



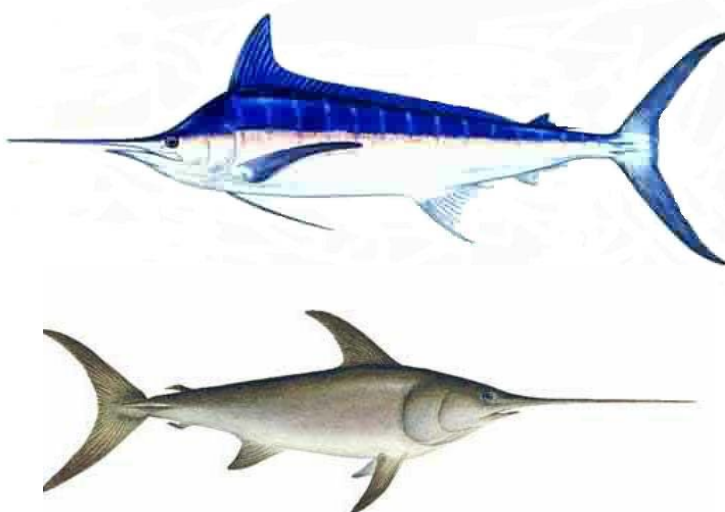
ISC/08/BILLWG-SS/05

Review and Bibliography of Recent Swordfish Stock Assessment Methods and Available Data for North Pacific Ocean

Dean Courtney
NOAA Fisheries
Pacific Islands Fisheries Science Center
2570 Dole St., Honolulu, HI 96822, USA

Gakushi Ishimura
NOAA Fisheries PIFSC Visiting Scientist
National Research Institute of Far Seas Fisheries
5-7-1 Orido, Shimizu, Shizuoka, Japan 424-8633

Lyn Wagatsuma
Joint Institute of Marine and Atmospheric Research
2570 Dole St., Honolulu, HI 96822, USA



DRAFT - 11/10/08, ISC BWG

**Review and Bibliography of Recent Swordfish Stock Assessment Methods
and Available Data for the North Pacific Ocean**

Dean Courtney¹, Gakushi Ishimura², Lyn Wagatsuma¹

¹Pacific Islands Fisheries Science Center, NOAA Fisheries, Honolulu, Hawaii

²Center for Sustainability Science, Hokkaido University, Japan

Draft

November, 2008

1. Recent Swordfish Stock Assessments in the Pacific Ocean

A bibliography of recent swordfish stock assessment primary and grey literature in the North Pacific Ocean (NPO), eastern Pacific Ocean (EPO) and south-west Pacific (SWP) are listed in Appendix A.

1.1 Swordfish Stock Assessments in the North Pacific Ocean (NPO)

1.1.1 ISC Swordfish Stock Assessments

Three North Pacific swordfish stock assessments have been conducted for the International Scientific Committee (ISC) for Tuna and Tuna-like Species in the North Pacific Ocean (Appendix A). The population dynamics models used included a preliminary surplus production model with ADModel Builder software (ISC/99/2.2; ISC2/99/PLEN/11) and more sophisticated statistical catch-at-age models with length composition using MULTIFAN-CL (ISC3/SWO-WG/02; ISC3/2002/09 and ISC/04/SWO-WG/07). In addition, simulated data were used to test the sensitivity of the MULTIFAN-CL swordfish model (ISC/04/SWO-WG/08). The 2004 MULTIFAN-CL assessment is reviewed here.

The 2004 MULTIFAN-CL assessment model was size/age-structured, sex-combined, and iterated at a quarterly time-step. Fourteen fisheries (1952-2003) were defined in four regions. Japanese longline (JLL) accounted for eight of the fisheries consisting of two target types in each of four regions. The two target types were night (shallow swordfish targeted night type) and other (deeper fishery that developed starting in 1970). The Hawaii longline was kept distinct from Japanese longline and divided into northeast and southeast sectors for another two fisheries roughly corresponding to swordfish targeting in the north and tuna targeting in the south. North Pacific driftnet fisheries in each region accounted for another four fisheries. Shared catchability across regions (e.g., within JLL-night, JLL-other, and Drift) implied that the same CPUE in two different regions corresponded to an equivalent density (fish per unit surface area) and allowed for the relative abundance of different regions to be linked. CPUE was interpreted as an index of relative abundance by assigning a unit of area (or volume) for each region and multiplying density by area to obtain relative abundance in numbers (i.e., number = density X area).

The 2004 MULTIFAN-CL model fits, including estimation of natural mortality, were sensitive to model structure. The assessment authors and the ISC Swordfish Working Group (SWG) concluded that model sensitivity was due to a lack of signal rather than a problem with model specification (ISC/04/SWO-WG/07; ISC/04/SWO-WG/08; ISC4/2004/07). Two alternative hypotheses were presented to explain the lack of signal in the data: either i) incomplete or inaccurate data or ii) low fishing mortality.

1.1.2 Relevance to the 2008 ISC BWG Swordfish Stock Assessment

If the lack of fishery signal in the 2004 assessment was due to incomplete or inaccurate data, then gains in model performance (reduced sensitivity to model structure) could be obtained in the current ISC Billfish Working Group (BWG) assessment cycle by

improving the quality of the data. Solutions designed to improve the data quality in the current ISC BWG assessment cycle include the following: i) Identification of population structure; ii) Updating of catch and effort data by fishery within assumed population structure; iii) Using alternative structural models of the population dynamics to test for sensitivity to model structure as well as signal in the data.

Additionally, if the lack of signal in the 2004 assessment data was due to a lack of contrast in the data, then incorporation of recent swordfish catch and effort data from the 2000 – 2004 Hawaii longline (HLL) moratorium may provide additional contrast. In particular, if the moratorium was of sufficient magnitude to reduce fishing effort and increase CPUE, then the resulting “signal” in the data may result in reduced model sensitivity to model structure and provide a better estimate of stock productivity.

1.1.3 Independent Swordfish Stock Assessments

Swordfish stock assessments for the North Pacific have also been evaluated independently (Wang et al. 2005; 2007; Appendix A), but were not reviewed in detail here.

Wang et al. (2005; 2007) appeared to have used a similar model and data structure as that used by the 2004 ISC assessment reviewed above, except that the models included sexual dimorphism. Wang et al. (2005; 2007) model results also appeared to suggest a lack of signal in the North Pacific swordfish fishery CPUE data. An additional caveat was model sensitivity to sexual dimorphism. As a result, the effect of sexual dimorphism should be evaluated in current ISC BWG assessment cycle, if possible.

Biological reference points ($F_{40\%}$ and $F_{0.1}$) for swordfish in the waters around Taiwan were also estimated independently from yield per recruit analysis (Sun et al. 2005).

1.2 Swordfish Stock Assessments in the Eastern Pacific Ocean (EPO)

1.2.1 IATTC Swordfish Stock Assessments

Swordfish stock assessments for the eastern Pacific Ocean (EPO) have been conducted by the Inter-American Tropical Tuna (IATTC) (IATTC Document SAR-5-05 SWO, IATTC Document SAR-7-07d, IATTC Document SAR-8-11, Appendix A), but were not reviewed in detail here.

EPO swordfish assessments methods have included the Deriso-Schnute delay difference model (Hinton and Deriso 1998) and standardized CPUE with GLMs and log-linear models (Hinton 2003) in a northern and southern region of the EPO (IATTC Document SAR-5-05 SWO), and size/age-structured stock assessment with SS2 (IATTC Document SAR-7-07d). The size/age-structured stock assessment with SS2 was single stock (spatial structure in a northern and southern region of the EPO was not included in the population dynamics) and sexually dimorphic (sexual dimorphism was included in length-at-age but a common weight-at-length relationship was used). Results of the size/age structured stock assessment with SS2 appeared to indicate a conflict between apparent trends in

CPUE between offshore and coastal fisheries. Stock structure of swordfish in the Pacific Ocean was also analyzed (IATTC Document SAR-8-11).

1.3 Comparison to Recent Swordfish Stock Assessments in the South-West Pacific Ocean (SWP)

1.3.1 WCPFC Swordfish Stock Assessments

Two South-West Pacific swordfish stock assessments have been conducted for the Western and Central Pacific Fisheries Commission (WCPFC) Scientific Committee (SC). The first in 2006 was limited to the South-West Pacific Ocean (SWP) and the second in 2008 included the SWP and South-Central Pacific Ocean (SCP). In 2006, two models (MULTIFAN-CL and CASAL) were used to assess SWP swordfish between the years 1952-2004 (WCPFC-SC2-2006/ME WP-3; WCPFC-SC2-2006/ME WP-4; WCPFC-SC2-2006/SA WP-7). In 2008, the same two models (MULTIFAN-CL and CASAL) were used to assess SWP and SCP swordfish between the years 1952-2007 (WCPFC-SC4-2008/SA-WP-6; WCPFC-SC4-2008/SA-WP-7). The 2008 MULTIFAN-CL assessment is reviewed here.

The 2008 MULTIFAN-CL assessment model was age-structured, sex-aggregated, single stock, iterated at a quarterly time-step, and spatially disaggregated into two roughly equal longitudinal units. Each longitudinal unit was further spatially disaggregated into northern, central, and southern zones of assumed homogenous fishery CPUE. Shared catchability across areas (e.g., Japanese longline CPUE) implied that the same CPUE in two different areas corresponded to an equivalent density (fish per unit surface area) and allowed for the relative abundance of different regions to be linked. CPUE was interpreted as relative abundance by assuming that the relative areas (or volumes) of each region were equal, (i.e., number = density X area). Earlier exploration indicated that model runs were not sensitive to alternative relative area options: i) the geographical surface area as defined on a map, ii) the maximum extent of the historically fished area, or iii) the maximum range in which swordfish were caught historically (WCPFC-SC2-2006/ME WP-3; WCPFC-SC2-2006/ME WP-4; WCPFC-SC2-2006/SA WP-7).

A total of 768 model specifications were explored within the SWP with 11 fisheries and 4 informative effort (CPUE) series. The stock status summary for the SWP represented a synthesis of 192 model runs that were judged to be plausibly consistent with the data and prior expectations of swordfish fisheries and biology. The data were not sufficient to estimate a stock recruitment relationship reliably and suggested some form of long term recruitment variability. However, model uncertainty was reduced relative to previous assessments. Two factors were identified that may have contributed to what the assessment authors characterized as a “perception of reduced uncertainty”: i) recent informative contrast between declines in catch and effort resulting in stock rebuilding, and ii) simplified spatial structure relative to earlier models. A “perception” of reduced uncertainty could have resulted from reduced model complexity (simplified spatial structure) as well as real reductions in model uncertainty gained from informative contrast in the data. The new spatial structure was based partly on PSAT tags in the SW Pacific and elsewhere suggesting directed seasonal migrations between the spawning and

foraging grounds that could be represented in the SWP by seasonal catchability without the need to explicitly partition areas.

A total of 144 model runs were explored within the combined SCP and SWP. However, there were no informative signals in either the CPUE or size composition data with which to quantify the estimation of stock productivity.

2. Available Data for North Pacific Swordfish Stock Assessments

2.1 Catch and CPUE

NPO swordfish catch statistics have been compiled in working papers and reports for the ISC. These data along with estimates of standardized CPUE will be updated by the member countries following the stock structure identified ISC BWG, and used as model input.

2.2 Life History and Biological Data

A very preliminary bibliography of primary and grey literature relevant to swordfish life history and biological data in the NPO are listed in Appendix B. Length at age for swordfish (LVB) are apparently currently available for males and females separately from the northwest, north-central and eastern Pacific Ocean (Appendix B). Research objectives for age, growth, and length at 50% reproductive maturity for NPO swordfish are reviewed in a previous ISC document (ISC/08/BILLWG-2/06). Recent comparative work regarding methodological differences among laboratories suggests caution when interpreting regional differences in swordfish life history (WCPFC-SC4-2008/BI-IP-2). Reproductive activity is reviewed in WCPFC-SC4-2008/BI-WP-6, and age and growth are reviewed in WCPFC-SC4-2008/BI-WP-1.

3. Potential software tools for the stock assessment of North Pacific swordfish

Here, we review two potential software applications for the Pacific swordfish stock assessment.

3.1 Bayesian Surplus Production Model with Importance Re-sampling (BSP)

BSP is a software package developed by Babcock and McAllister for tuna and tuna-like species stock assessment with the International Commission for the Conservation of Atlantic Tunas (ICCAT). BSP fits Bayesian/ non- Bayesian surplus production models (Schaefer or generalized) to the CPUE data by sampling/importance re-sampling (SIR) algorithm (Babcock and McAllister, 2003). With estimated parameters from the posterior distributions, users can conduct population projections and decision analysis. BSP requires a time series of catch and CPUE data, and a set of prior distributions of parameters in a case of fitting a Bayesian surplus production model. BSP was applied for the stock assessment of Pacific striped marlin assessment (ISC/05/MAR-WG/08 2005).

3.2 Size/Age-Structured Statistical Catch-at-Age with Stock Synthesis-2 (SS2)

SS2 is an age-structured population assessment tool available from the NOAA Fisheries Toolbox. SS2 includes a population simulation model to calculate the abundance and

mortality of a harvested population, an observation model to relate this population model to observable data from the population, and a statistical model to adjust parameters of the population model and observation model to achieve the best fit to all the data. SS2 has both an age-structured and a size/age-structured version. Both are capable of simultaneously examining data from several fisheries and several surveys, each with its own pattern of selectivity (Methot 2000). The size/age-structured version of SS2 has been implemented for stock assessment of swordfish in the EPO, striped marlin in the NPO, and bigeye tuna in the SCP and SWP (IATTC Document SAR-7-07d, ISC/07/MARWG&SWOWG-1/02, WCPFC-SC4_2008/SA-WP-2). Stock assessment results from the size/age-structured version of SS2 were comparable to those obtained with MULTIFAN-CL run on the same data (WCPFC-SC4_2008/SA-WP-2).

The size/age-structured version of SS2 adds a body size dimension to the population. This allows fuller use of size-based data. In the size/age-structured version of SS2, the population model includes: age and size dimensions through inclusion of an explicit growth function, selectivity patterns as functions of size and/or age, and body weight-at-age calculated from the interaction of size-selectivity and the modeled probability distribution of size-at-age. Geographic stock structure may not yet be included in the size/age-structured version of SS2. However a beta-version of SS3 is also available the may include a geographic option in the size/age-structured model.

Data requirements for the size/age-structured version of SS2 include the a time series of catch and CPUE data as needed for BSP plus time series of length and/or age frequency. Additionally, SS2 requires specification or estimation of length at age and weight at length relationships and age or length at 50% reproductive maturity. If sexual dimorphism and/or geographic stock structure are included, then sufficient data within each sexual morph and/or geographic stratum are required.

Literature Cited

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- Hinton, M.G. Deriso, R. 1998. Distribution and stock assessment of swordfish, *Xiphias gladius*, in the eastern Pacific Ocean from catch and effort data standardised on biological and environmental parameters. In: Barrett, I.; Sosa-Nishizaki, O.; Bartoo, N. (Eds.). 1998. Biology and fisheries of swordfish, *Xiphias gladius*. Papers from the International Symposium on Pacific Swordfish, Ensenada, Mexico, 11-14 December 1994. U.S. Dep. Commer., NOAA Technical Report NMFS 142: 161-179
- Hinton, M. G. 2003. Status of swordfish stocks in the eastern Pacific Ocean estimated using data from Japanese tuna longline fisheries. *Marine and Freshwater Research* 54(4) 393-399.
- IATTC Document SAR-5-05 SWO. Hinton, M. G., W. H. Bayliff, and J. M. Suter. 2005. Assessment of swordfish in the eastern Pacific Ocean. Inter. Amer. Trop. Tuna Comm. Stock Assessment Report 5-05 SWO.
- IATTC Document SAR-7-07d. Hinton, M.G.; Maunder, M.N. 2006. Status of the swordfish stock in the southeastern Pacific Ocean. Inter.-Amer. Trop. Tuna Comm. Stock Assessment Report 7: 249-282.
- IATTC Document SAR-8-11. Hinton, M.; Alvarado Bremer, J. 2007. Stock structure of swordfish in the Pacific. Working Group to review stock assessments. 8th Meeting, La Jolla, California, 7-11 May 2007. SAR-8-11. 11p.
- ISC/99/2.2. 1999. Very preliminary North Pacific swordfish assessment. Swordfish Working Group Meeting January 15-16, 1999. (P. Kleiber).
- ISC2/99/PLEN/11. 1999. Report of Swordfish Working Group Meeting 15-16 January 1999. (Anon.)
- ISC3/SWO-WG/02. 2002. Stock assessment of swordfish in the North Pacific using Multifan-CL. Swordfish Working Group Meeting, January 25-26, 2002. (P. Kleiber, K. Yokawa)
- ISC3/2002/09. 2002. Report of the Swordfish Working Group Meeting, January 25-26, 2002. (Anon.)
- ISC/04/SWO-WG/07. 2004. MULTIFAN-CL Assessment of swordfish in the North Pacific. Swordfish Working Group, January 29 and 31, 2004. (P. Kleiber, K. Yokawa)

ISC/04/SWO-WG/08. 2004. Evaluating the reliability of MULTIFAN-CL assessments of the North Pacific Swordfish swordfish population. Working Paper. Swordfish Working Group, January 29 and 31, 2004. (K. Bigelow, P. Kleiber).

ISC4/2004/07. 2004. Report of the Swordfish Working Group, January 29 and 31, 2004. (Anon.)

ISC/05/MAR-WG/08. 2005. Development of an Informative Prior "r", the intrinsic rate of population increase, for striped marlin (*Tetrapturus audax*). Working Paper. Marlin Working Group, September 30, 2005.

ISC/07/MARWG&SWOWG-1/02. 2007. SS2 Sensitivity runs for striped marlin assessment WG 2007. (K. Piner, R. Conser, G. DiNardo, J. Brodziak).

ISC/08/BILLWG-2/06. 2008. Draft ISC Billfish Research Plan: Research on Future Age and Growth and Length at 50% Reproductive Maturity Studies. (Anon.).

Labelle, M. 2002. An operational Model to evaluate assessment and management procedures for the North Pacific swordfish fishery. NOAA Technical Memorandum NMFS. NOAA-TM-NMFS-SWFSC-341.

Methot R. D. 2000. Technical description of the stock synthesis assessment program. NOAA Technical Memorandum NMFS-NWFSC-43.

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Sun, C.-L., Wang, S.-P., Porch, C.E., and Yeh, S.-Z. 2005. Sex-specific yield per recruit and spawning stock biomass per recruit for the swordfish, *Xiphias gladius*, in the waters around Taiwan. Fisheries Research 71:61-69.

Wang, S.-P., Sun, C.-L., Punt, A., and Yeh, S.-Z. 2005. Evaluation of a sex-specific age-structured assessment method for the swordfish, *Xiphias gladius*, in the North Pacific Ocean. Fisheries Research 73:79-97.

Wang, S., Sun, C., Punt, A., and Yeh, S. 2007. Application of the sex-specific age-structured assessment method for swordfish, *Xiphias gladius*, in the North Pacific Ocean. Fisheries Research 84:282-300.

WCPFC-SC2-2006/SA WP-7. 2006. South-west Pacific swordfish stock status summary from multiple approaches. WCPFC Scientific Committee Second Regular Session. August, 2006. (D. Kolody, N. Davies, R. Campbell).

WCPFC-SC2-2006/ME WP-3. 2006. A MULTIFAN-CL stock assessment for south-west Pacific swordfish 1952-2004. WCPFC Scientific Committee Second Regular Session. August, 2006. (D. Kolody, R. Campbell, N. Davies).

WCPFC-SC2-2006/ME WP-4. 2006. CASAL stock assessment for south-west Pacific swordfish 1952-2004. WCPFC Scientific Committee Second Regular Session. August, 2006. (N. Davies, R. Campbell, D. Kolody).

WCPFC-SC4-2008/BI-IP-2. 2008. Comparison of maturity and ageing of swordfish from Hawaiian and Australian waters. WCPFC Scientific Committee Fourth Regular Session. August, 2008. (J. Young, R. Humphreys, J. Uchiyama, and N. Clear).

WCPFC-SC4-2008/BI-WP-1. 2008. Age and growth of swordfish (*Xiphias gladius*) in North Pacific. (X. Valeiras, J. Mejuto, M. Ruiz).

WCPFC-SC4-2008/BI-WP-6. 2008. Reproductive activity of swordfish (*Xiphias gladius*) in the Pacific Ocean on the basis of different macroscopic indicators. (J. Mejuto, B. Garcia-Cortes, A. Ramos-Cartelle).

WCPFC-SC4-2008/SA-IP-2. 2008. Spatial structure in South Pacific swordfish stocks and assessment models. WCPFC Scientific Committee Fourth Regular Session. August, 2008. (D. Kolody, N. Davis).

WCPFC-SC4-2008/SA-IP-3. 2008. Data summary pertaining to the catch of swordfish by longline fleets operating in the southern WCPO. WCPFC Scientific Committee Fourth Regular Session. August, 2008. (R. Campbell)

WCPFC-SC4_2008/SA-WP-2. 2008. A preliminary stock assessment of bigeye tuna in the western and central Pacific Ocean using Stock Synthesis: A comparison with MULTIFAN-CL. WCPFC Scientific Committee Fourth Regular Session. August, 2008. (A. Langley, R. Methot).

WCPFC-SC4-2008/SA-WP-6. 2008. A MULTIFAN-CL stock assessment of south-west Pacific swordfish 1952-2007. WCPFC Scientific Committee Fourth Regular Session. August, 2008. (D. Kolody, R. Campbell, N. Davies).

WCPFC-SC4-2008/SA-WP-7. 2008. CASAL Stock assessment for south-west-central Pacific broadbill swordfish 1952-2007. WCPFC Scientific Committee Fourth Regular Session. August, 2008. (N. Davis, R. Bian, D. Kolody, R. Campbell).

Appendix A – Bibliography of Recent Swordfish Assessments

North Pacific Ocean (NPO)

The International Scientific Committee (ISC) for tuna and tuna-like species in the North Pacific Ocean (originally the Interim Scientific Committee or ISC; <http://isc.ac.affrc.go.jp>) has conducted swordfish stock assessments in the NPO. Three preliminary swordfish assessments have been conducted in the NPO for the ISC in 1999, 2002 and 2004 (listed below). Supporting working papers and reports for the ISC swordfish assessments are listed in Table 1.

ISC 02 (1999)

ISC/99/SWOWG/2.2 A Very Preliminary North Pacific Swordfish Assessment

D:\00_literature_Hawaii\01_Swordfish_literature\ISC02\ISC_02_SWO-WG_2.pdf

Summarized in

ICS2/99/PLEN/11 Report of the swordfish Working Group Meeting

http://isc.ac.affrc.go.jp/rep/isc_sw01.pdf

ISC 03 (2002)

ISC_03_SW0-WG_02 Stock Assessment of Swordfish in the North Pacific using MULTIFAN-CL

D:\00_literature_Hawaii\01_Swordfish_literature\ISC03\ISC_03_SW0-WG_02.pdf

Summarized in

http://isc.ac.affrc.go.jp/rep/isc_sw02.pdf

ISC 04 (2004)

ISC/04/SWO/07 MULTIFAN-CL Assessment of Swordfish in the North Pacific

D:\00_literature_Hawaii\01_Swordfish_literature\ISC04\ISC_04_SWO_07.pdf

Summarized in

<http://isc.ac.affrc.go.jp/rep/ISC4Plenary07SWO.pdf>

Independent assessments for the NPO swordfish have also been published in the primary literature (Wang et al. 2005 and 2007). Supporting life history information and the calculation of yield per recruit are provided from the Waters around Taiwan (Sun et al 2002 and 2005 Wang et al. 2003). The North Pacific swordfish model and data structure appear to follow the 2004 ISC swordfish assessment with the addition sexual dimorphism.

Sun, C.-L., Wang, S.-P., and Yeh, S.-Z. (available in pdf) 2002. Age and Growth of the Swordfish (*Xiphias Gladius* L.) In the Waters Around Taiwan Determined From Anal-Fin Rays. Fishery bulletin [fish. Bull.]. Vol. 100.

Sun, C.-L., Wang, S.-P., Porch, C.E., and Yeh, S.-Z. (available in pdf). 2005. Sex-Specific Yield Per Recruit and Spawning Stock Biomass Per Recruit for the Swordfish, *Xiphias Gladius*, in the Waters Around Taiwan. Fisheries research (amsterdam) [fish. Res.]. Vol. 71.

Wang, S.-P., Sun, C.-L., Punt, A., and Yeh, S.-Z. (available in pdf). 2005. Evaluation of a Sex-Specific Age-Structured Assessment Method for the Swordfish, *Xiphias Gladius*, in the North Pacific Ocean. Fisheries research (amsterdam) [fish. Res.]. Vol. 73.

Wang, S.-P., Sun, C.-L., and Yeh, S.-Z. (need pdf). 2003. Sex Ratios and Sexual Maturity of Swordfish (*Xiphias Gladius* L.) In the Waters of Taiwan. Zoological studies [zool. Stud.]. Vol. 42.

Wang, S., Sun, C., Punt, A., and Yeh, S. (available in pdf). 2007. Application of the Sex-Specific Age-

Structured Assessment Method for Swordfish, *Xiphias Gladius*, in the North Pacific Ocean. Fisheries research (amsterdam) [fish. Res.]. Vol. 84.

Eastern "Tropical" Pacific Ocean (EPO)

The IATTC (<http://www.iattc.org>) has conducted swordfish assessments in the EPO.

Hinton, M.G. Deriso, R. 1998. (*Available in pdf*) Distribution and stock assessment of swordfish, *Xiphias gladius*, in the eastern Pacific Ocean from catch and effort data standardised on biological and environmental parameters. In: Barrett, I.; Sosa-Nishizaki, O.; Bartoo, N. (Eds.). 1998. Biology and fisheries of swordfish, *Xiphias gladius*. Papers from the International Symposium on Pacific Swordfish, Ensenada, Mexico, 11-14 December 1994. U.S. Dep. Commer., NOAA Technical Report NMFS 142: 161-179

Hinton, M. G. 2003. (*Available in pdf*) Status of swordfish stocks in the eastern Pacific Ocean estimated using data from Japanese tuna longline fisheries. Marine and Freshwater Research 54(4) 393-399.

IATTC Document SAR-5-05 SWO. Hinton, M. G., W. H. Bayliff, and J. M. Suter. 2004. (*Available in pdf*) Assessment of swordfish in the eastern Pacific Ocean. Inter. Amer. Trop. Tuna Comm. Stock Assessment Report 5-05 SWO. http://www.iattc.org/PDFFiles2/SAR5%20SWO_%20ENG.pdf

IATTC Document SAR-7-07d. Hinton, M.G.; Maunder, M.N. 2006. (*Available in pdf*) Status of the swordfish stock in the southeastern Pacific Ocean. Inter.-Amer. Trop. Tuna Comm. Stock Assessment Report 7: 249-282. www.iattc.org/PDFFiles2/SAR-7-07d-SWO-assessment-2005.pdf

IATTC Document SAR-8-11. Hinton, M.; Alvarado Bremer, J. 2007. (*Available in pdf*) Stock structure of swordfish in the Pacific. Working Group to review stock assessments. 8th Meeting, La Jolla, California, 7-11 May 2007. SAR-8-11. 11p. www.iattc.org/PDFFiles2/SAR-8-11-SWO-stock-structure.pdf

The U.S. NMFS SWFC monitors highly migratory species within the EEZ of the Pacific Coast of the U.S., including stock assessments conducted by the IATTC and ISC and produces a report for U.S. Pacific Fishery Management Council (PFMC; <http://www.pcouncil.org/>). The SAFE is limited to reporting the IATTC 2004 EPO swordfish assessment and anticipating the ISC (2008) NPO swordfish assessment

2006 Stock Assessment and Fishery Evaluation (SAFE) of Pacific Highly Migratory Species (HMS) <http://www.pcouncil.org/hms/hmssafe/0906safe.html>

South-West Pacific (SWP) and South-Central Pacific (SCP)

The Western and Central Pacific Fisheries Commission (WCPFC) has conducted swordfish assessments in the SWP and SCP (<http://www.wcpfc.int>).

Two swordfish assessments for the SWP have been conducted for the WCPFC SC, the first in 2006 and the second in 2008 (listed below). Supporting working papers and reports for the SC swordfish assessments are listed in Table 2.

WCPFC-SC2-2006/SA WP-7 SOUTH-WEST PACIFIC SWORDFISH STOCK STATUS SUMMARY FROM MULTIPLE APPROACHES
http://www.wcpfc.int/sc2/pdf/SC2_SA_WP7.pdf

WCPFC-SC2-2006/ME WP-3 A MULTIFAN-CL STOCK ASSESSMENT FOR SOUTH-WEST PACIFIC SWORDFISH 1952-2004
http://www.wcpfc.int/sc2/pdf/SC2_ME_WP3.pdf

WCPFC-SC2-2006/ME WP-4 CASAL STOCK ASSESSMENT FOR SOUTH-WEST PACIFIC
BROADBILL SWORDFISH 1952-2004

http://www.wcpfc.int/sc2/pdf/SC2_ME_WP4.pdf

WCPFC-SC4-2008/SA-WP-6. A MULTIFAN-CL STOCK ASSESSMENT OF SOUTH-WEST PACIFIC
SWORDFISH 1952-2007

[http://www.wcpfc.int/sc4/pdf/SC4-SA-WP6_\[SWO_MFCL_revision_1\].pdf](http://www.wcpfc.int/sc4/pdf/SC4-SA-WP6_[SWO_MFCL_revision_1].pdf)

WCPFC-SC4-2008/SA-WP-7. CASAL Stock Assessment for South-West-Central Pacific Broadbill
Swordfish 1952-2007.

http://www.wcpfc.int/sc4/pdf/SC4-SA-WP7_SWO_CASAL.pdf

Relevance of New Zealand swordfish assessment?

A New Zealand Fisheries Plenary Review of the 2006 WCPFC assessment was conducted for New Zealand. New Zealand Fisheries Plenaries summarize biological, fishery, stock assessment and stock status information for 80 species or species groups within the New Zealand EEZ, each of which is split into 1-10 stocks. The Plenary takes into account the most recent data and analyses available to Fisheries Assessment Working Groups (FAWGs) and the Fisheries Assessment Plenary and also incorporates relevant analyses undertaken in previous years.

<http://fpcs.fish.govt.nz/Science/Plenary.aspx>

http://services.fish.govt.nz/fishresourcespublic/Plenary2007/SWO_07.pdf

Relevance of Australia and Indian Ocean Swordfish Assessments?

A review of the 2006 WCPFC swordfish assessment methodology was conducted for the IOTC in preparation for an Indian Ocean swordfish stock assessment

<http://www.iotc.org/files/proceedings/2006/wpb/IOTC-2006-WPB-08.pdf>

ICCAT?

Kimura, D.K.; Scott, G.P. 1994. Length-based separable sequential population analysis as applied to swordfish (*Xiphias gladius*). SCRS/1993/051. Col.Vol.Sci.Pap. ICCAT, 42 (1) : 85-96.

Table 1. Relevant ISC Swordfish Working Papers and Reports¹

Time Table

ISC01 – 1996

ISC02 – 1999, *SWG

ISC03 – 2002, *SWG

ISC04 – 2004, *SWG

ISC05 – 2005

ISC06 – 2006, **Background on STATWG, Operations Manual, Biol Ref Points

ISC07 – 2007, **Background Report of IATTC swordfish assessments

ISC08 – 2008, ***Working Papers relevant to 2009 Swordfish Assessment

****May also want to look at Striped Marlin Working Group Reports

2004 ISC4/2004/08 – Report of the Marlin Working Group, January 30 and 31, 2004.

Working Papers and Reports

*ISC2/99/PLEN/11 – Report of Swordfish Working Group Meeting 15-16 January 1999.

*ISC/99/2.2 – Very preliminary North Pacific swordfish assessment. *P. Kleiber*. Working Paper. Swordfish *ISC3/2002/09 – Report of the Swordfish Working Group Meeting, January 25-26, 2002.

*ISC3/SWO-WG/02 – Stock assessment of swordfish in the North Pacific using Multifan-CL. Working

*ISC4/2004/07 – Report of the Swordfish Working Group, January 29 and 31, 2004.

*ISC/04/SWO-WG/07 – MULTIFAN-CL Assessment of swordfish in the North Pacific. *Kleiber, P., Yokawa, K.* Working Paper. Swordfish Working Group, January 29 and 31, 2004.

*ISC/04/SWO-WG/08 – Evaluating the reliability of MULTIFAN-CL assessments of the North Pacific Swordfish swordfish population. *Bigelow, K. Kleiber, P.* Working Paper. Swordfish Working Group, January 29 and 31, 2004.

**ISC08 Background Report of IATTC swordfish retained catch on page 82 and 83

***ISC 08 Report of the Billfish Working Group.

***ISC/08/BILLWG-2/08 – Generalized Additive Model Analyses to Standardize Swordfish (*Xiphias gladius*) Catch Rates in the Hawaii-based Longline Fishery, 1995-2006

***ISC/08/BILLWG-2/02 U.S – Swordfish Fisheries in the North Pacific Ocean.

***ISC/08/BILLWG-2/06 – Draft ISC Billfish Research Plan: Research of Future Age & Growth and Length at 50% Reproductive Maturity Studies

***ISC/08/BILLWG-2/07 – Update of the Catch per Unit Effort distribution of Swordfish (*Xiphias gladius*) by the Japanese offshore and distant-water longline fishery in the Pacific.

***ISC/08/BILLWG-2/11 – A review of Taiwan's billfish fisheries in the North Pacific Ocean. ISC working paper

***ISC/08/BILLWG-2/12 – Standardization of Taiwanese distant water tuna longline catch rates for swordfish in the North Pacific, 1995-2006.

***ISC/08/BILLWG-2/13 – Preliminary economic overview of the swordfish longline

¹ ISC working papers and reports represent ongoing research and should not be cited without the individual author's permission.

Table 2. Relevant WCPFC Swordfish Working Papers and Reports²

Time Table

SC-1 (2005) * First Swordfish Assessment

SC-2 (2006) ** Second Swordfish Assessment

SC-3 (2007)

SC-4 (2008) *** Third Swordfish Assessment; **** Background Papers for Swordfish Assessment

Working Papers, Information Papers, and Reports

*WCPFC-SC1 SA WP-7. South-West Pacific Swordfish Assessment: 2005-6 Objectives and Preliminary Results.

http://www.wcpfc.int/sc1/pdf/SC1_SA_WP_7.pdf

*WCPFCSC1 SA WP6. Annual indices of swordfish availability in the south-west Pacific.

http://www.wcpfc.int/sc1/pdf/SC1_SA_WP_6.pdf

**WCPFC-SC2-2006/SA WP-7. SOUTH-WEST PACIFIC SWORDFISH STOCK STATUS SUMMARY FROM MULTIPLE APPROACHES http://www.wcpfc.int/sc2/pdf/SC2_SA_WP7.pdf

***WCPFC-SC2-2006/ME WP-3. A MULTIFAN-CL STOCK ASSESSMENT FOR SOUTH-WEST PACIFIC SWORDFISH 1952-2004 http://www.wcpfc.int/sc2/pdf/SC2_ME_WP3.pdf

***WCPFC-SC2-2006/ME WP-4. CASAL STOCK ASSESSMENT FOR SOUTH-WEST PACIFIC BROADBILL SWORDFISH 1952-2004 http://www.wcpfc.int/sc2/pdf/SC2_ME_WP4.pdf

*** WCPFC-SC4-2008/SA-WP-6. A MULTIFAN-CL STOCK ASSESSMENT OF SOUTH-WEST PACIFIC SWORDFISH 1952-2007. http://www.wcpfc.int/sc4/pdf/SC4-SA-WP6_SWO_MFCL_revision_11.pdf

*** WCPFC-SC4-2008/SA-WP-7. CASAL Stock Assessment for South-West-Central Pacific Broadbill Swordfish 1952-2007. http://www.wcpfc.int/sc4/pdf/SC4-SA-WP7_SWO_CASAL.pdf

****WCPFC-SC4-2008/BI-WP-1. AGE AND GROWTH OF SWORDFISH (*Xiphias gladius*) IN NORTH PACIFIC.

http://www.wcpfc.int/sc4/pdf/SC4-BI-WP1_SWO_age_and_growth.pdf

**** WCPFC-SC4-2008/BI-IP-2. COMPARISON OF MATURITY AND AGEING OF SWORDFISH FROM HAWAIIAN AND AUSTRALIAN WATERS. http://www.wcpfc.int/sc4/pdf/SC4-BI-IP2_SWO_maturity_and_ageing.pdf

**** WCPFC-SC4-2008/BI-WP-6. REPRODUCTIVE ACTIVITY OF SWORDFISH (*Xiphias gladius*) IN THE PACIFIC OCEAN ON THE BASIS OF DIFFERENT MACROSCOPIC INDICATORS.

http://www.wcpfc.int/sc4/pdf/SC4-BI-WP6_SWO_productivity.pdf

****WCPFC-SC4-2008/SA-IP-1 REPORT OF THE SOUTHERN WCPO SWORDFISH ASSESSMENT WORKSHOP APRIL 16-18, 2008. http://www.wcpfc.int/sc4/pdf/SC4-SA-IP1_SWO_workshop.pdf

**** WCPFC-SC4-2008/SA-IP-2. SPATIAL STRUCTURE IN SOUTH PACIFIC SWORDFISH STOCKS AND ASSESSMENT MODELS. http://www.wcpfc.int/sc4/pdf/SC4-SA-IP2_SWO_Spatial.pdf

**** WCPFC-SC4-2008/SA-IP-3. DATA SUMMARY PERTAINING TO THE CATCH OF SWORDFISH BY LONGLINE FLEETS OPERATING IN THE SOUTHERN WCPO. http://www.wcpfc.int/sc4/pdf/SC4-SA-IP3_SWO_data_summary.pdf

****WCPFC-SC4-2008/SA-IP-4. SWORDFISH CPUE TRENDS ACROSS THE SOUTHERN WCPO.

http://www.wcpfc.int/sc4/pdf/SC4-SA-IP4_Swordfish_CPUE_trends.pdf

**** WCPFC-SC4-2008/SA-IP-4. STANDARDIZED CATCH RATES IN BIOMASS FOR THE SOUTH CENTRAL AND WESTERN PACIFIC SWORDFISH (*Xiphias gladius*) FROM THE SPANISH LONGLINE FLEET FOR THE PERIOD 2004-2006.

http://www.wcpfc.int/sc4/pdf/SC4-SA-WP5_SWO_catch_rates.pdf

**** WCPFC-SC4-2008/SA-IP-5 REPORT FROM THE STOCK ASSESSMENT PREPARATORY WORKSHOP, NOUMEA, FEBRUARY 2008. http://www.wcpfc.int/sc4/pdf/SC4-SA-IP5_SA_preparatory_workshop_report.pdf

**** WCPFC-SC4-2008/BI-WP-4. STOCK STRUCTURE OF SWORDFISH (*Xiphias gladius*) IN THE PACIFIC OCEAN USING MICROSATELLITE DNA MARKERS. http://www.wcpfc.int/sc4/pdf/SC4-BI-WP4_SWO_stock_structure.pdf

****WCPFC-SC4-2008/EB-IP-5. PRELIMINARY OVERALL ESTIMATIONS OF BYCATCH LANDED BY THE SPANISH SURFACE LONGLINE FLEET TARGETING SWORDFISH (*XIPHIAS GLADIUS*) IN THE PACIFIC OCEAN AND INTERACTION WITH MARINE TURTLES AND SEA BIRDS: YEARS 1990-2005.

http://www.wcpfc.int/sc4/pdf/SC4-EB-IP5_BYC-6-INF-A-ESP-SWO-fishery-bycatch.pdf

² WCPFC working papers and reports represent ongoing research and should not be cited without the individual author's permission.

Appendix B – Very Preliminary Bibliography of Swordfish Life History and Biological Data in the North Pacific Ocean

Table 1. Available North Pacific swordfish length at age.

	Northwest Pacific	Central Pacific		Eastern Pacific
Citation	Sun et al. (2002)	De Martini et al. (2007)		Castro-Longoria (1995)
Location	Taiwan	Hawaii		Mexico
Have a copy of paper?	Have	Have		Need
Model	Generalized LVB	LVB	Generalized LVB	
Sexes Combined				
L_{∞} (cm)	NA	NA	NA	
κ				
K (/yr)	NA	NA	NA	
t_0 (yr)	NA	NA	NA	
m	NA	NA	NA	
Females				
L_{∞} (cm)	300.66	230.5	227.2	
κ		0.246		
K (/yr)	0.040		0.524	
t_0 (yr)	-0.75	-1.24	-2.41	
m	-0.785		0.448	
Males				
L_{∞} (cm)	213.05	208.9	221.0	
κ		0.27		
K (/yr)	0.086		0.070	
t_0 (yr)	-0.626	-1.37	-0.15	
m	-0.768		-1.27	

Table 2. Available North Pacific swordfish length at 50% maturity.

	Northwest Pacific	Central Pacific	Eastern Pacific	
Citation	Wang et al. (2003)	De Martini et al. (2000)	Hinton (1996),	
Location	Taiwan	Hawaii	?	
Index type	Histological	Histological	Gonadal	
Have a copy of paper?	Need	Need	Need	
Sexes Combined	150 cm EFL 168cm LJFL	144 cm EFL 162 cm LJFL	?	
Females	?	?	?	
Males	?	102 cm EFL	?	

Castro-Longoria, R. 1995. (*Need pdf*) Analysis of age, growth, and gonadal maturity of swordfish, *Xiphias gladius*, in the Mexican Pacific longline fishery. PhD dissertation, 114 p. Departamento de Ecología, Division de Oceanología, Centro de Investigación Científica y de Educación Superior de Ensenada, Ensenada, Mexico [In Spanish].

DeMartini, E.E., J.H. Uchiyama, and H.A. Williams. 2000. (*Need pdf*) Sexual maturity, sex ratio, and size composition of swordfish, *Xiphias gladius*, caught by the Hawaii-based pelagic longline fishery. Fishery Bulletin 98:489-506.

DeMartini, E.E., J.H. Uchiyama, R.L. Humphreys Jr., J.D. Sampaga, and H.A. Williams. 2007. (*Have pdf*) Age and growth of swordfish (*Xiphias gladius*) caught by the Hawaii-based pelagic longline fishery. Fishery Bulletin 105:356-367.

Hinton, M.G., R.G. Taylor, and M.D. Murphy. 1996. (*Need pdf*) Use of gonad indices to estimate the status of reproductive activity of female swordfish, *Xiphias gladius*: a validated classification method. Fishery Bulletin 95:80-84.

Sun, C.-L., S.-P. Wang, and S.-Z. Yeh. 2002. (*Have pdf*) Age and growth of the swordfish (*Xiphias gladius* L.), in the waters around Taiwan determined from anal-fin rays. Fishery Bulletin 100:822-835.

Wang, S.-P., C.-L. Sun, and S.-Z. Yeh. 2003. (*Need pdf*) Sex ratios and sexual maturity of swordfish (*Xiphias gladius* L.) in the waters of Taiwan. Zoological Studies 42(4):529-539.