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**REPORT OF THE SOUTHERN WCPO SWORDFISH ASSESSMENT
WORKSHOP APRIL 16–18, 2008**

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Report of the Southern WCPO
Swordfish Assessment
Workshop

April 16–18, 2008

Secretariat for the Pacific Community
Noumea, New Caledonia

Report of the Southern WCPO Swordfish Assessment Workshop

Abstract

The *Southern WCPO Swordfish Assessment Workshop* was held at the Secretariat for the Pacific Community (SPC), Noumea, New Caledonia, April 16–18, 2008. The primary objectives of the meeting were to provide a technical review of data, analyses and stock assessment modelling assumptions underpinning the stock assessment of broadbill swordfish in the southern WCPO which is being undertaken by CSIRO (Australia) and NIWA (New Zealand) scientists during 2008. In addition to the workshop discussion, the report includes a summary of available fisheries data, relevant biological research, an agreed workplan for the assessment, and brief histories of the swordfish fisheries in the Cook Islands, New Caledonia and French Polynesia.

1. Introduction

The *Southern WCPO Swordfish Assessment Workshop* was held at the Secretariat for the Pacific Community (SPC), Noumea, New Caledonia, April 16–18, 2008. The meeting was chaired by Adam Langley of the SPC, and attended by 18 participants from a number of fishing nations and organizations throughout the Western and Central Pacific Ocean (WCPO). A list of meeting participants is provided as Attachment A.

The primary objectives of the meeting were to provide a technical review of data, analyses and stock assessment modelling assumptions underpinning the stock assessment of broadbill swordfish in the southern WCPO which is being undertaken by CSIRO (Australia) and NIWA (New Zealand) scientists during 2008. The assessment is being undertaken at the request of the Western and Central Pacific Fisheries Commission (WCPFC), in relation to WCPFC Conservation and Management Measure 2006-3, which places limits on the number of vessels permitted to target swordfish in the WCPFC convention area, south of 20°S:

...The Commission will review this measure in 2008, on the basis of advice from the scientific committee, following their consideration of an updated swordfish stock assessment that improves the understanding of stock structure and assesses the status of swordfish throughout its range and distribution in the South Pacific Ocean.

The process for obtaining the updated assessment was described in the report of the Commission meeting held in December 2007:

72. Some CCMs raised questions regarding a planned assessment of southwest Pacific swordfish. Australia proposed that this will be a full assessment led by Australia and New Zealand on behalf of the Commission, peer reviewed by SPC, and submitted to SC4 for further review and consideration of management actions. Scientists from all CCMs are encouraged to contribute relevant data analyses and biological insight to the assessment, and an informal workshop is being held at SPC in April 2008 to facilitate this exchange of ideas.”

The results of the assessment will be presented to the 4th meeting of the Scientific Committee for the WCPFC in August 2008. Future swordfish research priorities discussed by the workshop are also included.

This report consists of a number of relevant points agreed by all workshop participants, while short summaries of the relevant parts of various working and background papers have been included as extracted by the rapporteurs (Robert Campbell, Nick Davies and Dale Kolody). The working papers have been circulated to all participants and other interested parties, however, they should not be cited without prior approval by their respective authors, as many of these papers were informal, or in a draft form. The order of the report has been altered somewhat from the order on the agenda, to improve readability and reflect the fact that many working papers were relevant to multiple agenda items and iteratively revisited.

Working papers were also submitted by a number of individuals unable to attend the meeting. A list of working and background papers discussed by the workshop is provided in Attachment B. The Agenda for the workshop is provided as Attachment C. Summaries of data and research available to the assessment is summarized in tabular form in Attachment D. Brief descriptions of the swordfish fisheries in the Cook Islands, French Polynesia and New Caledonia are presented in Attachment E.

1a. Background to the 2008 Southern WCPO Swordfish Assessment

A review of the 2006 stock assessment was presented (Kolody et al. 2006, Davies et al. 2006). The assessment represented a diverse exploration of stock assessment models and biological assumptions (e.g. see Figure 1). The final stock status summary was based on an ensemble of Multifan-CL models that were plausibly consistent with the fisheries data (catch in numbers, standardized CPUE, size composition) and biological research available at the time. The model selection uncertainty and parameter estimation uncertainty from this ensemble indicated that the stock status was highly uncertain, particularly with respect to MSY-related reference points (Figure 2).

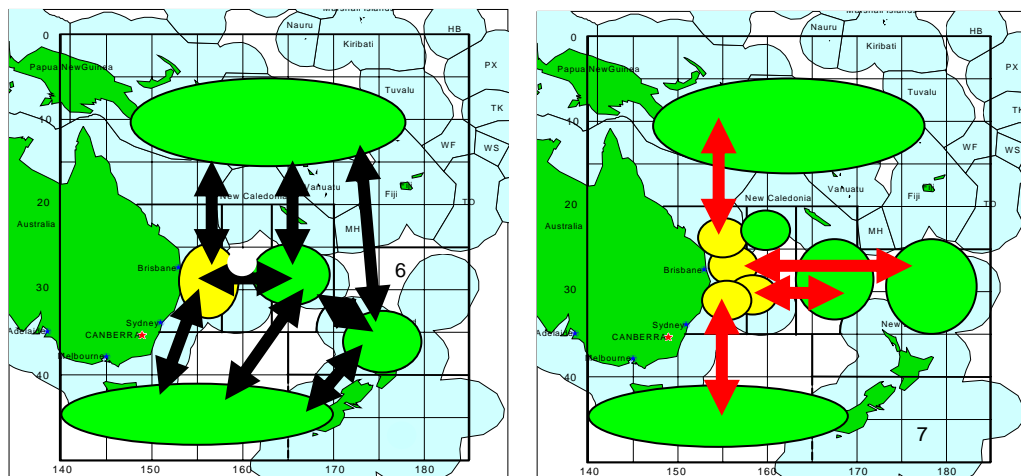


Figure 1. (from Kolody et al. 2006) Schematic representation of migration hypotheses and stock structure assumptions explored in the 2006 assessment. Left panel illustrates a conventional homogeneous mixing structure (as used in the final Multifan-CL

assessment), while the right panel illustrates a site fidelity model with migration to shared spawning grounds (explored in the Davies et al. 2006 CASAL assessment).

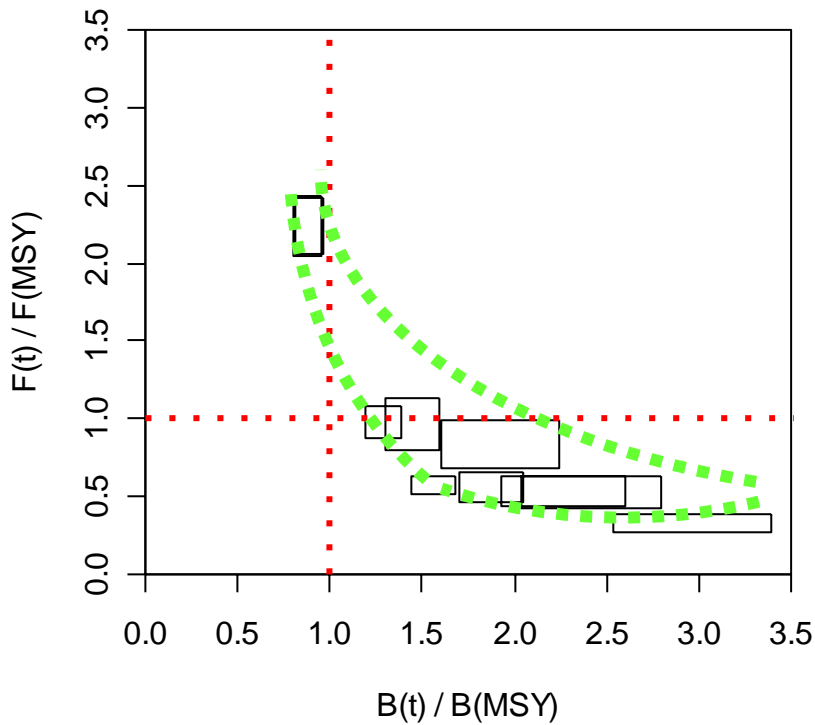


Figure 2. Plot of current biomass and current fishing mortality relative to MSY levels for the plausible ensemble. Each black box indicates the 95% confidence intervals (though not the correlation) associated with an individual model. The dashed (green) banana shape roughly outlines the space considered to be plausible (even though none of the models covered some of the region).

1b. Priority Issues identified from the 2006 Stock Assessment

A working paper summarized a number of issues that were identified in relation to the 2006 assessment (Kolody et al. 2008). These included:

The spatial domain of the 2006 assessment differed substantially from the management domain of CMM2006-3 (Figure 3).

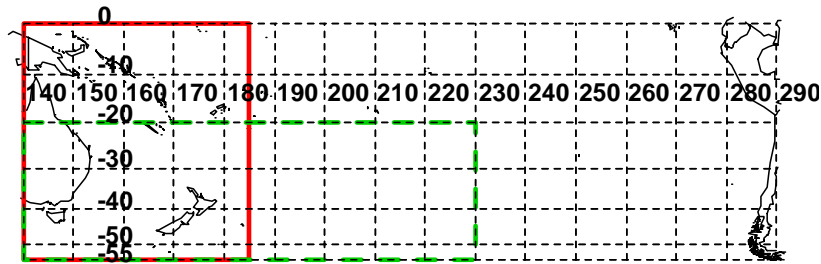


Figure 3. South Pacific map illustrating 2006 swordfish assessment domain (solid red box), and area of application of WCPFC Conservation and Management Measure 2006-3 (broken green box).

- 2) The data associated with the 2006 assessment extended only up to 2004, and the “one way trip” nature of the fishery history did not provide informative contrast to estimate stock productivity. In some key fisheries, recent declines in catch, and corresponding increases in CPUE may provide informative contrast to reduce productivity uncertainty.
- 3) Most large pelagic assessments are reliant on commercial CPUE trends as relative abundance indices, and are subject to biases from operational changes over time that cannot be easily detected or corrected. Additional data and analyses to help interpret catch rates is desirable.
- 4) The 2006 Multifan-CL assessment did not produce convincing estimates of seasonal migration within the sub-regions of the model. Conflicting trends in seasonal abundance between fleets that operate in the same region indicate a confounding between catchability and seasonal migration.
- 5) Growth (size-at-age) estimates used in the 2006 assessment for the SW Pacific swordfish stock suggest much slower growth rates compared to estimates from other Pacific populations. It is unclear whether this represents biological or methodological variation.
- 6) Maturity estimates from the SW Pacific indicate much older maturation than other studies in the Pacific (even after accounting for differences in age estimation).
- 7) Natural mortality is poorly quantified for swordfish.
- 8) Potential differences by sex in growth, maturity, mortality and migration are ignored in the assessment.

Using the CASAL modelling framework, one of a range of model structures explored in the 2006 assessment assumed migrations associated with spawning and site-fidelity. Under this scenario spawners migrated to a single area to spawn but then

returned to their respective foraging grounds (without mixing) from whence they originally recruited (Figure 1). This essentially represents separate stocks, remaining mostly in their foraging ground, but there is a shared spawning area where fisheries operate upon a mixed population. Recruitment processes were specific to each stock. Other model structures examined alternative assumptions for homogenous mixing, mixing on the spawning area only, and a single stock area. The effects of the structural and statistical assumptions on the CASAL model uncertainty were not fully explored in the 2006 assessment given the relatively narrow range of model options investigated.

A working paper was presented which describes a partial exploratory update of the SW Pacific swordfish Multifan-CL assessment from 2006 (Kolody 2008). The paper investigated i) the implications of alternate growth curves and maturity ogives, and ii) the inclusion of three additional years of data for some fleets (2005-2007). The alternative growth curve and maturity schedule were based on some comparative age estimation work discussed in section 3 below. The faster growth curve was coupled with a lower age at maturity (50% aged 4 years as opposed to the previous assumption of 9 years). The new data consists of the old data (up to 2004) plus: catch from Japan in 2005, standardized effort from Australia (1997-2007), catch from Australia to 2007, catch from all other fleets to 2006, and catch-at-length/mass data for most fleets updated to include 2005-6 (2004 for EU/Spain).

Thirty-two model specifications were explored in a balanced factorial design of assumptions (a subset overlapped with the models explored in 2006 corresponding to the most optimistic and pessimistic of the models from the Most Plausible Ensemble). Models with the faster growth and maturity, and slower growth and maturity both seemed to be plausibly consistent with the other fisheries data. Plausible models with faster growth/maturity were more pessimistic than the faster growth/maturity assumptions in terms of current stock status, but equivalent or slightly more optimistic in terms of projected spawning biomass in 2009 (assuming 2004 effort levels). While (most) models seemed to converge successfully, all of the models fit to the new data failed to meet the minimum plausibility criteria defined in the 2006 assessment. The relative importance of the different data sets contributing to this problem had not been examined in detail. Potential problems included: i) an odd mix of missing effort observations and poorly approximated catch observations (i.e. catch substituted for missing values) might have led to model conflicts, ii) the large amount of size sampling data from the New Zealand domestic fishery in the last 2-3 years (due to the new port sampling program) might have implications for the pattern of selectivities shared across fleets, and iii) the recent upward trend in the Australian CPUE breaks the “one-way-trip” pattern observed in 2006, and there might be structural constraints that prevent the model from properly describing the recruitment and migration processes required to explain this trend. The paper recommended focussing on the revised spatial structure in 2008 (described in section 4), rather than pursuing the 2006 spatial structure further.

2. Compilation and Review of Fisheries Data

2a. Catch and Effort Data

The working paper Campbell (2008) was presented. This paper provided a detailed summary of the catch and effort and commercial size data available for the stock

assessment. The data described pertains to longline fleets operating in that part of the WCPFC convention area which generally lies within the south Pacific. In particular, the area of interest was bounded to the north by the equator and to the east by the eastern boundary of the WCPFC Area (130°W or 230°E) whilst the southern boundary was placed at 50°S and the western boundary at 140°E.

The catch and effort was compiled from the following sources:

- Aggregated (month by 5x5-degree) swordfish catch and effort data held by SPC for all fleets operating in the southern WCPO.
- Operational level logbook data held by the Australian Fisheries Management Authority relating to the Australian domestic longline fleet operating in the Eastern Tuna and Billfish Fishery off eastern Australia.
- Operational level logbook data held by the Ministry of Fisheries, NZ relating to the New Zealand domestic longline fleet operating around New Zealand.

A listing of the longline fleets for which catch and effort data was available is provided in Table 1. Data was available from 24 fleets spanning the years 1952 to 2007. Annual summaries of the data, including nominal catch-per-unit-effort, by fleet and fleet type, within each of the spatial areas used in the stock assessment model (see below) are provided in the working paper, as well as maps displaying the spatial distribution of the catch across the southern WCPO for the main fleets catching swordfish.

The data were described in spatial units corresponding to the proposed spatial structure of the assessment as described in section 4 (Figure 4). These four Areas are defined as follows:

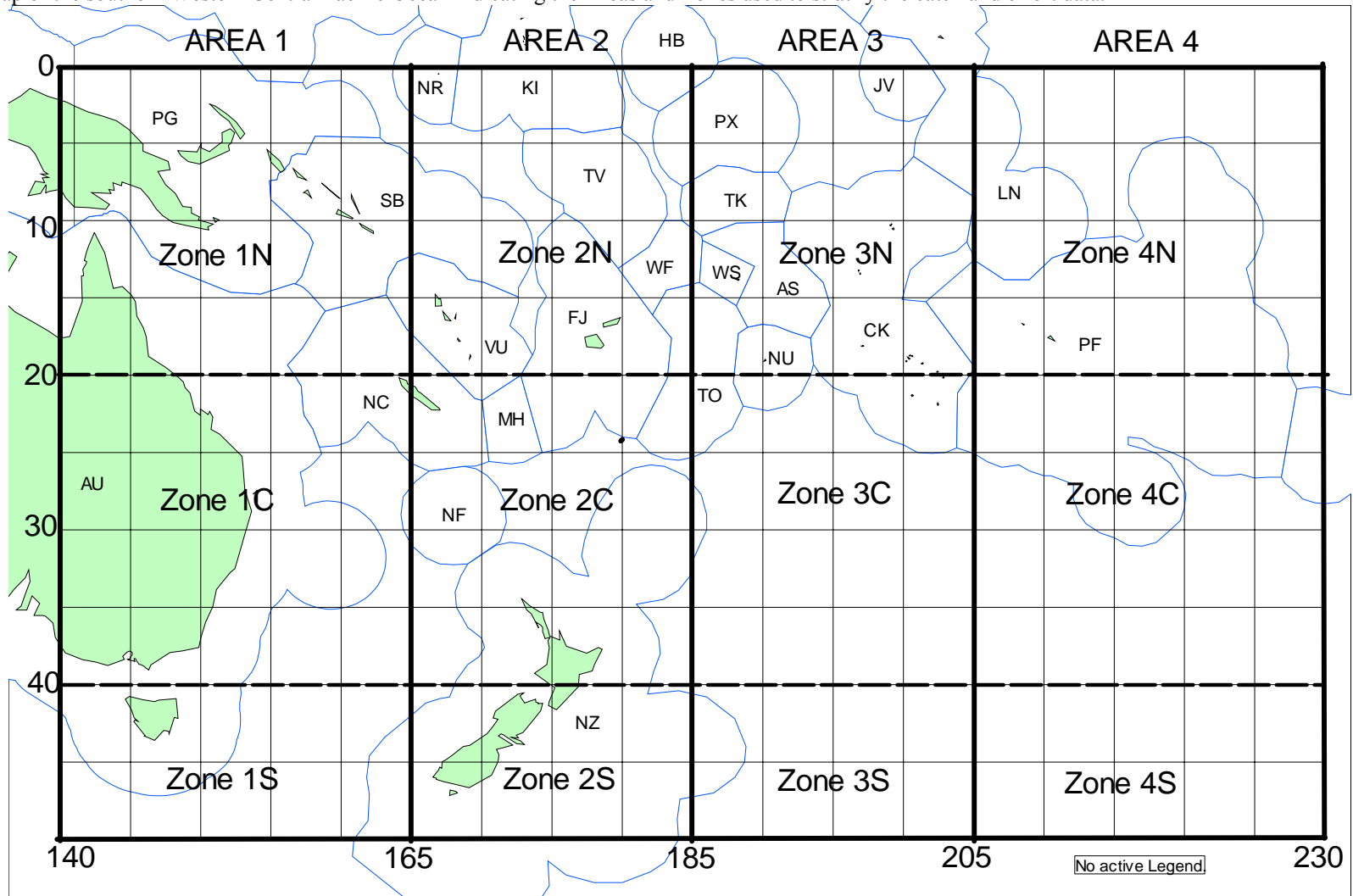
Area 1:	140-165°E, 0-50°S
Area 2:	165-185°E, 0-50°S
Area 3:	185-205°E, 0-50°S
Area 4:	205-230°E, 0-50°S

Table 1. Listing of the longline fleets operating in the southern WCPO for which catch and effort data are available. The following summary statistics are also provided: (a) Fleet Type used to categorise fleet, (b) The first and last years for which data was available, (c) The spatial extent of the data as defined by the number of 5x5-degree squares of latitude and longitude, (d) Total effort over all years (Hundreds of Hooks), and (e) Total Catch over all years in i) number of fish caught and ii) tonnes, estimated whole weight. The final year of data is not complete for some fisheries.

Nation	Abbrev. Flag	Fleet Type	Data Years		Spatial Extent	Effort		Catch	
			First	Last		Hhooks	Number	Tonnes	
Japan	JP	DWFN	1952	2005	169	29,488,014	1,135,130	76,750	
Australia	AU	AU	1985	2008	34	1,279,098	346,953	18,692	
Korea	KR	DWFN	1962	2006	151	25,793,328	375,143	16,384	
Taiwan	TW	DWFN	1964	2006	146	15,794,200	180,058	11,491	
New Zealand	NZ	NZ	1989	2007*	31	1,151,700	129,528	6,693	
Spain	ES	DWFN	2004	2006	41	51,280	70,943	5,034	
China	CN	DWFN	1996	2006	95	1,279,637	32,379	1,311	
Fiji	FJ	PIN	1989	2006	38	3,221,827	25,458	1,222	
French Polynesia	PF	PIN	1992	2006	39	1,652,488	16,555	965	
Cook Islands	CK	PIN	1994	2006	41	299,627	10,809	587	
Vanuatu	VU	PIN	1995	2006	120	838,675	7,622	372	
Tonga	TO	PIN	1982	2006	28	445,592	6,298	294	
New Caledonia	NC	PIN	1983	2006	24	691,675	5,331	290	
American Samoa	AS	PIN	1996	2006	27	705,029	2,147	255	
Papua NewGuinea	PG	PIN	1993	2006	19	533,055	5,281	236	
Western Samoa	WS	PIN	1993	2006	4	637,193	3,121	202	
Solomon Lslands	SB	PIN	1981	2005	14	381,116	1,418	72	
United States	US	DWFN	1997	2004	7	11,935	104	6	
Philippines	PH	OTH	2002	2003	4	1,818	99	5	
Indonesia	ID	OTH	2004	2005	13	8,906	64	3	
Nuie	NU	PIN	2005	2006	6	7,665	48	3	
Kiribati	KI	PIN	2003	2003	5	1,985	31	1	
Tuvulu	TV	PIN	2005	2005	2	65	1	0	
Fed. States Micronesia	FM	PIN	1995	1998	2	565	5	0	

* Quarters 1-3 only

Figure 4. Map of the southern Western Central Pacific Ocean indicating the Areas and Zones used to stratify the catch and effort data.



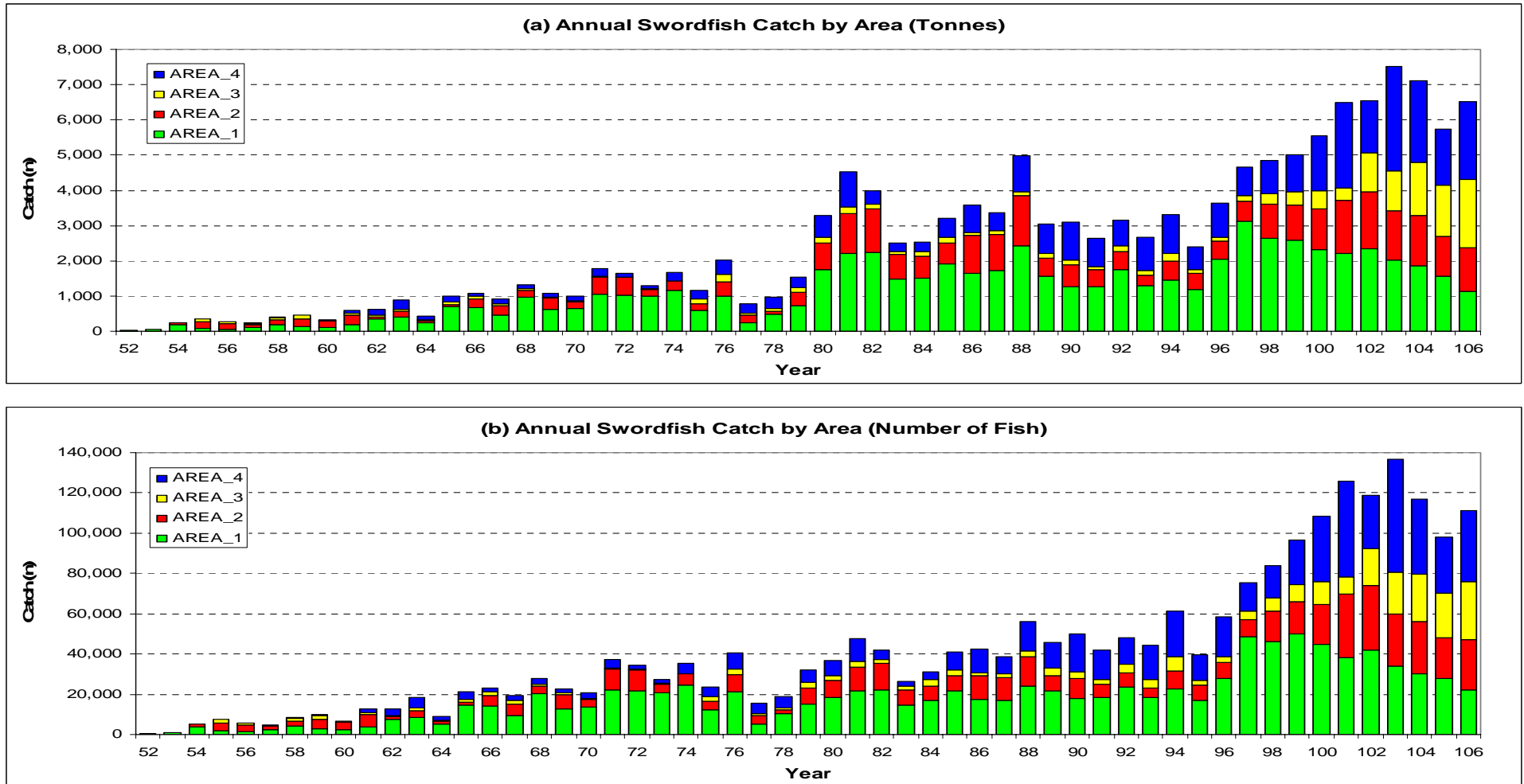


Figure 5. Annual catch, (a) tonnes, (b) numbers, of swordfish taken by longline fleets operating in each of the four assessment areas of the southern WCPO. (First year is 1952)

As the catch of swordfish is not homogenous across each Area, each Area was further stratified into a Northern (0-20°S), Central (20-40°S) and Southern (40-50°S) region giving a total of 12 spatial-zones across the southern WCPO. Each of these zones is shown in Figure 4.

Total annual catch, stratified by assessment Area, is displayed in **Error! Reference source not found.** Total annual catch was less than 2,000 t before 1980 and averaged around 3,000 t between 1980 and 1995. After this time, the total annual catch increased rapidly peaking at around 7,500 t in 2003. The preliminary catch estimate for 2006 is around 6,500 t. It was noted that there has been a large decrease in the catch of swordfish caught in the south-west Pacific over the past decade (mainly due to a decline in Area 1 from 3,110 t in 1997 to 1,140 t in 2006) though this decline had to some extent been offset by an increase in the catch of swordfish in Areas 3 and 4 (increasing from around 950 t in 1997 to over 4,300 t in 2006).

The working paper Mejuto et al. (2008b) was also tabled and discussed. This paper includes information about CPUE data from the Spanish fleet throughout the Pacific by size and sex. However, this paper is primarily focussed on reproductive activity and is summarized under fisheries independent research.

Summary of Workshop Discussion for Agenda Item 2a:

- The Workshop noted that the 2006 catch and effort data for Japan was still not available and that the 2006 data for Taiwan was largely incomplete. Only the fishery data for Australia and New Zealand fleets was available for 2007. As such, the Workshop recommended that the assessment be conducted up to the end of 2007 with the last available catch for each fleet used to substitute for the missing catches in 2006 and 2007.
- Workshop participants from Cook Islands, Tonga, Fiji, New Caledonia and French Polynesia noted the availability of operational data for their fleets and that this data is presently held by SPC. However, the Workshop also noted the possible limited utility of this data for CPUE standardization due to changing fleet structure and fishing strategies that might not be represented in logbooks. The Workshop requested a brief summary of changes in fleet operational characteristics from PIN participants (particularly over the last 10 years).
- The Workshop was informed of the existence of a large amount of operational level catch/effort data relating to Taiwanese vessels landing fish in Pago Pago. The Workshop recommended requesting this data to assist in the calculation of an abundance index (based on CPUE standardization) in Regions 3 and 4.
- The Workshop recommended that the project team identify specific data gaps limiting swordfish assessments in the WCPO.

2b. CPUE Standardization

Two working papers were discussed under this agenda item.

Campbell, Unwin and Davies (2008) provided a detailed description of the analyses undertaken to standardise the Australian and New Zealand catch and effort data to obtain an index of swordfish abundance (availability) within the central zones of Areas 1 and 2. For both fleets, operational level logbook data was available and a range of spatial-temporal and operational level factors were used to standardise effort.

The paper also described ongoing collaborative work being undertaken with Dr Miyabe at the NRIFSF in Shimizu, Japan to derive standardised CPUE indices based on 1x1-degree Japanese catch and effort data stratified by hook-per-baskets.

For the Australian fleet, comprehensive logbook data is available from the third quarter of 1997 to the end of 2007. A two-step model was used with the Binominal distribution used to model the probability of obtaining a non-zero catch with a log-Gamma distribution used to model the size of the positive catch rate. Each model included the following factors: *year, quarter, region, hooks-per-float, proportion of hooks with light-sticks, bait-type, start-time of set, moon-phase and southern-oscillation index*. Two factors accounting for competition between vessels were also incorporated into the models. Only the data pertaining to the “core” swordfish catch region in the Australian fishery was fitted to each model. For the New Zealand fleet the best available index was confined to the period from the first quarter of 1998 to the third quarter of 2007 and only used the data associated with “core” swordfish vessels. The analysis used a General Additive Model and fit a large number of operational and environmental variables.

A comparison of both the annual and quarterly standardised CPUE indices obtained for the Australian and New Zealand fleets is shown in Figure 6a-b with the trends in both displaying a good degree of agreement. The workshop noted that the indices

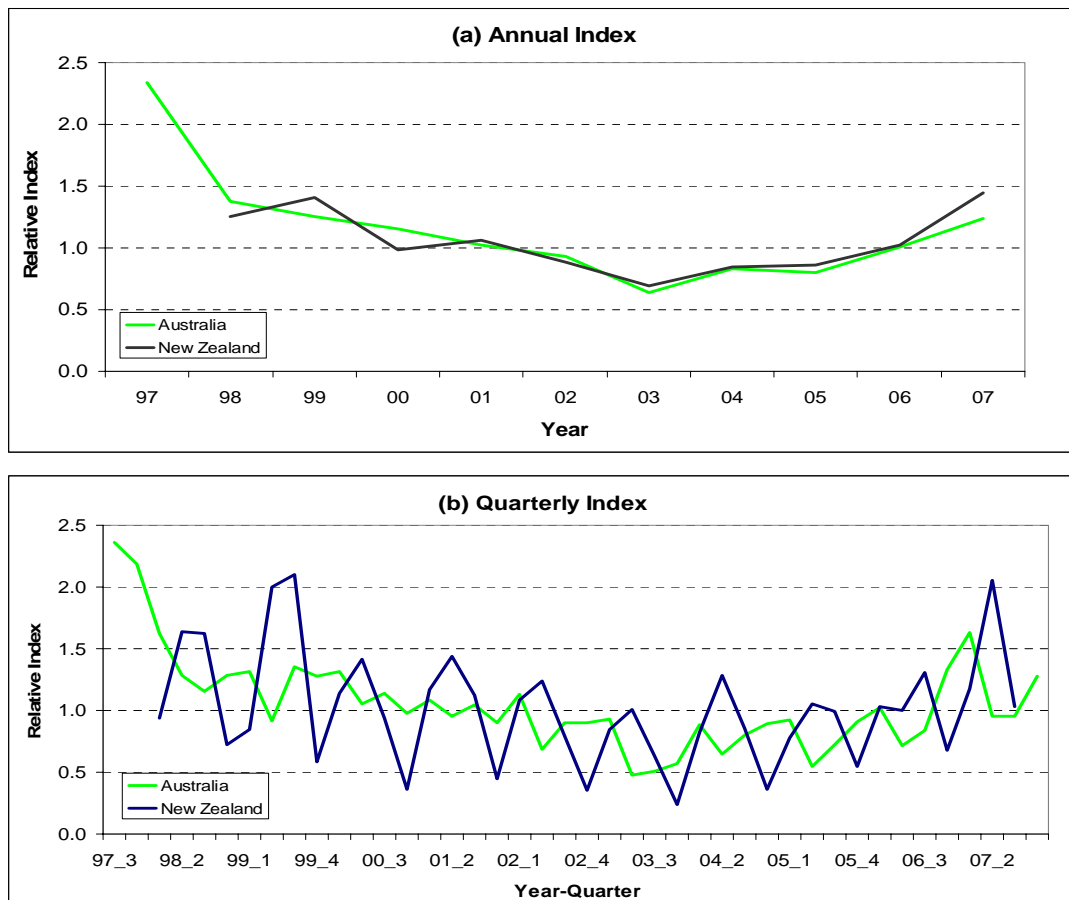


Figure 6. Comparison of the (a) annual , and (b) quarterly, time-series of standardised CPUE index for the Australian and New Zealand fleets.

based on the initial analyses using the Japanese data were somewhat inconsistent with the Australian and New Zealand indices in that they showed a continuing decline to 2005 (that last year for which data was available). However, it was noted that these results were preliminary and that further work was required to finalise these analyses.

The standardised CPUE indices from the Australian and New Zealand fleets (together with the analyses of the Japanese 1x1-data) provide “abundance” indices for the central zones of Areas 1 and 2. Campbell et al (2008) also describes an attempt to obtain a CPUE-based index for other Areas and zones in the assessment model. In particular, if the current assessment is to extend the spatial coverage of the previous assessment (which was confined to the SW Pacific) to the east, and possibly out to the eastern boundary of the WCPFC convention area, then it would be important to obtain some index of swordfish abundance within these eastern regions. Unfortunately the coverage of the Japanese fleet in these regions (between 185-230E) is poor and as such is not sufficient to use to construct an index. The aggregated monthly-5x5-data was therefore used and nominal 5x5-and-quarter-stratified CPUE indices within a core catch area were calculated for each fleet.

The resulting indices were discussed by the workshop but it was noted that there was a considerable lack of consistency in the trends of the indices for different fleets within the same Area and zone. It was also noted that these differences are likely to be due to the fact that the fishing practices (i.e. target species) for many of the fleets differ and that many fleets have also undertaken significant shifts in fishing practices over the past 10-20 years. As the stratified-nominal indices presented had not been “standardized” to account for these changes it was likely that many would not be a good indicator of swordfish abundance. The workshop noted that if periods where fishing practices had remained relatively stable could be identified, then the associated indices during these periods may provide a better index of underlying swordfish abundance. For this purpose, representatives from the Cook Islands, New Caledonia and French Polynesia provided summaries of the tuna and billfish fisheries within their EEZs and the changes associated with these fisheries over time (Attachment E).

Mejuto et al. (2008b) described standardized catch rate analyses from the Spanish fleet. As the authors were not able to present this paper to the workshop, the abstract is provided here to describe its contents. Standardized catch rates in weight were obtained using General Linear Modeling (GLM) from sets carried out by the Spanish surface longline fleet targeting swordfish in the South central and South western Pacific areas during the 2004-2006 period. Year, quarter, area, gear-type and the ratio between swordfish and blue shark species were used as model factors. The model tested explained 75% of CPUE variability. As in the case of the Atlantic, most of the CPUE variability was attributed to the ratio between the two species and secondly, to the gear factor. Other significant, although less important factors were quarter and area and the interaction between the two, while the year was considered the least important of all the factors examined during this period. The time period covered is too short to be able to lead to any conclusions on the standardized CPUE trend, but the results suggest that activity was stable during the Spanish fleet’s initial period of operation in these regions.

Summary of Workshop Discussion for Agenda Item 2b:

- The Workshop endorsed the use of the Australian standardised CPUE index for 1997-2007 as an abundance index for the Central zone in Region 1 and the use of the “core” NZ standardised CPUE index for 1998-2007 as an abundance index for the Central zone in Region 2.
- The Australian and New Zealand CPUE indices were noted to have similar trends over the past decade.
- When partitioned by size class, the increasing trend in Australian CPUE in recent years was seen to be largely a result of recent increases in the number of small fish being caught in the fishery, and evidence for an increase in recruitment in recent years (possibly at levels higher than observed in the late 1990s).
- The Workshop was informed that collaborative work with Dr Miyabe in Shimizu was presently underway on calculating a standardised CPUE index for the Japanese fleet and encouraged this work to continue.
- The Workshop noted that a preliminary Japanese standardized CPUE index in Region 1C continues to decline and does not display the increasing trend observed in the Australian index.
- The Workshop noted the difficulties being experienced in undertaking the Japanese CPUE analyses and recommended that for future WCPO assessments a full exchange of data is needed to facilitate these analyses.
- The Workshop noted that it might be possible to use information on the catch of non-swordfish species in the total catch to help identify targeting practices for those fleets for which operational level data was not available.
- The Workshop noted that the Area-Quarter-stratified nominal CPUE indices calculated for the main fleets showed inconsistent trends over time within similar regions. It also noted that the Japanese index within Region 1C diverged from the standardized index in the same region. It was noted that these indices do not fully account for operational changes.
- The Workshop was informed that a large amount of operational level data relating to the Taiwanese distant-water fleet operating in the eastern region has been collected by the US from vessels landing in Pago Pago. Given the potential utility of this data to help construct a swordfish index within this eastern region, the Workshop recommended that a request be made to access this data for this purpose.
- A working paper provided to the Workshop by Spain indicated a flat trend in CPUE for the Spanish fleet for the years 2004-06. However, the Workshop noted that the index was based on data from a large spatial area (from tropical north Pacific through to the South-West-South-Central Pacific) and as such was not directly relevant to any of the regions in the assessment model. It was also questioned whether the “ratio” variable was a valid factor to be used in the standardizing model. As noted in the report of pelagic longline catch rate standardization meeting, held in Honolulu in February 2007 (Hoyle et al, 2007) the proportion of the ‘other’ species may be strongly confounded with the catch of the species of interest, and also affected by the abundance of the other species. Including this covariate may remove some of the temporal abundance signal from the data and is not recommended.
- The Workshop recommended maintaining the separation of fleets across the different zones and regions of the assessment model for possible use in the analysis of future management options.

The workshop concluded that the lack of reliable and consistent CPUE trends in the South-Central Pacific was a major impediment for producing credible assessment results for this region of the proposed assessment domain.

2c. Size and Sex Composition

The working paper Campbell (2008), presented under Agenda Item 2a, provided a detailed summary and description of the commercial size data collected from longline fleets in the assessment region which is available for the stock assessment. This data was compiled from the following sources:

- i. Length (lower jaw to caudal fork) data held by SPC pertaining to individual swordfish sampled from longline fleets operating across the southern WCPO.
- ii. Processor measured and recorded dressed weights (trunked) pertaining to swordfish landed at various ports within the Australian Eastern Tuna and Billfish Fishery operating off eastern Australia.
- iii. Port sampling lengths (lower jaw to caudal fork) pertaining to swordfish landed within the domestic New Zealand longline fishery.
- iv. Dressed weight and length (orbital-eye to caudal fork) data held at NRIFSF, Japan pertaining to individual swordfish sampled from longline fleets operating across the southern WCPO.
- v. Length (lower jaw to caudal fork) provided by Spain pertaining to individual swordfish sampled from longline fleets operating across the Pacific Ocean.

A listing of the longline fleets for which size data was available is provided in Table 2. Data is available from 21 fleets spanning the years 1971 to 2007. Histograms of the size of swordfish caught by each fleet within each Area and quarter of the year, provided in the working paper, were noted.

Table 2. Listing of the longline fleets operating in the southern WCPO for which size sampling data for swordfish are available. The following summary statistics are also provided: (a) Fleet Type used to categorise fleet, (b) Source of the data, (c) Data type (DWT=dressed weight, OFL=Orbital-fork length, LJL=Lower jaw-fork length) (d) The first and last years for which data was available, (e) The spatial extent of the data as defined by the number of 5x5-degree squares of latitude and longitude, (f) Total number of individual swordfish sampled. The workshop noted that New Zealand port sampling data was missing from the is table.

Nation	Abbrev. Flag	Fleet Type	Data Source	Size Type	Data Years		Spatial Extent	Number Fish
					First	Last		
Australia *	AU	AU	AFMA	DWT	1997	2007	32	244775
New Zealand	NZ	NZ	NIWA	LJL	2005	2007	16	13242
Spain	SP	DW	Spain	LJL	2004	2004	24	9548
Japan **	JP	DW	NRIFSF	OFL	1971	2002		8607
Japan	JP	DW	SPC	LJL	1987	2004	44	5291
Fiji	FJ	PN	SPC	LJL	1994	2006	24	1600
Papua New Guinea	PG	PN	SPC	LJL	1996	2006	11	1397
New Zealand	NZ	NZ	SPC	LJL	1992	2005	16	1387
Tonga	TO	PN	SPC	LJL	1995	2006	8	1235
New Caledonia	NC	PN	SPC	LJL	1993	2006	8	798
Taiwan	TW	DW	SPC	LJL	1997	2006	19	703
Cook Islands	CK	PN	SPC	LJL	1995	2005	8	432
Solomon Island	SB	PN	SPC	LJL	1996	2004	7	258
French Polynesia	PF	PN	SPC	LJL	1996	2006	13	253
Korea	KR	DW	SPC	LJL	1992	2006	16	231
Western Samoa	WS	PN	SPC	LJL	1998	2005	4	206
Vanuatu	VU	PN	SPC	LJL	2003	2005	14	158
Philippines	PH	OT	SPC	LJL	2003	2003	2	116
China	CN	DW	SPC	LJL	1996	2005	11	33
United States	US	OT	SPC	LJL	2004	2004	1	11
American Samoa	AS	PN	SPC	LJL	2002	2004	4	7
Marshall Islands	MH	PN	SPC	LJL	1993	1993	1	3
Fed. State Micronesia	FM	PN	SPC	LJL	2002	2002	1	1

* Truncated weights, ** Data aggregated by 10x20-degrees of latitude and longitude

The working paper Campbell, Davies and Griggs (2008) was presented. In this working paper a more detailed summary and description of the size and sex composition data collected from the Australian and New Zealand domestic longline fisheries is provided. This data is the most comprehensive available within assessment Areas 1 and 2.

Swordfish length, weight and sex observations have been collected by the New Zealand Scientific Observer programme since 1987 and these data have been used to derive length frequencies, length-weight relationships and sex ratios for the catches. Between 12 and 705 swordfish have been sampled annually by observers from 1987 to 2007, though the samples collected before 1996 were almost exclusively from foreign licensed vessels targeting southern bluefin tuna. Since July 2005, a port sampling programme has been implemented in New Zealand with the aim of estimating the annual length, weight, and sex composition of swordfish in landings from the New Zealand tuna longline fishery. Individual fish weights in the processed state were collected from fish processors and were converted to estimates of total fish length using a relationship derived from observer measurements of fish fork length and processed weight. Length-specific sex ratios derived from samples collected by scientific observers on board vessels were then used to apportion the port sample length frequencies by sex.

Within Australia a size sampling program commenced in mid-1997 and has collected processed weight data for swordfish handled by the main processors and market facilities along the east coast. Between July 1997 and June 2007 a total of 244,784 individual swordfish weights have been collected under this program, representing around 78% of the swordfish landed in the fishery. These data have been used to derive a range of size-based indicators for the fishery, including the size-compositions, by quarter, of swordfish landed within each the main regions of the fishery, quarterly time-series of mean and 95-percentile weights, and the proportion of small, prime and large fish, within each of the main regions along the east coast. The

workshop noted that there has been a significant decline in the weights of swordfish sampled in the principal landing port of Mooloolaba over time (Figure 7a) and that there has also been a corresponding decline in the proportion of prime and large fish in these samples (Figure 7b).

The working paper also provided some details of the sex of swordfish collected by observers from both Japanese and Australian longliners operating off eastern Australia. The data from the Japanese fleet covers the years 1991-97 whilst the data from the Australian fleet covers the years 2001-07. Of the 3890 swordfish sampled in the ETBF the sex ratio between male and female fish is close to 50:50 (52%: 48%) while the 2832 swordfish sampled on Japanese vessels the sex ratio is 75%:25% female to male. The reasons for these differences presently remain unknown, but may be due to differences in the locations fished as the Japanese fleet, in general, fished in the more southern regions off eastern Australia. The sex ratios of New Zealand swordfish catches also indicate higher proportions of females, particularly in the large size classes.

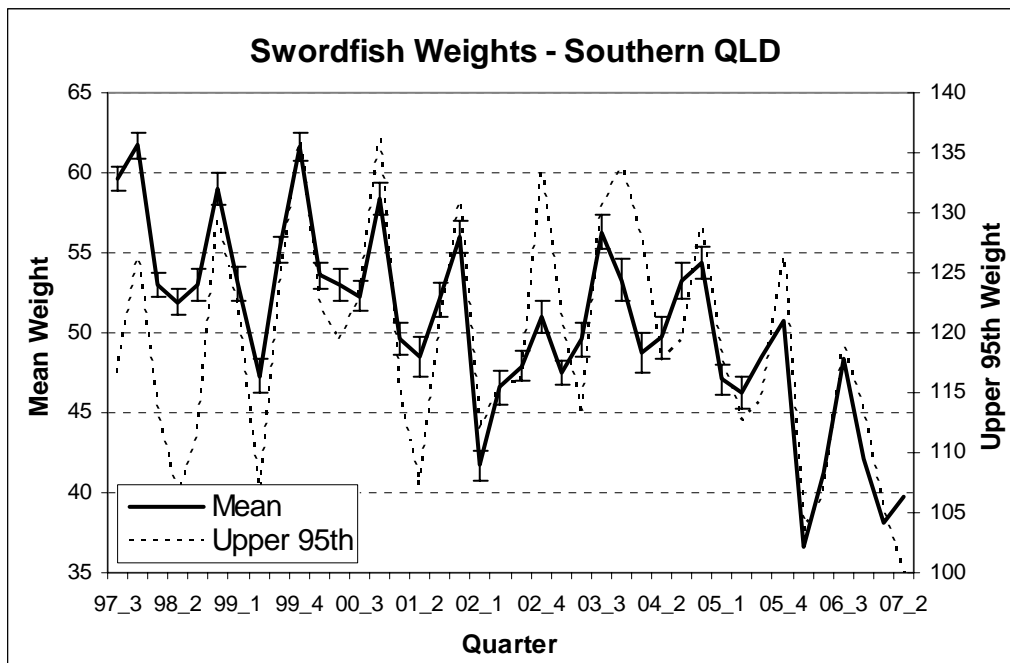


Figure 7a. Time series (by quarter) of the mean and upper 95th weight of broadbill swordfish sampled in Mooloolaba. (Note: 95 % confidence intervals on the mean weights are also shown.).

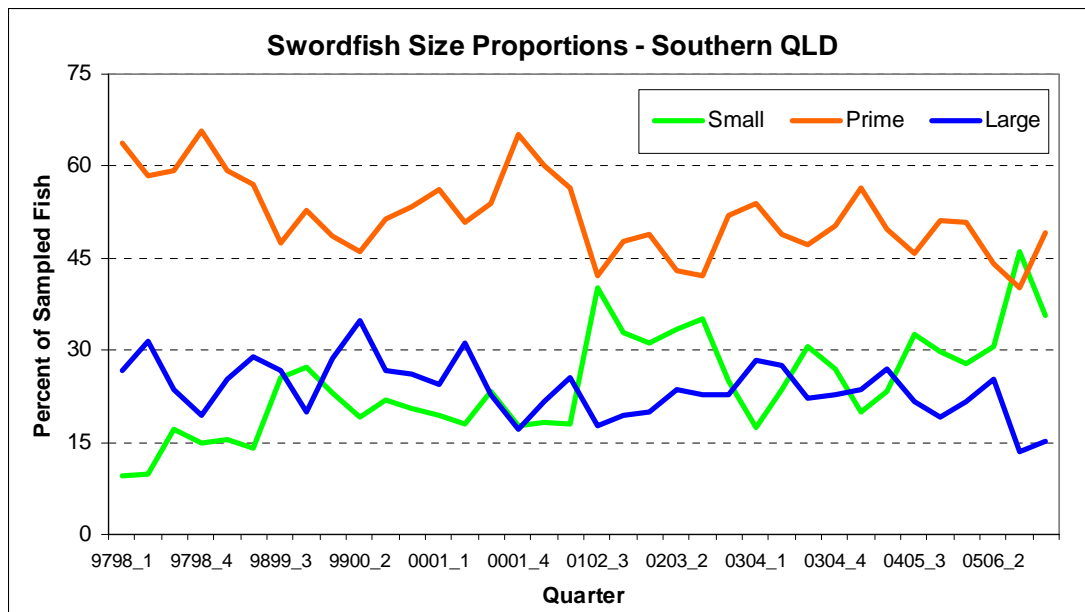


Figure 7b. Time series (by quarter) of the estimated proportion of broadbill swordfish within each size category landed and sampled in Mooloolaba.

Workshop Discussion Summary for item 2c:

- The Workshop noted that the size-data for 2005-06 was not available for the Japanese and EU fleets and that size data from some of the Pacific Island Nations was also not yet available in recent years. The 2006 size data for the Taiwanese fleet is also likely to be incomplete.
- The Workshop agreed that further size analyses, with data compared over similar spatial and temporal periods, needed to be undertaken to decide which fleets had sufficient data, and sufficiently distinct size composition to merit separation by fleet.
- The Workshop recommended using New Zealand observer size data up to 2005 and port-sampling size data thereafter.
- The Workshop noted that the large amount of size composition data (and the associated high levels of sampling, generally greater than 70% coverage of the commercial catch) available for both the New Zealand and Australian fleets and the generally much poorer levels of size data associated with most other fleets.
- The time-series of mean weights of swordfish landed in Australia indicates a decrease over time in the average size of swordfish caught by the Australian fleet. In order to investigate whether this decrease could be associated with spatial shifts in the location of the fleet and a spatial heterogeneity in the size distribution of swordfish, the Workshop recommended that this analysis needs to be undertaken at a finer spatial/temporal resolution.
- The Workshop noted that some size data collected from the Japanese commercial fleet operating in the south-west Pacific in the 1950s had a high proportion of a large fish and was quite distinct from other size composition data collected from other regions of the Pacific. Noting the unusual features of the data and the fact that the origins of this data remain uncertain, as do the

sampling methods used to collect the data, the Workshop decided that this data should not be included in the assessment.

- The Workshop was informed by participants from Fiji and Cook Islands that individual swordfish packing weight data are available. It was recommended that a request is made to obtain this data.
- The Workshop noted a general lack of sex composition data for most fleets (with the exception of some observer collected data on Japanese operations in Australian and New Zealand waters and recent Australian and New Zealand domestic fleets). The Spanish fleet also collects considerable sex composition data, but this has not been made available to the assessment team. It was recommended that this data be summarized as part of the assessment, but the Workshop considered that not enough data was available to justify fitting a sex-disaggregated model.

3. Fisheries Independent Research

3a. Growth Studies

Two working papers were discussed in relation to item 3a.

Young et al. (2008) was presented to the workshop, describing recent work in comparing estimates of growth rates (and maturity described in section 3b). Large differences in growth rates are estimated for different swordfish populations, and it is unclear whether this is the result of real biological differences or methodological differences between labs. Readings of anal fin rays (at this stage the most reliable measure of swordfish age) were compared between readers from two laboratories (NMFS Honolulu and CSIRO Hobart). Because there is considerable variability in the clarity of fin ray bands within and between fish, there is a degree of subjectivity in the readings made, particularly between different readers. A random selection of fin ray sections taken from Australian-caught fishes were reread using characters described in DeMartini et al (2007) and compared with fin ray counts previously determined for the same sections (Young and Drake 2003). Results are shown in Figure 8. Recounts of fin ray sections from the CSIRO collection by a NMFS scientist were less than original CSIRO estimates. The same rays were reread by an independent CSIRO scientist who had previous experience with the reading methodology. These last readings agreed closely with the counts made by the NMFS. The paper concluded that the initial CSIRO readings were consistently higher than the subsequent readings and the need for independent age validation research was stressed.

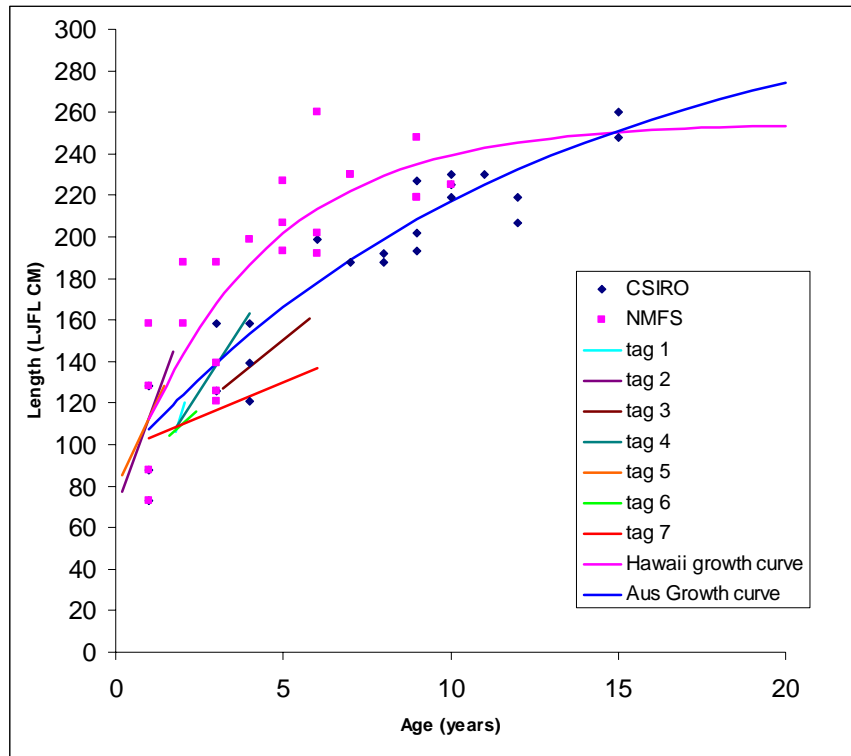


Figure 8. Female swordfish fin ray age estimates from a small number of Australian samples from readers at two different labs (original CSIRO readings and NMFS) (Figure 6 from Young et al. 2008). The superimposed growth curves are derived from comprehensive studies of Australian and Hawaiian swordfish. Tag growth increments represent swordfish samples from Australian and New Zealand tagging (of unknown sex).

Valeiras et al. (2008) describes swordfish age and growth studies in the North-West Pacific. A total of 450 anal fin spines were analyzed from years 2005 to 2006 for ageing and growth studies. The lower jaw fork lengths of the aged individuals ranged from 74 to 235 cm for the males and from 71 to 294 cm for the females. Fish ages ranged 0 to 13 years old and the mean lengths by age were calculated for males and females. Growth parameter estimates were calculated from 406 cut spine sections which provided readable growth annuli by sex. The preliminary growth parameters based on standard VB growth function are the following: for males, L_{∞} (asymptotic length)=271.4 cm, k (growth coefficient)=0.121, t_0 (age at zero length)=-1.543; for females, L_{∞} =376 cm, k =0.0701, t_0 =-2.162. The relationships between LJFL and anal

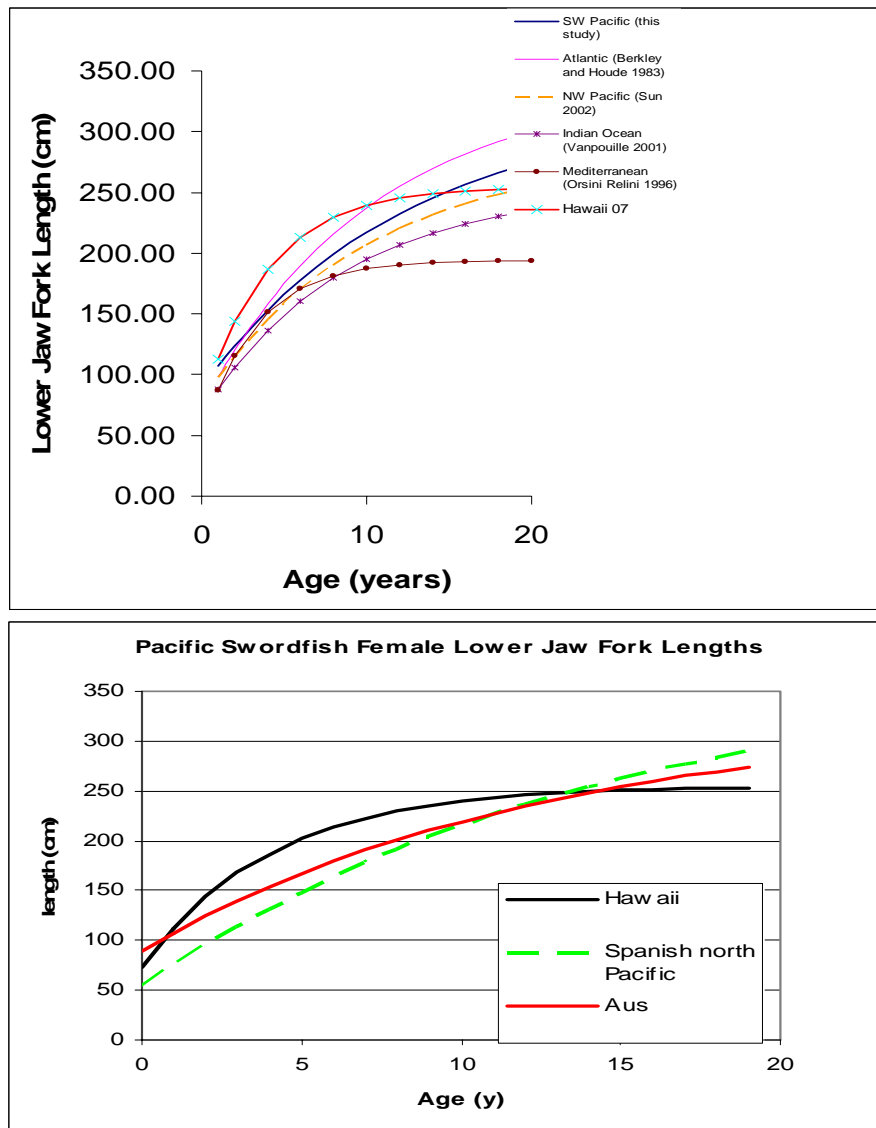


Figure 9. Comparison of swordfish female growth curves from various studies. Top panel from Young et al. (2008). Bottom panel produced at workshop.

fin spine radius were calculated for both sexes. The trends in the monthly marginal increment ratio was not conclusive regarding growth bands formation along the year. A comparison of female growth curves estimated from different studies is show in Figure 9.

Summary of Workshop Discussion for Agenda Item 3a:

- The Workshop noted that a number of differences exist between the results of age and growth studies undertaken on swordfish throughout the Pacific. In particular, significant differences had been observed in the results of recent studies undertaken by Australia and Hawaii.
- The Workshop was informed that ongoing work investigating the reasons for these differences, and including the comparison of age estimation methods between Australian and Hawaiian labs, had indicated substantial differences among readers and that a rereading of some of the Australian data indicated a closer fit to the Hawaiian growth curve. Despite this recent work, the

Workshop noted the need to undertake age validation studies to help resolve remaining uncertainties in these studies.

- Despite the above work, the Workshop noted that two alternative growth curves were recognized to be plausible on the basis of the different readings, and a refitting of stock assessment models to the data available in 2006. The Workshop agreed that both these two growth curves should be used in the 2008 assessment.
- The Workshop noted a working paper provided by Spain detailing the results of a recent growth study on swordfish. However, the Workshop noted that this study was undertaken in the north-west Pacific, and noting studies which indicate that the swordfish resource in this region is highly likely to be a separate stock from that found in south-west Pacific, recommended that this growth curve not be included in the 2008 assessment.

3b. Age-at-Maturity

One working papers were presented under this Agenda item.

Young et al. (2008) discussed potential causes for differences in maturity estimates from different swordfish populations. This variability may reflect the response of these fish to differing physical and biological oceanographic conditions both within and between oceans. However, these differences could also result from different methodologies and interpretations of collected data. In the Pacific Ocean there are a number of differing estimates. Those from the southwestern Pacific gave a preliminary estimate of age at 50% maturity between 8 and 10 years (Patterson et al. 2002). In contrast, De Martini et al. (2000) reported an age at maturity of between 4 and 5 years from the Hawaiian swordfish fishery. A study was carried out by the authors at the Aiea Labs in Hawaii on original material of archived slides of gonads from swordfish collected from the eastern Australian and Hawaiian longline fisheries. During June 25-July 4, 2007 the authors reviewed histological slides of female swordfish gonadal sections in various stages of reproductive development. Some potential sources of discrepancy were identified, including i) differences in the age/size relationships (section 3a above) have a major effect on the age of maturity estimates (but not maturity-at-size), ii) Sample preservation methods are important (all of the Hawaii slides used ovarian tissues fixed at sea when fish were first brought aboard ship, while Australian observers are not permitted to use fixatives aboard ship), and iii) distinguishing immature from mature-resting fish is very difficult based on histological features alone.

Summary of Workshop Discussion for Agenda Item 3b:

- The Workshop noted that the results of separate studies undertaken on swordfish throughout the Pacific indicate a range of ages at 50%-maturity.
- The Workshop also noted that a methodological review being undertaken by Australian and Hawaiian scientists indicated that some of these differences are based on differing interpretations of maturity. Differences in the histological methods used in the original Australian and Hawaiian studies also appear to have contributed to differences in interpretations. Age-at-50% maturity was also influenced by differences in alternative growth curves.

- The Workshop noted that two alternative maturity schedules were plausible based on the different maturity studies and a refitting of stock assessment models to the data available in 2006, and recommended that these two maturity schedules be used in the 2008 assessment.

4. Spatial issues in the assessment

In addition to the papers described previously, 4 working papers were discussed under this agenda item.

Kasapidis et al. (2008) described recent genetic work from Spanish swordfish samples throughout the Pacific. Abstract: The genetic structure of swordfish (*Xiphias gladius*) in the Pacific Ocean was assessed by analyzing 594 individuals from 6 different regions, genotyped with 13 microsatellite loci. The results showed very low genetic differentiation among the different geographical areas, which was not statistically significant. These data confirmed the low genetic differentiation of swordfish within Pacific and were not able to reveal any genetic structure.

Abascal et al. (2008) described preliminary results from recent PSAT deployments from Spanish commercial vessels operating in the Eastern Pacific Ocean. Between March-June 2007, a total of 21 SWO generally above 50 kg round weight were tagged and released around Nazca Ridge (off northern Chile). Swordfish showed the typical diel vertical migration pattern, being close to the surface at nighttime and deep during the day, usually reaching depths of around 400-600 meters. Light-level based geolocations are still being processed. Based on the preliminary results of the Kalman filtered tracks, it seems none of the fish tagged moved north of 2°S, nor west of 105°25'W. But it cannot be ruled out that fish would continue to move further north and west after tag detachment. Further analysis is expected to provide useful information on habitat preferences, fish associations, and population structure that will contribute to future stock assessments.

Mejuto et al. (2008a) described reproductive studies on swordfish from Spanish longline operations throughout the Pacific. Abstract: A total of 23,639 swordfish females were analysed. The percentage of females larger than 145 cm shows important differences among areas. Maximum percentages were obtained in temperate waters South of 25° S and the lowest values in warm areas where small females were observed. The overall sex-ratio obtained was 51%. The sex-ratios at size suggest that females are predominant as of 170 cm although different patterns of sex-ratio at size were obtained between zones. The gonad index detects areas as producing the most intense maturation activity in females, ranging from the central Pacific between 10°N and 10°S to the West of 120°W where the greatest gonad development was observed. The results would indicate that reproductive activity is mostly carried out in certain areas of the central-western Pacific but that there may also be sporadic-seasonal or moderate reproductive events in some of the other areas adjacent to these. At the same time, the SE Pacific show resting females with active feeding behaviour. The most active areas with maturity events are linked to warm waters where the characteristic spawning patterns of sex-ratio at size are caused by the higher abundance/catchability of males over females within particular size ranges. The results match well with similar indicators observed for the Atlantic swordfish. However, the Pacific shows

somewhat broader warm areas than the Atlantic, suggesting that the potential spawning areas for the Pacific swordfish could be relatively broader and eastern than those reported for the Atlantic. Figure 9 shows the spatial pattern of swordfish gonad indices from the Spanish fleet in the Pacific Ocean.

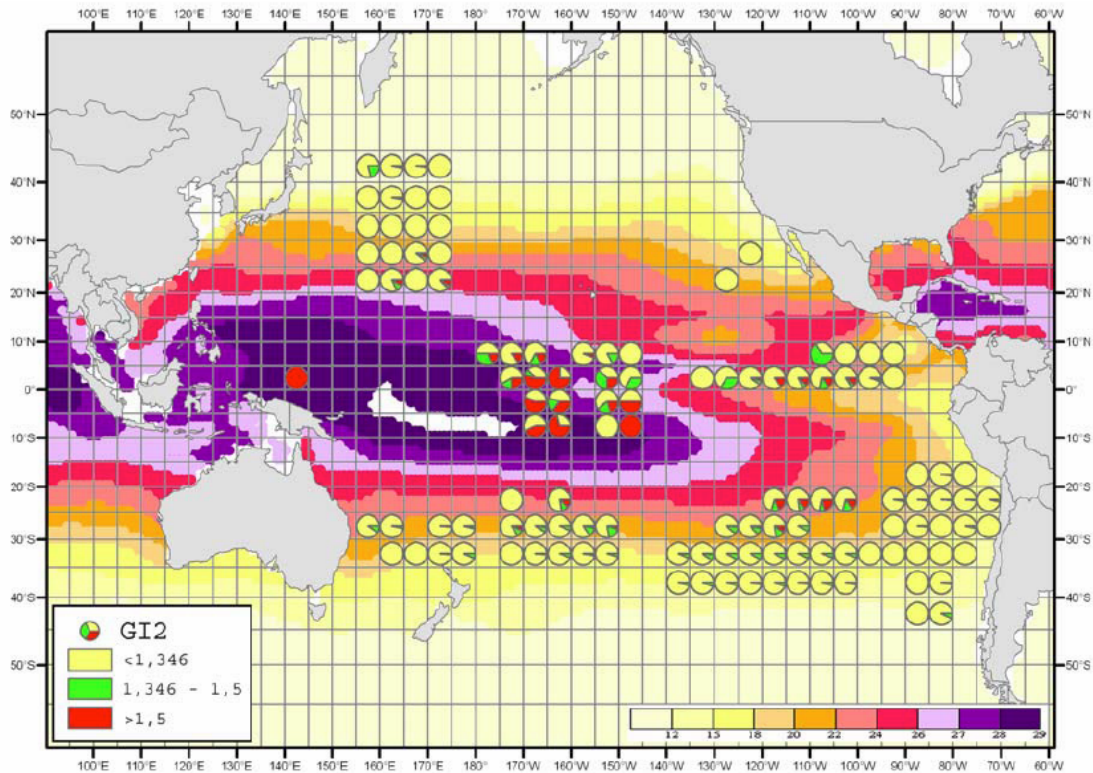


Figure 9. Occurrence of each of the three gonad index (GI2) ranges defined, in each 5°x5° square observed F in the Pacific ocean, for females with sizes LJFL \geq 145 cm and for all observations combined. (Figure 7 from Mejuto et al (2008a).

Kolody and Davies (2008) provided a general review of the research and hypotheses associated with south Pacific swordfish stock structure and migration dynamics, and spatial considerations used in other swordfish assessments. The evidence discussed included population genetics, larval surveys, fishery characteristics (distributions and seasonal patterns in catch, CPUE, and size composition), and inferences from recent Pop-up Satellite Archival Tags (PSAT) and conventional tags deployed in Australia and New Zealand. The paper recommended a southern WCPO assessment domain with 4 longitudinal sub-units (**Figure 3**). The revised structure was argued on the basis of: it i) provides compatibility with CMM06-3, ii) reduces problems related to representing latitudinal seasonal migration, iii) is suitably disaggregated to represent differential harvesting in different sub-regions, iv) can be iteratively revised with different eastward boundaries in relation to evolving opinions about data quality and stock connectivity with the Eastern Pacific Ocean.

This paper also discussed how the homogenous mixing and spawning site fidelity migration hypotheses (Figure 1) might be more appropriately considered in a broader Pacific context in the future (Figure 10). Exploration of a broad-scale spawning site fidelity model would likely require data from outside of the WCPO, however there is

no evidence at this time to indicate that it is more appropriate than the homogenous mixing model proposed.

Kolody and Davies (2008) also described a preliminary analysis of PSAT and conventional tags, in which it was argued that the longitudinal movement of swordfish seems to be consistent with a diffusive process. The paper illustrates that other simple movement models are also plausibly consistent with the small amount of tagging data that are available. It was suggested that the adoption of the movement parameters estimated from the diffusion model should be interpreted as an upper bound on migration rates. If the alternative models are actually more “correct” (e.g. if swordfish undertake directed longitudinal seasonal migrations in the SW Pacific), then the extrapolation of movement estimates based on short term tag displacements would be expected to over-estimate the actual amount of random diffusive displacement experienced in the long term. Estimates for longitudinal observation error variances, and diffusion rate parameters were provided. A simple process was described in which diffusion rates could be estimated and translated into bulk transfer coefficients that are compatible with the structural assumptions of the assessment models.

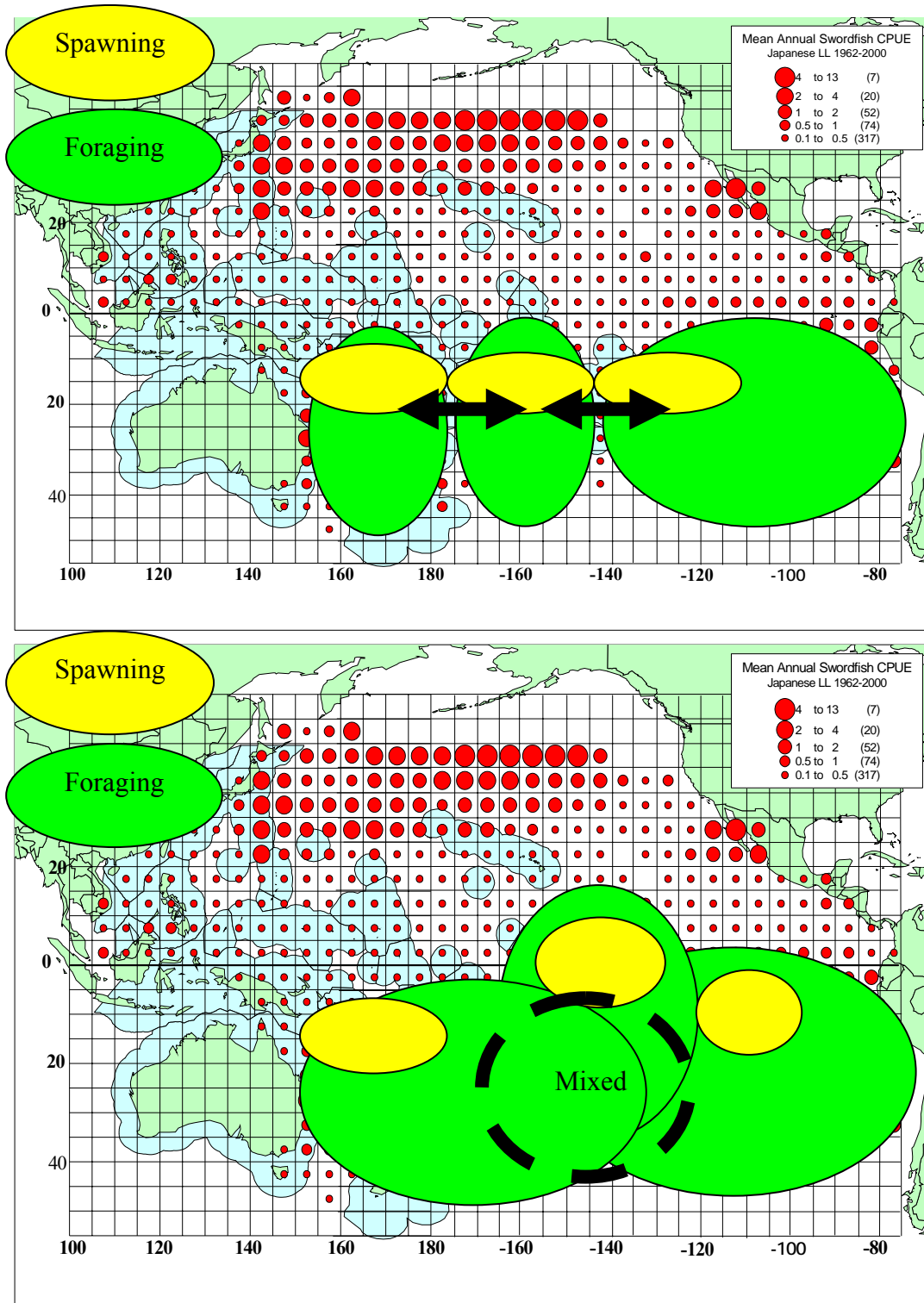


Figure 10. (from Kolody and Davies 2008) Schematic representation of two possible stock structure representations for South Pacific swordfish: top panel = homogeneous mixing, bottom panel = foraging site fidelity.

Summary of Workshop Discussion of Agenda Item 4:

- The Workshop endorsed a model domain within the southern WCPO (0-50 S, 140E-130W) as encompassing the main region of interest for assessing the swordfish stock located within the south-west and south-central Pacific Ocean (Figure 4).
- Given the spatial distribution of fishing effort of individual fleets and the associated catch of swordfish across this domain, the following 4 region structure:
 - Region 1: 140-165°E
 - Region 2: 165-185°E
 - Region 3: 185-210°E
 - Region 4: 210-230°E

with an additional three zones defined within each region:

- North: 0-20°S
- Central: 20-40°S
- South: 40-50°S

was also endorsed as a reasonable delineation for fishery definitions across the model domain.

- Noting the:
 - continuity of catch and CPUE across the Tasman Sea for Australian and Japanese fisheries,
 - similarities in CPUE temporal trends for the main fleets catching swordfish in these regions, and
 - some movement of tagged swordfish from region 1 to 2,

the Workshop considered that there was a compelling argument to consider the swordfish resources located in Regions 1 and 2 to be part of the same stock

- The Workshop noted that there was no strong evidence supporting the assumption of a single stock across the southern Pacific, but noted that there is some evidence based on the distribution of catch, CPUE, genetics and spawning locations suggesting the possibility of two separate stocks:
 - Whilst swordfish are mainly caught within the central temperate zones in regions 1 and 2, the catch of swordfish in regions 3 and 4 is mainly within the northern equatorial zone.
 - The spatial distribution of Japanese CPUE suggests a possible discontinuity between south-western and north-eastern equatorial areas of the southern WCPO (though the central zones of regions 3 and 4 do indicate high Japanese and Spanish CPUE).
 - The generally decreasing trends in nominal CPUE for the major fleets catching swordfish in regions 1 and 2 (Japan, Australia and New Zealand) are dissimilar with the generally increasing nominal CPUE trends of the major fleets catching swordfish in the northern zones of regions 3 and 4 (Japan, Korea and Taiwan).
 - Larval surveys and reports of very small swordfish found within the waters of French Polynesia indicate spawning in the northern zone of Region 4. However, the workshop noted that spawning in this region may be associated with EPO stocks, which are not known to spawn in the cooler waters near South America.
 - Based on larval sampling there was little evidence of spawning in Region 3, though the workshop noted that recent research undertaken

- by Spain indicated the presence of ripe spawners in this region. However, the Workshop noted that this research was based on a gonad condition index which could not be taken as conclusive evidence that spawning was taking place in this region and that a histological study would provide more compelling evidence. It was also noted that very small swordfish were observed within the southern region of the Cook Islands during 2007 though this is seen as unusual.
- Observations of swordfish movement within the EPO, based on recent Spanish tagging, seemed to be consistent with movement assumptions adopted in the IATTC, and were not informative with respect to the south-western and south-central stock structure.
 - Genetic evidence from all sources remains inconclusive, though
 - Reeb et al. (2000) provide compelling evidence for a distinction between north-west and south-west populations
 - Bremer et al. (2006) provide a compelling argument for distinguishing between north-east and south-east populations and between south-west and south-east populations, with the boundary uncertain (and not well sampled)
 - The most recent work, Kasapidis et al. (2008), did not identify compelling evidence for South Pacific stock structure (but the Workshop noted the low statistical power of the genetic method used).
 - While the workshop noted that the spatial distribution of catch and CPUE on their own provide only indirect and inconclusive evidence regarding stock structure, the combination of information from all sources (including genetic and reproductive studies) may provide stronger evidence.
 - The Workshop was informed that a run of the 2006 assessment model updated to include the more recent catch and effort data failed to produce plausible results. The complicated migration dynamics assumed in the highly disaggregated spatial structure used in this model were thought to be one of the problems and was seen as justifying the simpler spatial structure adopted for the 2008 assessment model.
 - Analysis of the recent tagging data undertaken in Regions 1 and 2 indicate that North-South (probably spawning) migrations appear to be more dominant than East-West movements. Estimation of diffusion rate coefficients in the longitudinal direction based on this tagging data provides bulk transfer coefficients that can be input into the spatially disaggregated assessment model.

Based on the above information, the Workshop reached the following conclusions:

- 1) There is strong evidence for treating the swordfish within Regions 1 and 2 as a single stock unit as in the 2006 assessment. However, the eastern extent of this population remains uncertain, as does the appropriate management boundary in relation to the WCPO and the EPO.
- 2) It was considered plausible that the swordfish located in the Central zones of Regions 3 and 4 might be more closely linked to the populations from Regions 1 and 2 than the swordfish located in the Northern zones of Regions 3 and 4 (the latter may be more closely linked to the EPO stock).

- 3) The Workshop noted the need to extend the examination of the spatial distribution of catch and CPUE between the southern WCPO and the EPO (as this information was not available at the workshop).
- 4) Given the lack of compelling evidence for a single stock across all 4 regions of the southern WCPO, and the lack of reliable swordfish abundance indicators in regions 3 and 4, the Workshop recommended that the primary focus of the 2008 assessment should be on the swordfish resource located in the southwest Pacific (Regions 1-2), and that additional sensitivity analyses should be undertaken to include regions 3 and/or 4 (with the northern zones excluded) if possible. If problems are encountered in extending the assessment that qualitative stock status statements should be provided on the basis of data-based indicators.

5. Stock Assessment Workplan

After consideration of the points raised and discussed during the workshop, the following workplan of tasks was outlined for completing the 2008 southern WCPO swordfish stock assessment:

Final Data Assembly (to be completed by 9 May 2008):

- Workshop requested a brief summary of changes in PIN fleet operational characteristics (particularly over the last 10 years)
- Obtain Cook Islands, Tonga, Fiji, New Caledonia, French Polynesia operational data (workshop noted possibly limited utility for CPUE standardization, due to changing fleet structure and fishing strategies that might not be represented in logbooks).
- Obtain Japanese 2006 catch and effort data
- Obtain Taiwanese 2006 catch and effort data
- Obtain Spanish 2005-7 length and sex composition data
- Request Taiwanese operational level catch/effort data for the fleet landing in Pago Pago (from USA).
- Request other principle species catch composition for purposes of identifying targeting shifts
- Obtain swordfish packing data from Fiji and Cook Islands.

Additional Data analyses:

- Qualitative examination of spatial continuity of CPUE patterns from Japanese fisheries
- Comparison of size frequency distributions for all fleets disaggregated by year, quarter, area and zone over comparable strata for determination of fleet definitions (noting that disaggregation might be worthwhile for exploring management options).
- Explore CPUE trends in PIN fleets to identify periods of stable fleet operations
- Fine spatial-scale disaggregation of Australian size composition data over time
- Taiwanese CPUE standardization using operational level data
- Complete Japanese CPUE standardization

- Consider use of non-swordfish species catches as a proxy for operational variables for targeting practices
- Comparative plots of stratified nominal CPUE indices versus species catch composition over time (e.g. for Taiwan and Korea)
- Summarize sex composition from all observer data.

Assessment modelling:

- Software:
 - Multifan-CL
 - CASAL
 - Stock Synthesis 2/3 was discussed as an option but discouraged in the short term because the most recent developments (related to migration) were largely untested
- Structural assumptions
 - Spatial units:
 1. Areas 1 and 2 as the highest priority
 2. Areas 3 and/or 4 to be included if reliable data can be obtained
 - Time-steps – annual vs quarterly – it was recognized that selectivity may need to differ by quarter to account for seasonal migration in the new model structure.
 - Growth and Maturity
 - Two alternative growth curves were recognized to be plausible on the basis of Young et al. (2008) and Kolody (2008)
 - Two alternative maturity schedules were recognized to be plausible on the basis of Young et al. (2008) and Kolody (2008)
 - Natural Mortality – the range of options is to be revisited in relation to the new growth curves
 - Sex dimorphism –
 - Considered a low priority considering existing uncertainty in growth curves. Might be explored with CASAL
 - In the first instance, migration rates will be imposed on the basis of diffusion rate estimates from tagging studies. Migration rates may be estimated as part of model fitting if this leads to substantive improvements in model fit and plausible migration estimates.
 - Use of PSAT tag tracks directly in models (assuming that each track can be analysed as a series of conventional tag recaptures)
 - Considered a low priority given small number of tags and unrepresentative release times. Might explore with CASAL
 - Fleet disaggregation with respect to selectivity
 - Maximum of 4 Areas x 3 zones x number of nations
 - Reduce number of fleets on the basis of length frequency comparisons and shared selectivity assumptions
 - Seasonally-variable selectivity may be required to explain seasonal changes in size composition due to migration
 - Fleet disaggregation with respect to catchability
 - Depends on how many informative CPUE series can be defined (maximum of 6)
 - Regional scaling factors need to be derived in relation to shared catchabilities

- Seasonal catchability estimates are expected to be required to explain differences in seasonal CPUE due to seasonal migration (and potentially the confounded effect of seasonal targeting)
- Uncertainty Quantification
 - MPD grid – Confounded Experimental Design might be used to capture 2 way interactions if full factorial design not computationally feasible.
 - Grid includes relative weightings of different data sources in the objective function
 - Model plausibility diagnostics need to be defined
 - Generate credibility intervals for MPD selection
- Reference Points to report:
 - Total and Spawning Stock Biomass = TSB, SSB
 - TSB(2007)/TSB(1997)
 - SSB(2007)/SSB(1997)
 - TSB(2007) / TSBNF(2007)
 - SSB(2007) / SSBNF(2007)
 - TSB(2007)/TSB(MSY)
 - SSB(2007)/SSB(MSY)
 - F(2007)/F(MSY)
 - Projections:
 - 10 year constant catch projections
 - Constant effort (maximum effort from years 2001-5, as per CMM2006-3)
 - Alternative Catch/Effort scenarios: +50%, +100%
 - Ensure low future recruitment scenarios are included
 - TSB(2012) / TSB(2007)
 - SSB(2012) / SSB(2007)
 - TSB(2012) / TSB(1997)
 - SSB(2012) / SSB(1997)
 - TSB(2012) / TSB(MSY)
 - TSB(2017) / TSB(MSY)
 - Likelihood profiling of ratio reference points when appropriate

6. Research priorities for reducing South Pacific Swordfish Stock Assessment uncertainty

The workshop discussed a number of longer term research items for reducing swordfish stock assessment uncertainty. It was noted that most of these initiatives should involve collaborative work with broader Pacific Ocean initiatives (North Pacific, IATTC).

Area of uncertainty	Issue(s)	Examples of past & current work	Tasks
Size/age/maturity	<ul style="list-style-type: none"> • Estimate age at maturity, spawning frequency and 	<ul style="list-style-type: none"> • Young & Drake (2004) 	<ul style="list-style-type: none"> • Ad hoc – observer data

Area of uncertainty	Issue(s)	Examples of past & current work	Tasks
	<p>fecundity, identify spawning areas and seasons</p> <ul style="list-style-type: none"> • Discrepancies between east Australian estimates and those from other fisheries • Regular collection of hard parts (fin rays) and estimation of age- and sex composition of catches • Refinement of length-age key 	<ul style="list-style-type: none"> • Young et al. (SC3-BI-WP-1) 	<p>and biological samples</p> <ul style="list-style-type: none"> • Dedicated – data and sample analysis and desk-top comparison with other studies. • Ad hoc – sample collection and observer data on sex composition • Independent validation from conventional tagging studies and oxy-tetracycline marking • Radiocarbon ageing • Sampling of very small swordfish in tropics
<p>Movement and mixing rates</p>	<ul style="list-style-type: none"> • Describe size- and sex-dependent movement patterns, e.g., spawning grounds, forage areas. • Local depletion around bathymetric features, such as seamounts • Particular uncertainty of population linkages in the South-Central Pacific region 	<ul style="list-style-type: none"> • satellite tagging (Holdsworth et al. SC3_BI_WP-3, CSIRO) 	<ul style="list-style-type: none"> • logbook data mining and analysis, sourcing additional fleet data, • conventional tagging • sex determination from conventional tags on recapture • PSAT tagging in representative time/area strata • Long-term

Area of uncertainty	Issue(s)	Examples of past & current work	Tasks
			dispersal estimates from conventional tagging <ul style="list-style-type: none"> • Sex determination from genetics
Stock structure	<ul style="list-style-type: none"> • genetic and otolith micro-chemistry sampling to determine population structure, e.g., homogenous Pacific-wide vs. limited mixing among sub stocks • Particular uncertainty of South-Central population dynamics • Preliminary exploration of parasite markers in New Zealand was not encouraging 	<ul style="list-style-type: none"> • Reeb et al. (2000) 	<ul style="list-style-type: none"> • Otolith and genetic sample collection • South-Central Pacific sampling very weak • Otolith microchemistry methods need development for pelagic fisheries • analysis of size composition data to identify homogenous spatial units
Fishery Size and sex composition data	<ul style="list-style-type: none"> • Size composition from 1950s commercial fishery identified 		<ul style="list-style-type: none"> • Investigate historical size data for Japanese longline fleet 1950s • Expand port sampling and observer programs
Catch rates	<ul style="list-style-type: none"> • Distinguish swordfish targeting from targeting of other species • Habitat use and variations in fishing power and catchability • Develop time-series for 	<ul style="list-style-type: none"> • observer and logbook programs 	<ul style="list-style-type: none"> • observer and port sampling logbook collecting operational level data for sex-specific length frequencies

Area of uncertainty	Issue(s)	Examples of past & current work	Tasks
	<p>fleets other than distant-water Japanese longline</p> <ul style="list-style-type: none"> • Sex-specific catch rates 		<ul style="list-style-type: none"> • Experimental validation of CPUE standardization assumptions • Explore proxies for quantifying targeting • Analyses of Oceanographic variability impacts on catch rates
Fishing mortality rates	<ul style="list-style-type: none"> • Verified catch estimates for all fleets • Discards and under- or non-reporting of catches 	<ul style="list-style-type: none"> • Observer, landings and logbook programs 	<ul style="list-style-type: none"> • Compare size compositions from observed and unobserved sets in appropriate strata.
Abundance indices	<ul style="list-style-type: none"> • Fisheries independent • Recruitment indices (Cook Islands, French Polynesia) 		<ul style="list-style-type: none"> • Identify which fleets are catching small fish • Explore relation between small fish catch and subsequent recruitment in core fisheries as recruitment index • Understand recording/retention practices and encourage consistent reporting

Area of uncertainty	Issue(s)	Examples of past & current work	Tasks
Assessment Model Estimator performance	<ul style="list-style-type: none"> • Not sure how well models perform, or how robust to assumption violations • Can simple models/analyses replace more complicated assessments 		<ul style="list-style-type: none"> • Simulation testing to describe estimator performance • Compare models of differing complexity with data-based indicators
Management Strategy Evaluation	<ul style="list-style-type: none"> • Need to define robust harvest strategies to meet management objectives 		<ul style="list-style-type: none"> • Conduct pilot MSE • Expand to broader WCPFC

Attachment A: List of Participants

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Attachment B: List of Working and Background Papers

1. Working Papers for the Southern WCPO Stock Assessment Workshop (Note that many of these are draft and informal papers should not be cited without prior approval by the authors. Many of them will be revised and submitted to the WCPFC-SC in 2008.)

- Abascal, F.J., Mejuto, J., Quintans, M. and Ramos-Cartelle, A. 2008. Swordfish Pop-Up Tagging in the Southeastern Pacific Ocean. Draft Working Paper to the 4th meeting of the Scientific Committee for the WCPFC.
- Campbell, R. 2008. Data summary pertaining to the catch of swordfish by longline fleets operating in the southern WCPO.
- Campbell, R., N. Davies and L. Griggs. 2008. Swordfish size and sex composition for Australian and New Zealand Longline fisheries.
- Campbell, R., M. Unwin and N. Davies. 2008. Swordfish CPUE trends across the southern WCPO.
- Kasapidis, P., A. Magoulas, B. García-Cortés, J. Mejuto. 2008. Stock structure of swordfish (*Xiphias Gladius*) in the Pacific Ocean using microsatellite DNA markers.
- Kolody, D. 2008. Exploratory update of the 2006 South-West Pacific swordfish Multifan-CL assessment.
- Kolody, D., N. Davies and R. Campbell. 2008. Review of issues in the 2006 SW Pacific swordfish assessment.
- Kolody, D. and N. Davies. 2008. Spatial structure in South Pacific Swordfish Stocks and Assessment Models.
- Mejuto, J., B. García-Cortés and A. Ramos-Cartelle. 2008a. Reproductive activity of swordfish (*Xiphias Gladius*) in the Pacific Ocean on the basis of different macroscopic indicators.
- Mejuto, J., B. García-Cortés and A. Ramos-Cartelle. 2008b. 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.
- Valeiras, X., J. Mejuto, M. Ruiz. 2008. Age and growth of swordfish (*Xiphias Gladius*) in the North Pacific.
- Young, J., R. Humphreys, J. Uchiyama and N. Clear. 2008. Comparison of swordfish maturity and ageing from Hawaiian and Australian waters.

Background papers cited in the workshop report:

- Alvaredo Bremer, J.R. Hinton, M.G. and Greig, T.W. 2006. Evidence of the spatial genetic heterogeneity in Pacific swordfish revealed by the analysis of *LDH-A* sequences. *Bull. Mar. Sci.* 79(3): 493-503.
- Davies, N., R. Campbell, and D. Kolody. 2006. CASAL Stock Assessment for South-West Pacific Broadbill Swordfish 1952-2004. Methods Specialist Working Group paper WCPFC-SC2 ME-WP-4 presented at the 2nd meeting of the Scientific Committee of the Western and Central Pacific Fisheries Commission, held 7-16 August, Manila, Philippines.
- DeMartini EE, Uchiyama JH, Williams HA (2000) Sexual maturity, sex ratio, and size composition of swordfish, *Xiphias gladius*, caught by the Hawaii-based pelagic longline fishery. *US Fish Bull* 98:489-506
- DeMartini, E. E., James H. Uchiyama, Robert L. Humphreys Jr., Jeffrey D. Sampaga, Happy A. Williams (2007) Age and growth of swordfish (*Xiphias gladius*) caught by the Hawaii-based pelagic longline fishery *Fish. Bull.* 105:356-367.

- Hinton, M.G., and M. Maunder. 2006. Status of the swordfish stock in the southeastern Pacific Ocean. Inter.-Amer. Trop. Tuna Comm. Stock Assessment Report 7: 249-282.
- Hoyle, S., K. Bigelow, A. Langley and M. Maunder. 2007. Proceedings of the Pelagic Longline Catch Rate Standardization Meeting, held 12-16 February 2007, Honolulu, Hawaii.
- Kolody, D.S., R.A. Campbell, and N. Davies. 2006. South-West Pacific swordfish stock assessment (year 2). Final report for Australian Fisheries Management Authority (Canberra), project R04/0995.
- Nishikawa, Y., Honma, M., Ueyanagi, S. and Kikawa, S. (1985) Average distribution of larvae of oceanic species of scombrid fishes, 1956–1981. Far Seas Fisheries Research Laboratory, Shimizu. S Series 12.
- Reeb, C.A., L. Arcangeli, and B.A. Block. 2000. Structure and migration corridors in Pacific populations of the swordfish *Xiphius gladius*, as inferred through analyses of mitochondrial DNA. Marine Biology 136: 1123-1131.
- Young, J. and A. Drake. 2002. Reproductive dynamics of broadbill swordfish (*Xiphius gladius*) in the domestic longline fishery off eastern Australia. Final report for project 1999/108, Fisheries Research Development Corporation, Canberra, Australia.

Attachment C: Agenda for Southern WCPO Swordfish Stock Assessment Workshop

16-18 April 2008
SPC, Noumea

1. (Wed) Introduction
 - Workshop Objectives
 - 2006 Assessment Overview
 - Major uncertainties in 2006 assessment:
 - a) Stock boundaries
 - b) Internal migration
 - c) Size-at-age
 - d) Maturity
 - e) M
2. (Wed) Spatial Structure
 - South Pacific Stock Structure
 - Internal structure within the assessment
3. (Wed-Thurs) Review and Compilation of Fisheries Data
 - Catch and Effort Data
 - a. Coverage by fleet
 - b. changes in fishing behaviour
 - Catch rates
 - a. Standardization
 - Size and sex Composition
 - a. Space/time coverage by fleet
 - b. Japanese samples from the early 1950s
4. (Thurs) Review of Fisheries Independent Research
 - Size-at-age by sex
 - Maturity
 - Tags
 - a. Conventional
 - b. P-Sat
 - Genetic connectivity
 - Information from other swordfish stocks
5. (Thurs-Fri) 2008 Assessment
 - Major Assumptions
 - Input data analyses
 - Software
 - Sensitivity Analyses / Uncertainty quantification
 - Model diagnostics / selection
 - Workplan
6. (Fri) Research priorities for reducing assessment uncertainty

Attachment D: Summary Tables of swordfish data by area (as defined in the Report of the Southern WCPO Swordfish Assessment Workshop Figure 4) and actions arising as a result of the Workshop.

Fisheries Data available for stock assessment	Area 1	Area 2	Area 3	Area 4	
Catch and effort data	Operational catch and effort data from Australian domestic fleet including specific gear and operational information to conduct standardisation.	Operational catch and effort data from New Zealand domestic fleet including specific gear and operational information to conduct standardisation (issues – potential bias in recent years due to explicit swordfish targeting).	Korean, Taiwanese and Spanish fleets have largest fisheries in this area. Issues: 5x5 catch and effort data available but operational level data not accessible to assessment team for CPUE standardization	Korean, Taiwanese and Spanish fleets have large fisheries in this area. Issues: 5x5 catch and effort data available but operational level data not accessible to assessment team for CPUE standardization	
	New Zealand fishery very small in this region	Australian fishery small in this region			
	Aggregated (5x5xmonth) catch and effort for Japanese fleet (issues – 1x1xMonth standardisation and analysis is being conducted in Japan through liaison with stock assessment team in Australia)	Aggregated (5x5xmonth) catch and effort for Japanese fleet (issues – 1x1xMonth standardisation and analysis is being conducted in Japan through liaison with stock assessment team in Australia)	Japanese swordfish catch insignificant in this region	Aggregated (5x5xmonth) catch and effort for Japanese fleet (issues – 1x1xMonth standardisation and analysis is being conducted in Japan through liaison with stock assessment team in Australia)	
	Standardised Spanish CPUE has been provided by Spain (issues: standardization applied to aggregate of these 4 areas plus equatorial regions north of the equator; concerns about the use of non-target/target species ratio as a standardisation factor; only years 2004-6 covered)				
	Aggregated and operational catch and effort data from Pacific Island Nation domestic fleets (issues – most fisheries are very small, assessment team has insufficient understanding of fleet operational characteristics and fishery history)				
	Papua New Guinea and New Caledonia are most substantial PIN fisheries	Fiji is most substantial PIN fishery	Cook Islands is most substantial PIN fishery	French Polynesia is most substantial PIN fishery	
	Australian and New Zealand data available to 2007 Japanese and Taiwanese data unavailable (or incomplete) for 2005 and				

	2006 All other fleets data available through 2006	
Size data	Comprehensive coverage of size data from Australian port sampling and observer program (issue – observer data not yet included).	Comprehensive coverage of size data from New Zealand port sampling and observer program (issue – port sampling only in recent years).
	Comprehensive Spanish size composition data collected, but only 2004 has been made available for the assessment team	
	Size sampling sparse and inconsistent for most fleets	
Sex data	Limited sex data available historically. This is changing for some fleets through recent sampling and observer programs	

Fisheries Independent (and semi-independent) research	Area 1	Area 2	Area 3	Area 4
Tagging data	PSAT tagging conducted by Australia over previous 18 months (issues – small number of tags and short release durations; analysis incomplete). Suggests spawning occurs in area 1.	Minor movements of fish tagged in Area 1 into Area 2.		
	Minor movements of fish tagged in Area 2 into Area 1.	PSAT tagging conducted by New Zealand over previous 18 months (issues – small number of tags short release durations). Suggests spawning occurs in area 2.	Minor movements of fish tagged in Area 2 into Area 3.	
	Conventional tag release/recovery data (issues – small number of releases, dependent on fisheries for recovery and returns; program poorly publicized outside of Australia and New Zealand)			
	PSAT tagging from Northern and Eastern Pacific Ocean (issues – low numbers, short durations). No movements reported into Southern WCPFC convention area.			
Genetic data	Reeb et al (2000) suggests that North-west and South-West Pacific populations are distinct, while most other Pacific populations cannot be distinguished			
	Bremer et al (2006) suggests that North-west and South-West Pacific populations are distinct, and South-West and South-East stocks are distinct. Significant differences in other populations not identified.			
	Kasapidis et al (2008) suggest no genetic differentiation within Pacific, though there is weak evidence for distinction between North-West and South West populations and between South-West and South-Central populations.			
	Issues: genetic studies may not be able to identify important sub-population structure			
Maturity Studies	Mejuto et al 2008 found high proportions of spawning-ripe swordfish in the equatorial Pacific (10N-10S, 170W-45W), and to a lesser extent the South-East Pacific (east of 120W), and limited numbers of spawning-ripe swordfish elsewhere. Samples were large but coverage was not uniform, and seasonality not described.			
	Young and Drake (2002) found high proportions of spawning-ripe swordfish in the SW Pacific. Samples were primarily limited to the spatial extent of the Australian fishery.			

	Young et al (2008) describe difference in the interpretation of age at maturity for female swordfish depending on the quality of histological samples, analytical methodology and size-at-age estimates.
Japanese Larval Surveys	Nishikawa et al 1985 describe large concentrations of swordfish larvae in Area 1, but lesser concentrations were observed throughout the tropical South Pacific, except for the far eastern region. Larval survey coverage was not uniform in space or time, with large gaps in the south-central Pacific.
Age/growth	Young et al (2008) compare growth rate estimates from different regions. It is unclear to what extent different growth rates are estimated due to differences in methodology, or due to regional biological differences. Mejuto et al (2008) estimate swordfish growth rates from the North Pacific. The estimates are similar to the Young et al 2003 estimates for the SW Pacific, However, they differ from the DeMartini et al. (2006) North Pacific swordfish estimates and from the Young et al (2008) comparative readings from a second Australian reader and a Hawaiian reader. Independent age validation methods should be pursued for swordfish

recommended actions	Area 1	Area 2	Area 3	Area 4	
Catch and effort data	Use only "core" New Zealand fleet CPUE in area 2. (omit recent spatial expansions)		Attempt to acquire Taiwanese operational level logbook data from U.S. (acquired in Pago Pago)		
	Use only "core" Australian fleet CPUE in area 1.		Explore utility of Japanese, Korean and Taiwanese CPUE in areas 3 and 4. Provide comparison of CPUE trends among fleets operating in the same area and for the same fleet using catch rates standardized with and without operational level data as an indication of value of operational level data.		
	Complete Japanese CPUE standardization for areas 1 and 2				
	Request operational level data and fishery development descriptions from PINs to help interpret catch rates as abundance indices (this is a long term objective).				
	Request Japanese and Taiwanese catch data for 2006 with primary urgency, all fleet data for 2007 would be ideal				
	Do not use the spatially aggregated Spanish CPUE indices at this time				
Size data	Include Australian observer data. Analyze Australian data with spatial disaggregation to ensure that size trend is not a spatial effect.	Obtain packing data from Fiji to acquire individual fish size information.	Obtain packing data from Cook Islands to give individual fish size information.	Inquire about French Polynesia packing data.	
	Re-iterate request for Spanish size composition data. Encourage size sampling for all fleets in the future				
Sex data	No assessment action at this time. Encourage further sampling and data circulation for all fleets				
Tagging data	Seek to update tagging analysis if substantial numbers of additional tag results becomes available.				
Genetic data	No assessment action at this time. Encourage further sample collection, particularly from South-Central Pacific (areas 3-4)				
Maturity Studies	Assessment to consider alternative maturity schedules consistent with the differing maturity interpretations. Encourage further sampling and analytical work.				
Age/Growth Studies	Assessment to consider alternative growth curves, consistent with the different studies. Encourage comparisons of ageing methodology among labs. Methods of direct age validation should be pursued (e.g. conventional tagging coupled with oxy-tetracycline marking).				

Attachment E: Brief descriptions of the swordfish fisheries in the Cook Islands, New Caledonia and French Polynesia.

1. Cook Islands fishery summary

The Cook Islands longline fishery is characterised by two distinct fishing techniques, vessels fishing in the northern part of the zone (above 15° South) target albacore tuna, setting lines with an average of 30 hooks per basket, and trip lengths averaging 6 weeks. Some vessels retain swordfish catches to be sold on the local market (Pago Pago), while others (usually Asian captains) discard swordfish to keep space for tuna catches. All vessels operating in the northern fishery unload to canneries in Pago Pago.

Vessels fishing in the southern part of the zone cater to the fresh fish market, with specific swordfish targeting beginning in 2002, when fishermen from the East Australian swordfish fishery introduced the targeting techniques of shallow night setting and the use of light sticks. The average number of hooks per basket is 15.

The distribution of effort for the northern fleet spans right throughout the northern CK zone, and although in the past vessels roamed above and below 15° south, in recent years this has become less frequent with the fleet usually keeping fishing activity north of approximately 14° south.

From 2002 to 2005, the fleet structure of vessels operating out of Rarotonga consisted of vessels ranging in length from 10m to 34m and GRT ranging from 8 to 275mt, with vessels above 16m targeting tuna for the export markets. The larger vessels would roam between the northern and southern bounds (15° south) of the zone. Fishing activities for the smaller scale vessels concentrated around Rarotonga, and sea mounts in the southern part of the zone.

The fleet structure of vessels operating out of Rarotonga changed from 2006 onwards, consisting of 7 small scale vessels with length and GRT ranging from 11m to 16m and 10mt to 35mt, respectively. These vessels target swordfish to cater for local demand. In 2007 this was reduced to 5 vessels.

Based on anecdotal information bait preferences varied among fishing companies with squid being the preferred bait for swordfish, or using a mix of squid and pilchards. However in recent times the use of pilchards has become preferable due to the rise in squid prices.

In 2007, Steve Beverly carried out some work on Rarotonga based vessels. During this time a tagged swordfish was landed with a conventional tag. There was heavy fouling on the tag and difficult to identify. Fishermen mentioned that they had seen this before but thought it was a parasite, or some sort of growth on the fish. There was also a high number of 'rats' (length <50cm, weight <5kg) caught in the fishery that year.

Data sources for the fleet include logsheet, unloadings, port sampling and some observer data.

2. New Caledonia fishery summary

From 1983 to 1993 the New Caledonian longline fleet was dominated by large (40 meters in length) freezer vessels originally from Japan which were operated by joint-venture domestic companies.

On these large vessels, the Japanese fishing masters had imported Japanese fishing strategies which were especially implemented in the early 80s. In particular, since the fishing activity was directed to export to Japan, the vessels had much more seasonal fishing patterns and albacore was not at all a target species at this time. These fishing practices changed however slightly during the 80s when it appeared that albacore could be sold at an interesting price on the domestic market. This market grew regularly in volume over time.

The first 100% New Caledonian fresh longliners (from 16 to 20 meters) were first introduced in 1994 and progressively improved their catch rates. Despite the objective of exporting most of the catch to Japan albacore was more and more predominant and almost all other species, including swordfish, became by-catch.

A major event occurred in 1999 with the opening of a second fishing port in New Caledonia where small fresh vessels were based. This doubled the number of longliners. Due to smaller cruising range these vessels however fish closer to the port. This may explain why in 1999, there is a drop in the CPUE of swordfish whose fishing grounds in the EEZ appear to lay far from the ports.

The regular decrease in this CPUE since then can be explained by a New Caledonian fleet targeting more and more albacore.

3. French Polynesia fishery summary

i) Foreign longline fleet (DWFN)

The tuna fishery in the French Polynesia EEZ was dominated by DWFN between 1950 and 1992. Catches of albacore averaged approximately 4,000 mt per year until the mid 1960s when DWFN started targeting bigeye in the northern part of the EEZ, north of 10°S. Catches were dominated by bigeye and yellowfin tunas in more recent years. While very high catches were estimated for some years, total catches by the DWFN averaged 3,300 mt between 1990 and 2000. No DWFN have operated in the French Polynesia EEZ since 2001 as access licences for these fleets were not renewed.

Japan and Korea were the only DWFN fleets licensed to operate within the French Polynesia EEZ, with 65 vessels operating within the EEZ in 1988. Up to 49 Japanese longline vessels fished within the French Polynesia EEZ between 1984 and 1991. No activity has been recorded by Japanese longline vessels in the French Polynesia EEZ since 1992.

Korean longline vessels operated in the French Polynesia EEZ between 1984 and 2001, with a peak of 46 vessels in 1999. Only three Korean vessels were reported in

the French Polynesia EEZ in 2001 with no vessels reported in subsequent years. Relatively few vessels from other DWFNs (Taiwanese longline vessels) have reported any activity in the French Polynesia EEZ and most effort was reported from areas near the northern boundary of the French Polynesia EEZ.

The number of longline hooks set by DWFNs in the French Polynesia EEZ peaked at over 6 million per year in 1988, although the number of hooks set was less than 4 million per year for most years between 1984 and 2000, with an average of approximately 2.8 million hooks per year. Longline sets by DWFN used an average of approximately 2,450 hooks per set between 1984 and 2000, with the hooks per set being relatively stable for this period.

Steadily increasing swordfish CPUEs were reported by the Japanese fleet until the early 1980s when swordfish CPUEs declined and stabilised at low levels. The declines in CPUEs of swordfish may be due to a shift in targeting and areas of operations, as both species are more abundant in sub-tropical and temperate waters. As all DWFN focussed on the northern areas of the EEZ since at least the early 1980s, the CPUEs for temperate species were expected to decline. The CPUEs for swordfish for Taiwanese and Korean vessels have been relatively low and constant.

All this data for foreign fleets which have operated in the French Polynesia EEZ were reviewed in the French Polynesia National Tuna Report n#9 (Brett Molony, SPC-OFP, March 2006).

ii) Domestic fleet

Three major categories (fleets) of domestic fishing vessels operate in the French Polynesia EEZ: tuna longliners, *bonitiers* (pole-and-line) and *poti-marara*. Both the *bonitier* and *poti marara* fleets operate in coastal waters (less than 25 nm from islands) in the French Polynesia EEZ and are considered coastal fleets. A large number of these vessels exist, but the cumulative catch of tuna and other species by this fleets are not easy to quantified because they operate from a large number of islands and data holding are relatively low. Nevertheless, no swordfish catch has been recorded in logsheet data since 1992.

Since 1990, the number of domestic longline vessels in the French Polynesia EEZ has expanded, especially since the mid 1990s. In 2006, the domestic longline fleet of French Polynesia consisted of 39 fresh tuna longline vessels (13–20 m in length), 4 mixed (fresh and frozen vessels) longline vessels (21 m in length) and 28 freezer vessels (23–26 m in length).

Logsheet data for the domestic longline fleet dates back to 1992. Since 1997, annual catches by the domestic longline fleet have averaged approximately 5,800 mt per year. The major target species are albacore tuna (an average of 3,400 mt per year since 1997), with lesser amounts of bigeye (500 mt) and yellowfin (660 mt) tunas. Sharks (260 mt), blue marlin (260 mt) and other fishes (760 mt) are also retained by this fleet. Effort has increased rapidly since 2000, with a total estimated effort exceeding 21 million hooks for 2004.

Albacore catch rates in the French Polynesia EEZ peaked during 1998, before declining to low levels, especially since late 2002. Yellowfin and bigeye CPUEs also

declined throughout the main longline fishing areas during the same period. Catches and CPUEs of all three species have remained at relatively low levels since 2002.

Swordfish is not targeted by French Polynesia longline fleet, and has to be considered as a bycatch (83 mt in 2006, 1.6% of total catch). Concerning size data, very small swordfish (< 60 cm LJFL) are seasonally caught in the northern part of French Polynesia EEZ. The Marqueses Islands Area is considered a spawning area. Swordfish CPUEs of the domestic longline fleet have declined through time, especially since 2000. However, some of the trends may be due to changes in fishing strategy: a single vessel targeted swordfish in the south of the EEZ in 1996 and two vessels in 2006. But difficulties faced by wholesalers to export this product did not allowed development of this fishery.

Those trips were experimental trip to target swordfish. The first one occurred in September and October 1996 with a Hawaiian fishing master: the longline vessel Arevamanu was targeting swordfish in the seamounts area around Rapa Island (23°S-32°S/150°W-140°W). Results were encouraging concerning the resource: 33 days at sea, 17 sets, 12.310 hooks, 13.1 mt total catch, 9.6 mt swordfish catch. The second one occurred in November and December 2006: two longline vessels, Moorea Rava'ai 6 and Vaeana were targeting swordfish in the southern part of French Polynesia EEZ (155°W-140°W/24°S-31°S). They used typical longline setup for swordfish: set at night, use of light sticks (3 per basket), shallow setting (12 hooks per basket). Concerning the setting practice to target swordfish, results were encouraging too:

- Moorea Rava'ai 6: 30 sets, 36.332 hooks, 261 fish and 85 swordfish (average length: 182 cm LJFL);
- Vaeana : 30 sets, 46.896 hooks, 403 fish and 83 swordfish (average length: 175 cm LJFL).

All those data are available at SPC-OFP. The southern swordfish stock is very interesting for French Polynesia, as for other small islands developing states, as a good resource in complement of albacore tuna resource. French Polynesia want to contribute to study this stock, and to participate in a collaborative tagging project.