in the analysis. Size sample data are truncated at small sizes for some fisheries, and this "hole" in the data cannot be easily accommodated as yet in MFCL. The MFCL model estimated very high levels of natural mortality (>0.6 per year) which led to extremely small estimates of the effect of the fisheries on the swordfish population. Forcing the natural mortality to a more reasonable level (0.2 per year) resulted in higher, but still modest, estimates of fishery impact with current levels of fishing mortality averaging approximately one third of that at MSY, and with current biomass approximately 70% higher than biomass at MSY and approximately 49% of what biomass would have been without fishing. Substantial fluctuations in abundance were predicted in all model runs, some with downward trends and some upward. The trends were highly sensitive to details of the structural setup of the model. The model showed fisheries as playing only a modest role in causing abundance fluctuations when natural mortality was forced to 0.2 per year, and a negligible role at higher levels of natural mortality. Further analyses should include data from additional fisheries catching swordfish in the region; additional MFCL structures, including spatial and fishery definition structures should be tested; and MFCL should be adapted to deal with truncated size samples.

Keith Bigelow described some exploratory testing of the sensitivity of MULTIFAN-CL (MFCL, Fournier et al. 1998) to simulated swordfish data through the use of an operational model (ISC/04/SWO-WG/08). Four simulated swordfish population and fishery scenarios were developed for MFCL analysis. Scenarios differed in spatial stratification and time-series variation in catchability. MFCL fit the simulated length-frequency, catch and effort data with differing structural assumptions for natural mortality and catchability. Results of the simulated "actual" values and estimated MFCL parameter values are summarized for natural mortality (M), mean biomass, starting biomass, ending biomass, mean recruitment, mean fishing mortality (F) by year, and reference points BF_e/BF_s and BF_e/B_e. Estimated length-at-age and the growth trajectory were in good agreement with actual values. For each scenario, there was a substantial departure in the estimated value of natural mortality as mean values were ~0.6 yr^{-1} compared to simulated values of 0.2 yr^{-1}. Reference point estimates of BF_e/BF_s and BF_e/B_e were better determined if there was no underlying trend in catchability. In general, there was less bias in estimating a trend in catchability when there was no actual trend compared to assuming a lack of a catchability trend when there was an actual trend.

5.1 Conclusions concerning status of stocks:

Previous ISC analyses have suggested that swordfish stocks in the North Pacific were not overexploited under current levels of fishing effort. Previous SWO-WGs noted that considerable additional research was required to improve the stock assessments and that the development of stock assessment models was still in early stages.

Assessments of the status of swordfish stocks were presented this year for a region of the North Pacific (north of 10° N and west of 130° W), in contrast to previous analyses, some of which were conducted for an area lying north of the equator. New analyses (GLM and Habitat-based Standardization) of CPUE based on data from Japanese longline vessels now show declining trends mainly driven by declines in CPUE in the northwest portion of the study area (north of 10° N and west of 170° E). The cause of the decline is not known at present (e.g., stock abundance, environmental variability, changes in fishing practices). For compatibility between MULTIFAN-CL and the new analyses, the data were analyzed from 10° N instead of from the equator.

An independent analysis based on the MULTIFAN-CL model also detects such a decline in the northwest region of the fishery. However, the MULTIFAN-CL trends in predicted biomass are very sensitive to details of the model structure, creating uncertainty in the model outputs. In all cases the model showed fisheries as playing no more than a modest role in causing declines in abundance.

It is unclear whether observed changes in indices are a result of fluctuations in abundance, or the preliminary nature of both CPUE and MULTIFAN-CL analyses. It is clear that the fishery should be monitored closely. Research should be continued and data collection improved to ensure that means are available to address management decisions as they arise.

6.0 FUTURE WORK PLAN

Based on the presentations of progress in biological and oceanographic research, stock assessment and the fishery database, the work plan developed at the January 2002 meeting of the SWO-WG was reviewed and updated. The updated plan (Attachment 4) identifies research projects addressing critical needs to construct new time series of abundance indices across the North Pacific and to improve swordfish stock assessments. It also lists SWO-WG participants who expressed interest in collaboration on specific projects or have responsibility for particular tasks. These scientists would be expected to initiate or continue the research and coordinate activities with their collaborators, including arrangements for data sharing. Most of the projects have already been started.

One of the critical needs remains to further develop spatially explicit, integrated models for stock assessment. Significant progress has been made already, as reported above, and research will continue under the revised work plan with an expanded study area of the entire North Pacific region. For this purpose, genetic analysis or other information about stock structure in the North Pacific is very important.

Continued biological and oceanographic research is needed in support of improved stock assessment. Relevant biological research includes studies of age and growth (particularly regional differences in growth rates), studies of movement patterns using conventional, archival, and PSAT tags; and research on population genetics and spatial variation in otolith elemental composition to clarify stock structure and natal origin, respectively. Considerable progress has been achieved in these areas since the last meeting of the working group and participants agreed to continue the research. In order to test and evaluate stock assessment models, the group agreed to continue the development and application of the swordfish simulator constructed by Marc Labelle (Oceanic Fisheries Program, Secretariat of the Pacific Community). Work is already underway using data generated by the simulator to test the MULTIFAN-CL model. This research will continue as a collaborative project among SWO-WG participants.

The working group agreed on the fundamental importance of establishing a comprehensive database of swordfish fishery data and making it accessible to SWO-WG scientists engaged in stock assessments and related research. With respect to swordfish data, gaps remain in the database; filling these gaps remains a high priority. The SWO-WG is seriously concerned with the lack of detailed fisheries statistics from ISC member (and non-member) countries that report annual swordfish catches to the FAO in excess of 1,000 mt. The SWO-WG strongly recommends that all ISC data contributors ensure that their respective data correspondents submit available category I through III data to the ISC Database Administrator in accordance with established ISC protocols.

The SWO-WG considered three issues requested by the STATWG for all ISC species working groups:

1. Define subareas of the Pacific suitable for reporting of Category I data.
The SWO-WG recommends that sub-areas not be established at this time until results from a more comprehensive analysis can provide sub-area designations that are based on a better understanding of stock structure. The SWO-WG concluded that sub-area designations is premature at present and would inevitably require re-definition in the future.

2. Define standard measurement types for each species for reporting of Category III data.
The SWO-WG recommends the adoption of eye-to-fork length (EFL) as the standard for body length measurements on swordfish. The SWO-WG notes the conventional use of lower jaw to fork length (LJFL) in the Atlantic. However, the historic and continued use of EFL in virtually all fisheries statistics from the Pacific requires the need to establish EFL as the standard measure. Furthermore, conversions from EFL to other measurements including LJFL are available.

3. Evaluate conversion relationships among various length and/or weight measurements and the standard for reporting of Category III data.

The SWO-WG noted that a comprehensive report on conversion relationships between various length-to-length, length-to-weight, and weight-to-weight measurements exists (Uchiyama et al. 1999, Length-weight interrelationships for swordfish, *Xiphias gladius* L., caught in the central North Pacific, NOAA Technical Memorandum NMFS SWFSC no. 284, 82 p.). Participants working in the central and eastern Pacific note that the conversions developed in this report are used as their standard. Participants from Japan will investigate the applicability of these conversion standards for the western Pacific. At the next ISC, the SWO-WG will either make a recommendation to adopt the Uchiyama et al. (1999) report as the standard or make specific recommendations for alternative conversions. The SWO-WG also recommends that standard conversions will need to be re-examined periodically to maintain their accuracy. The SWO-WG asks that the STATWG ensure that data correspondents specify the conversion factors used in the datasets supplied to the ISC database.

Finally, the SWO-WG strongly recommends that the annual catch totals supplied in Table 1 must also include catches from major fisheries that are unloaded in foreign ports.

7.0 TIME AND PLACE OF THE NEXT MEETING

Participants agreed that the working group should plan to meet in conjunction with the next scheduled ISC plenary meeting. Furthermore, since many participants serve on multiple species working groups, participants agreed that the species working groups need to be scheduled in a manner that allows more time between working groups to better develop conclusions and recommendations.

8.0 CLOSING REMARKS

The working group adopted the report and forwarded it to the plenary. The Chairman expressed his appreciation to all participants and to the rapporteurs for their contributions and cooperation in completing a successful meeting.

Table 1. Swordfish catch (metric tons) in the North Pacific reported by ISC participants[1].

	Japan						Chinese Taipei[4]			Mexico[5]	United States[6]						
											Hawaii	California					
Year	Distant-water and Offshore Longline[2]	Coastal Longline	Driftnet	Harpoon	Other[3]	Total	Distant-water Longline	Offshore Longline	Total	All Gears	Longline	Longline	Gill Net	Harpoon	Unknown	Total	Grand Total
1952	9,138	941	0	2,558	79	12,716	-	-	-	-	-	-	-	-	-	-	12,716
1953	11,180	439	0	1,399	124	13,142	-	-	-	-	-	-	-	-	-	-	13,142
1954	12,957	394	0	810	124	14,285	-	-	-	-	-	-	-	-	-	-	14,285
1955	13,784	326	0	818	176	15,104	-	-	-	-	-	-	-	-	-	-	15,104
1956	15,407	308	0	772	86	16,573	-	-	-	-	-	-	-	-	-	-	16,573
1957	14,956	334	0	855	71	16,216	-	-	-	-	-	-	-	-	-	-	16,216
1958	19,336	341	0	1,063	96	20,836	-	-	-	-	-	-	-	-	-	-	20,836
1959	18,034	365	0	890	69	19,358	-	-	-	-	-	-	-	-	-	-	19,358
1960	21,091	351	1	1,191	93	22,727	-	-	-	-	-	-	-	-	-	-	22,727
1961	20,721	350	1	1,333	40	22,445	-	-	-	-	-	-	-	-	-	-	22,445
1962	10,559	377	0	1,369	55	12,360	-	-	-	-	-	-	-	-	-	-	12,360
1963	10,162	398	0	743	74	11,377	-	-	-	-	-	-	-	-	-	-	11,377
1964	5,974	391	4	1,006	82	7,457	-	-	-	-	-	-	-	-	-	-	7,457
1965	7,786	419	0	1,908	222	10,335	-	-	-	-	-	-	-	-	-	-	10,335
1966	8,970	413	0	1,725	59	11,167	-	-	-	-	-	-	-	-	-	-	11,167
1967	10,196	484	0	891	52	11,623	-	261	261	-	-	-	-	-	-	-	11,884
1968	8,295	536	0	1,539	1,167	11,537	-	281	281	-	-	-	-	-	-	-	11,818
1969	7,792	296	0	1,557	1,246	10,891	0	292	292	-	-	-	-	-	-	-	11,183
1970	5,659	427	0	1,748	1,049	8,883	-	182	182	-	5	-	-	612	10	627	9,692

[1] Catch data are currently unavailable for Republic of Korea, Philippines, and some other other countries catching swordfish in the North Pacific.

[2] Catches by gear for 1952-1970 were estimated roughly using FAO statistics and other data. Catches for 1971-2002 are more reliably estimated.

[3] For 1952-1970 "Other" refers to catches by other bait fishing methods, trap nets, and various unspecified gears.

For 1971-2002 "Other" excludes estimated catches by other bait fishing methods and trap nets.

[4] Offshore longline category includes some catches from harpoon and other fisheries but does not include catches unloaded in foreign ports. Estimates of catches for 2002 are preliminary.

[5] Estimates of catch for 1999-2001 are preliminary.

[6] Estimated round weight of retained catch. Does not include discards.

Table 1. Swordfish catch (metric tons) in the North Pacific reported by ISC participants[1] (continued).

Year	Japan								Chinese Taipei[4]			Mexico[5]	United States[6]						Grand Total
													Hawaii	California					
	Distant-water and Offshore Longline[2]	Coastal Longline	Driftnet	Harpoon	Other Bait Fishing	Trap Net	Other[3]	Total	Distant-water Longline	Offshore Longline	Total	All Gears	Longline	Longline	Gill Net	Harpoon	Unknown	Total	
1971	5,095	332	1	473	12	37	54	6,004	-	257	257	-	1	-	-	99	3	103	6,364
1972	4,453	520	55	282	8	1	25	5,344	-	352	352	2	0	-	-	171	4	175	5,871
1973	4,421	404	720	121	2	23	37	5,728	-	460	460	4	0	-	-	399	4	403	6,591
1974	4,388	508	1,304	190	11	16	164	6,581	1	460	461	6	0	-	-	406	22	428	7,470
1975	5,603	602	2,672	205	33	18	45	9,178	29	470	499	-	0	-	-	557	13	570	10,247
1976	6,087	691	3,488	313	165	14	76	10,834	23	487	510	-	0	-	-	42	13	55	11,399
1977	7,180	834	2,344	201	62	7	57	10,685	36	527	563	-	17	-	-	318	19	354	11,602
1978	7,273	984	2,475	130	96	22	62	11,042	-	436	436	-	9	-	-	1,699	13	1,721	13,199
1979	7,769	973	983	161	38	15	76	10,015	7	608	615	7	7	-	-	329	57	393	11,023
1980	5,214	824	1,746	398	22	15	33	8,252	10	679	689	380	5	-	160	566	62	793	9,734
1981	6,202	675	1,848	129	40	9	73	8,976	2	567	569	1,575	3	1	461	267	20	752	10,297
1982	5,002	839	1,257	195	51	7	43	7,394	1	758	759	1,365	5	2	911	156	43	1,117	10,635
1983	7,007	955	962	166	27	9	120	9,246	0	789	789	120	5	1	1,321	58	378	1,763	11,918
1984	6,608	1,141	971	117	91	13	125	9,066	-	954	954	47	3	14	2,101	96	678	2,892	12,959
1985	8,728	980	1,026	191	59	10	136	11,130	-	742	742	18	2	46	2,368	211	792	3,419	15,309

Table 1. Swordfish catch (metric tons) in the North Pacific reported by ISC participants [1] (continued).

Year	Japan								Chinese Taipei[4]			Mexico[5]	United States[6]						Grand Total
													Hawaii	California					
	Distant-water and Offshore Longline[2]	Coastal Longline	Driftnet	Harpoon	Other Bait Fishing	Trap Net	Other[3]	Total	Distant-water Longline	Offshore Longline	Total	All Gears	Longline	Longline	Gill Net	Harpoon	Unknown	Total	
1986	7,861	960	1,170	123	32	9	186	10,341	-	652	652	422	2	4	1,594	236	696	2,532	13,947
1987	8,336	819	910	87	29	11	198	10,390	3	1,515	1,518	550	24	4	1,287	211	300	1,826	14,284
1988	7,906	665	1,048	173	12	8	206	10,018	-	1,041	1,041	613	24	19	1,092	180	344	1,659	13,331
1989	5,661	742	1,397	362	15	10	215	8,402	50	1,491	1,541	690	218	29	1,050	54	224	1,575	12,208
1990	5,100	687	1,026	128	11	4	53	7,009	143	1,309	1,452	2,650	2,436	18	1,028	50	137	3,669	14,780
1991	4,160	799	424	153	18	5	84	5,643	40	1,390	1,430	861	4,508	39	836	16	137	5,536	13,470
1992	6,545	1,173	840	381	15	6	56	9,016	21	1,473	1,494	1,160	5,700	95	1,332	74	44	7,245	18,915
1993	7,656	1,394	292	309	41	4	3	9,699	77	1,174	1,251	806	5,909	165	1,400	169	36	7,679	19,435
1994	6,778	1,357	421	308	30	4	7	8,905	21	1,155	1,176	567	3,176	740	799	153	8	4,876	15,524
1995	5,816	1,386	561	423	33	7	2	8,228	142	1,135	1,277	424	2,713	279	755	96	31	3,874	13,803
1996	6,006	1,063	428	597	44	4	5	8,147	21	1,130	1,151	428	2,502	347	752	81	10	3,692	13,418
1997	6,072	1,213	365	346	57	5	6	8,064	20	2,177	2,197	2,351	2,881	664	707	84	3	4,339	16,951
1998	5,404	1,186	470	476	66	2	6	7,610	12	1,900	1,912	3,575	3,263	422	924	48	13	4,670	17,767
1999	5,071	1,047	724	416	46	5	3	7,312	93	2,234	2,327	1,112	3,100	1,333	606	81	2	5,122	15,873
2000	5,054	1,112	808	497	45	5	13	7,534	107	2,470	2,577	2,179	2,949	1,908	646	90	9	5,602	17,892
2001	4,860	899	732	230	28	15	11	6,775	940	2,727	3,667	2,300	220	1,763	375	52	5	2,415	15,157
2002	4,753	-	-	-	-	-	-	4,753	1,572	4,280	5,852	-	204	1,302	302	90	3	1,901	12,506

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Attachment 2. Working Papers and Information Papers

ISC/04/SWO-WG/01 U.S. Swordfish Fisheries in the North Pacific Ocean
(Russell Y. Ito and Atilio L. Coan, Jr.)

ISC/04/SWO-WG/02 Biological Research Conducted During 2002-2003 in Support of Swordfish Stock Assessment
(Robert L. Humphreys, Jr., Michael Musyl and Edward E. DeMartini)

ISC/04/SWO-WG/03 Population Structure of Swordfish in the Pacific Ocean: A Review of Genetic Studies Based on the Analysis of Nuclear and Mitochondrial Data
(Jaime R. Alvarado Bremer, Michael G. Hinton and Thomas W. Grieg)

ISC/04/SWO-WG/04 Estimation of Abundance Index for Swordfish Caught by Japanese Longliner in the North Pacific in 1956-2002
(Hirokazu Saito and Kotaro Yokawa)

ISC/04/SWO-WG/05 Estimation of Abundance Index of Swordfish Caught by Japanese Longliners by the Habitat Model
(Kotaro Yokawa)

ISC/04/SWO-WG/06 Comparison of Three Abundance Indices Estimated by Catch and Effort Data of Japanese Offshore and Distant Water Longliners
(Kotaro Yokawa)

ISC/04/SWO-WG/07 MULTIFAN-CL Assessment of Swordfish in the North Pacific
(Pierre Kleiber and Kotaro Yokawa)

ISC/04/SWO-WG/08 Evaluating the Reliability of MULTIFAN-CL Assessments of the North Pacific Swordfish Population
(Keith Bigelow and Pierre Kleiber)

ISC/04/SWO-WG/09 Preliminary Results of Seasonal Change in Diets of the Swordfish, *Xiphias gladius*, in the Subtropical and Transitional Waters of the Western North Pacific
(Tsunemi Kubodera, Hikaru Watanabe and Kotaro Yokawa)

ISC3/2002/09 Report of the Swordfish Working Group Meeting (tabled at the third meeting of the ISC, convened in Nagasaki, Japan, January 2002)

Attachment 3. Agenda

Swordfish Working Group Meeting

Fourth Meeting of the Interim Scientific Committee
for Tuna and Tuna-like Species in the North Pacific Ocean (ISC)

January 29 and 31, 2004
Plumeria Room, Ala Moana Hotel, Honolulu, Hawai`i

<u>Chair: Robert Humphreys</u>

1. Opening
    - Welcoming remarks and introductions of participants
    - Review of Agenda
    - Selection of Rapporteurs

2. Review of Fisheries
    - United States
    - Canada
    - Japan
    - Chinese Taipei
    - Republic of Korea
    - Mexico

3. Compilation of Fishery Statistics
    - Appointment of committee to compile tables of catch, effort, other data

4. Review of Research Progress
    - Collaborator's reports on status of swordfish research projects outlined in Appendix 4 ("Future Work Plan of the Swordfish Working Group") and adopted at 3rd ISC SWG Meeting in Nagasaki Japan
    - Biological and Oceanographic Research relevant to swordfish
    - Status of Stocks

5. Research Recommendations and Revised Work Plan

6. Future Arrangements

7. Drafting, Review and Adoption of Report

Attachment 4. Future Work Plan of the ISC4 Swordfish Working Group

Objective	**Research Project**	**Collaborators**
1. Conduct biological and oceanographic research in support of improved stock assessment	AGE AND GROWTH:	
	a) Continue to evaluate regional differences in age and growth	Humphreys, Sun
	b) Expand collection of data on size- and sex-composition of catch	Skillman, Sun, Yokawa
	MOVEMENT:	
	a) Estimate patterns of movement and growth rates using conventional tags	Holt, Yokawa, NTU
	b) Determine patterns of movement and behavior using archival and PSAT tags	Musyl, Yokawa, Saito, NTU
	STOCK STRUCTURE:	
	a) Set priorities for reanalysis of genetics samples and collect samples of young swordfish from specific areas	Hinton, Yokawa, Sun, Humphreys, Chow
	b) Assess the use of otolith elemental composition to uniquely identify geographically separate nursery areas in juvenile swordfish	Humphreys, Yokawa

Attachment 4. Future Work Plan of the ISC4 Swordfish Working Group (continued).

Objective	Research Project	Collaborators
2. Develop and apply stock assessment models	a) Develop and apply integrated, spatially-explicit models of stock and fishery dynamics incorporating effects of environment, gear, fishing practices, fleet dynamics, and other factors.	Kleiber, Bigelow, Yokawa, Hinton
	b) Develop sex-specific age-structured model	Sun, Yokawa, Conser, Kleiber
3. Develop, test, and apply basin-scale swordfish simulation model	Use simulator to help develop and evaluate stock assessment models	Kleiber, Bigelow, Yokawa, Hinton
4. Develop comprehensive swordfish fishery database	a) Construct abundance indices for major fisheries in the North Pacific	Hinton, Kleiber, Yokawa, Sun
	b) Incorporate swordfish statistics for all fisheries catching swordfish in the North Pacific but not yet included in the database.	ISC Database Administrator