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BIGEYE TUNA AGE, GROWTH AND REPRODUCTIVE BIOLOGY (PROJECT 35) – PROGRESS REPORT

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S. Nicol[1], K. Sisior[2], S. Retalmai[3], D. Itano[4], K. Schaefer[5], J. Farley[6], H. Honda[7], C. Sanchez[1], M. Hosken[1]

[1] Oceanic Fisheries Programme, Secretariat of the Pacific Community, B.P. D5 - 98848, Noumea Cedex, New Caledonia.
[2] Bureau of Marine Resources, Ministry of Natural Resources, Environment and Tourism, PO Box 359, Koror State, PW 96940 Palau.
[3] National Oceanic Resource Management Authority, PO Box PS122, Palikir, Pohnpei, FM 96941, Federated States of Micronesia.
[4] Pelagic Fisheries Pelagic Fisheries Research Program, University of Hawaii, 1000 Pope Road, MSB 312, Honolulu, Hawaii 96822, USA.
[5] Inter-American Tropical Tuna Commission, 8604 La Jolla Shores Drive, La Jolla, CA 92037, USA.
[6] CSIRO Marine and Atmospheric Research, PO Box 1538, Hobart, TAS 7001, Australia.
[7] National Research Institute of Far Seas Fisheries, Fisheries Research Agency, Japan.

Executive Summary

The 4th session of the Western and Central Pacific Fisheries Commission Scientific Committee recommended that the "comprehensive research plan on Pacific-wide bigeye age, growth and reproductive biology project" be implemented to help reduce uncertainty in this knowledge to improve the precision of stock assessments. The Fifth Regular Session of the Commission in December 2008 endorsed funding for phase 1 of this plan, "a 2 year pilot study in the EEZs of Palau and Micronesia to determine the sampling requirements for the broader Pacific-wide phase 2 component of the plan". This document articulates the progress of this pilot study.

The work plan for the pilot project scheduled sampling of bigeye for the period October 2009 to January 2010 with presentation of results and recommendations for Phase 2 at SC6. The low level of observer coverage on longline vessels over the past 12 months has restricted the opportunities for collection of otoliths and gonads from medium to larger individuals and the minimum sample size required has not yet been achieved. This problem is being rectified through the assistance of the Luen Thai Fishing Venture (LTFV). LTFV operate in Palau, FSM and RMI and have negotiated with the vessels they manage to collect samples for the project. Sampling is expected to be completed in August 2010. Laboratory analysis is now scheduled for September to November 2010 and the final report provided to the WCPFC secretariat in December 2010.

A consequence of the longer time frame required to collect samples for the pilot study is that no definitive advice can be provided to SC6 on whether to progress to Phase 2 of this project in 2011. The SC may wish to postpone any decision on future funding until it considers the final report. Consideration of this report could occur either out of session, at the pre-assessment workshop or at SC7.

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1.0 Introduction

1.1 Background

The 3rd session of the Western and Central Pacific Fisheries Commission Scientific Committee recommended that a project on bigeye growth and reproductive biology be implemented to help reduce uncertainty in these parameters to improve the precision of the stock assessments. The Fourth Regular Session of the Commission in December 2007 endorsed funding for 2008 to prepare a comprehensive research plan on Pacific-wide bigeye growth and reproductive biology. This plan was prepared in the first half of 2008 and comprised two components: (1) a comprehensive review of current knowledge on bigeye age, growth and reproductive biology; and (2) the research plan broken into an initial pilot phase to determine the sampling regime required to address the knowledge gaps with the precision required for stock assessment purposes and a full implementation phase. The report (WCPFC SC4 BI-WP-7) was presented to the 4th session of the Western and Central Pacific Fisheries Commission Scientific Committee which recommended its implementation. The Fifth Regular Session of the Commission in December 2008 endorsed funding for phase 1 (pilot) of this plan.

1.2 Synopsis of Current Knowledge

The review of current knowledge demonstrated considerable knowledge uncertainty in the WCPO with information from the central Pacific scant. Sex ratio information has been consistently collected across the equatorial Pacific Ocean in space and time however information on size at maturity, spawning area, season, and frequency and fecundity is derived from only a few studies (EPO, Philippines and Coral Sea, Figure 1). The methods used to estimate these parameters have also varied between each study making comparison problematic. The differences in estimates however supports the hypothesis that reproductive parameters used in the current stock assessment models are influenced by prevailing oceanography and variation in estimates can be expected both in longitudinal and latitudinal dimensions.

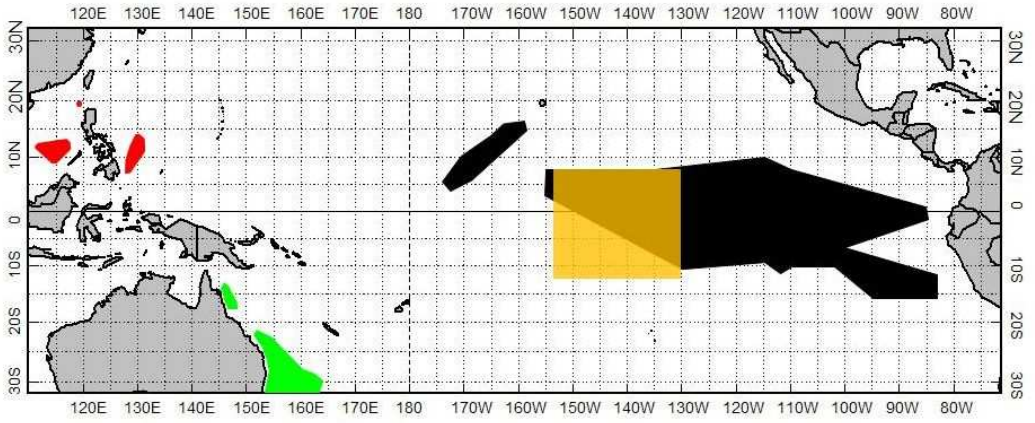


Figure 1. Location of recent studies on bigeye where reproductive parameters have been estimated; Schaefer et al. 2005 (black); Zhu et al. 2010 (orange); Farley et al. 2006 (green); Sun et al. 2006 (red).

Differences in growth between locations (Figure 2), has been observed between the studies in the EPO and WCPO, however sample sizes across space in the WCPO are small. Ageing methods have also varied without validation between methods. It is unclear whether the observed differences in growth rate are the consequence of method comparison, sample size, or evidence of actual variation. The growth curve is highly influential in the current stock assessments for bigeye (Hoyle et al 2008).

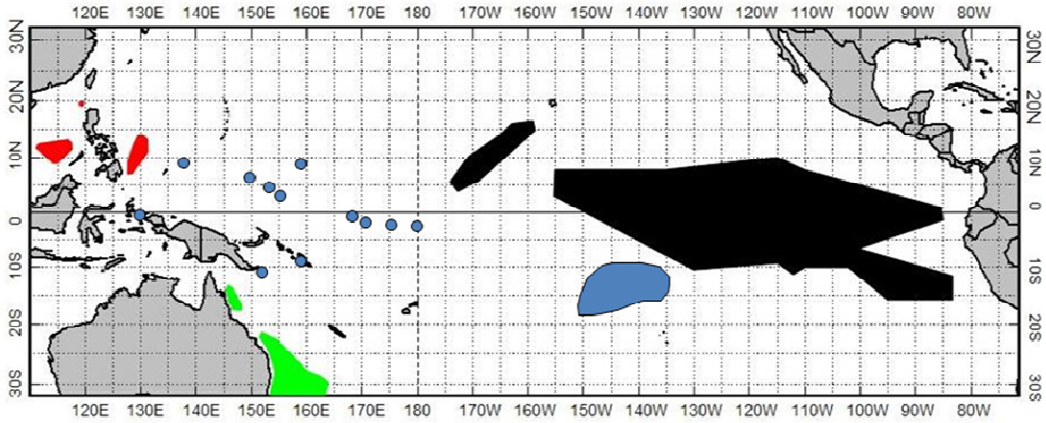


Figure 2. Location of recent studies on bigeye where age-growth have been estimated; Schaefer et al. 2005 (black); Farley et al. 2006 (green); Sun et al. 2006 (red); Leroy 2001 (blue).

1.3 Pacific wide research plan for bigeye age, growth and reproductive biology

The goal of the 'Pacific-wide Bigeye Growth and Reproductive Biology Study is to improve stock assessment and management of bigeye tuna in the Pacific Ocean. The specific objectives are:

1. To obtain data that will contribute to, and reduce uncertainty in, the maturity schedule used in stock assessment models, over the equatorial and sub-equatorial range of bigeye.
2. To obtain comprehensive information on the growth rate of bigeye and the spatial and seasonal variation expected in this rate.
3. To obtain information on bigeye fecundity, and the influence of age and size on batch fecundity, at a resolution suitable for use in stock assessment models.
4. To obtain information on the spatial and seasonal variation in spawning frequency and location, at a resolution suitable for use in stock assessment models.

1.4 Design & Analysis

A spatially stratified design that blocks longitude, latitude and size with individuals within these blocks randomly sampled has been adopted. To maximise opportunities for comparison with existing information (Schaefer et al. 2005, Farley et al. 2006, Schaefer and Fuller 2006, Sun et al. 2006) two options are being considered for spatial blocking: (1) a fine scale design where blocking applies at a 32° longitude × 10° latitude (Figure 3a); and (2) a coarser scale design where blocking occurs at a 32° longitude × 20° latitude (Figure 3b). Response terms, fixed effects and random

effects for this design are detailed in Table 1. The results of the pilot study will be used to determine whether the fine or coarse scale blocking satisfy the data needs of the stock assessment models. In addition, as spawning is assumed seasonal in sub-equatorial regions, occurring during periods when sea surface temperatures (SST) are > 24°C, a temporal block of quarter is included to estimate this effect.

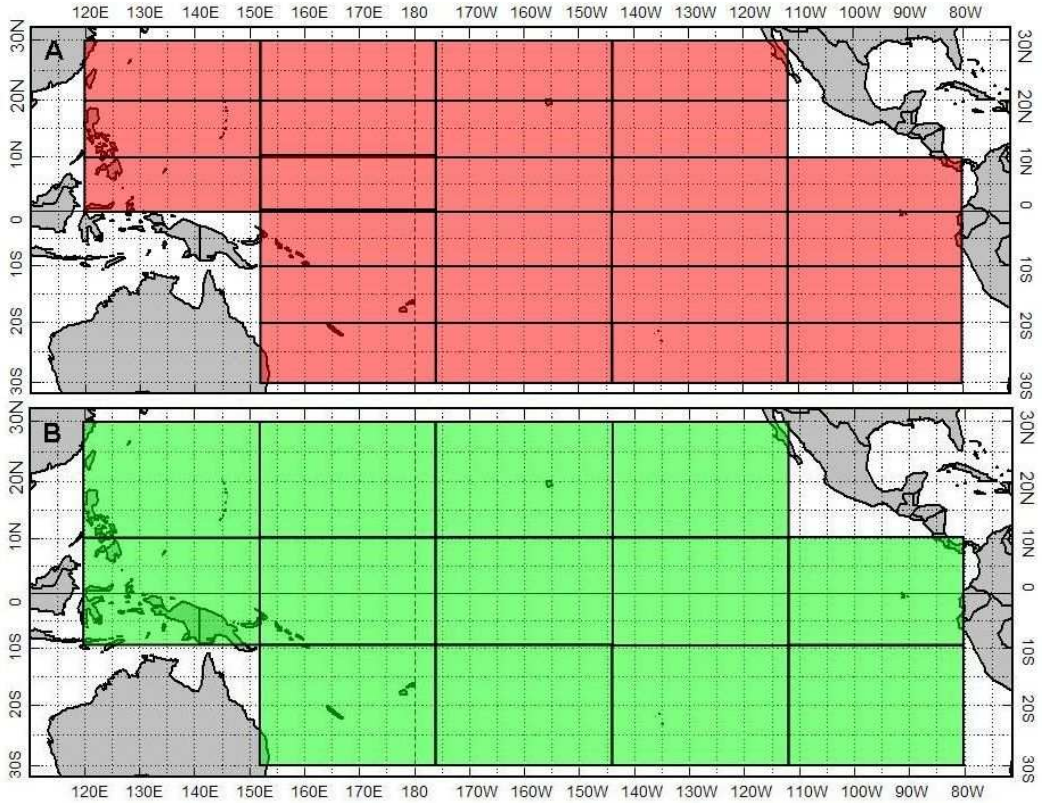


Figure 3 Proposed blocking designs for the collection of samples for the study on bigeye reproductive and growth biology. (A) Fine scale resolution; (B) Coarse scale resolution

Table 1. Response terms, fixed effects, covariates and random effects proposed for the analysis of the data collected for the study of bigeye reproductive and growth biology.

Response Terms	Growth rate, Maturation, Spawning fraction, Fecundity
Fixed Effects	Quarter
Covariates	Length, Age, Latitude, Longitude, SST
Random Effects	block, capture method (Purse Seine, Hand Line or longline), set (depth)

Where practical the following biological material and capture data will be collected for each individual sampled: gonad (for sexing, maturation, atresia and spawning frequency determination, batch fecundity); sagittal otoliths and if feasible the first spinoform ray of the first dorsal fin (for age determination); fork length of fish (nearest cm); weight of fish (nearest g); capture location (longitude and latitude); capture time; vessel name and flag; port sampled or observer sampled; fishing method and set information (eg. hook/net depth); sea surface temperature (SST) when available.

Histological methods (Schaefer et al. 2005, Sun et al. 2006) should be applied to determine sex, maturity state and spawning status. Batch fecundity should be estimated using the hydrated oocyte method (Schaefer et al. 2005, Sun et al. 2006). Ovaries which have visibly enlarged oocytes will be initially selected and following microscopic examination should they be determined to have migratory nucleus they should then be used for estimating batch fecundity. Preparation and ageing of otoliths should follow the methods outlined in Farley et al. (2006) and Schaefer et al. (2005). For dorsal spines the methods should follow those outlined in Sun et al. (2001).

To facilitate comparison with the study of Schaefer et al. (2005) in the EPO, individuals should be sampled for each 10 cm length interval from 30 to 150+ cm in the WCPO. This regime should sample across the full range of maturity states for females. Expert opinion recommends that at least 6 individuals be sampled per block to ensure adequate statistical power. However power analysis to confirm this recommendation is warranted. This analysis will use existing bigeye data collected from the pilot study. To avoid the potential for insufficient sampling the numbers per fish size are outlined in Table 2.

Table 2. Number of fish per size class that is recommended to be sampled by port samplers and observers

Size	Number samples per strata	Commentary
30-40	12 fish	Macroscopic examination unreliable, approximate 50:50 sex ratio, double number of samples
40-50	12 fish	
50-60	6 fish	Macroscopic examination possible onboard fishing vessels provided technicians are suitably trained
60-70	6 fish	
70-80	6 fish	
80-90	6 fish	
90-100	6 fish	
100-110	6 fish	
110-120	6 fish	
120-130	6 fish	
130-140	6 fish	
140-150	6 fish	
>150	6 fish	

1.5 Pilot study

The pilot study will determine the sampling requirements for each strata of the Pacific wide study and the feasibility of sampling from longline and purse-seine vessels over a 2 year period. Region 3 is the priority of the WCPO stock model and has been selected to immediately satisfy some of the data needs of the stock assessments for bigeye. Fish caught from the Palau and Micronesia EEZs are on average larger in size than the other areas with region 3. The stock assessment model currently assumes that these are older fish with higher reproductive output. The fish could also be younger but faster growing individuals. Undertaking the pilot study in this area will resolve this issue in addition to providing the information necessary to determine the sampling requirements of the Pacific-wide study. As both EEZs are located in the WCPO warmpool, there is little expectation of seasonal variability in reproduction and sampling in a single season only would be required for this pilot study. This

would equate to 78 samples from each EEZ. Sample quality can vary and to ensure adequate samples are collected 154 samples from each EEZ is required.

2.0 Pilot study work plan & progress

2.1 Work plan

The work plan for the pilot is reflected in the following milestones table.

Date	Activity	Progress
February 2009	Inception	Project included as activity in service agreement between SPC and WPCFC
March 2009	Preliminary visit to Palau & FSM for training and project coordination	Completed.
April 2009	Quality assurance test of commercial ageing service providers	4 BET otoliths sent to Tropical Fish Ageing for analysis. Reliability confirmed by CSIRO and the commercial supplier considered unsuitable for tropical tuna ageing. Otoliths to be read by mix of CSIRO and SPC scientists.
May 2009	Appointment of data collection coordinator.	Selection process completed and co-coordinator appointed
June 2009	Second Palau, FSM, SPC project coordination meeting	Completed.
July 2009	Otolith drill extraction training of trainers.	Completed
August 2009	Third Palau, FSM, SPC project coordination meeting	Completed
September 2009	Training and provisioning of Palau and FSM observer and port samplers with extraction equipment and data records.	Completed
October 2009	Data collection.	Commenced but due to low observer coverage for longline vessels over the past 12 months the required number of samples has not yet been collected. Sampling is expected to be completed in August 2010.
November 2009	Data collection.	
December 2009	Data collection.	
January 2010	Data collection.	
February 2010	Histology & ageing.	Delayed due to incomplete sampling. Expected completion now March 2011
March 2010	Histology & ageing.	
April 2010	Histology & ageing.	
May 2010	Histology & ageing.	
June 2010	Data analysis.	
July 2010	Pilot study report preparation.	
August 2010	Presentation of pilot study	Presentation delayed until SC7

results to SC6.

2.2 Progress

Observer (at sea and port) Training

Training of observers has been undertaken in Palau, Federated States of Micronesia, Solomon Islands, Cook Islands, Marshall Islands and Fiji in conjunction with Regional Observer Program training activities. The training consisted of instruction and practicals in extraction of otoliths (using a variety of methods), sex identification, gonad identification, storage of samples and data recording. The training was conducted over a 2-3 day period and included presentations on the scientific use of biological samples and the purpose in fisheries management. In addition observers were also instructed in the collection of other biological samples (genetic, stomach, liver, muscle) so that they are able to contribute to other WCPFC endorsed activities. In total 73 observers have been trained to a standard where they can competently undertake biological sampling for the project.

Figure 4. Photos of observers being trained in biological sampling

Sample collection

Sampling has been undertaken for the pilot project1, Phase 2 and for yellowfin. The work plan for the pilot project scheduled sampling of bigeye for the period October 2009 to January 2010 and this has been the priority activity. However, the low level of observer coverage on longline vessels over the past 12 months has restricted the opportunities for sampling of medium to larger individuals and the required number of samples has not yet been collected. This problem has been recently rectified through the assistance of the Luen Thai Fishing Venture (LTFV). LTFV operate in Palau, FSM and RMI and have negotiated with the vessels they manage to collect samples for the project. Sampling is expected to be completed in August 2010.

Sampling from the Luen Thai vessels however requires higher levels of co-ordination. On board the longliners, the fish are tagged with a numbered cable tie around the mouth. During the gill and gutting the gonad, stomach, muscle, and liver samples are collected by the vessel crew and label with the same cable tie number. The otoliths are extracted when the fish get to the processing plant the otoliths by the port samplers. Most specimens are able to be sampled using this method at FSM and RMI. In Palau only reject fish are able to be sampled for otoliths.

Sampling for Phase 2 was commenced to utilise all trained observers and the 100% purse seine coverage that is currently in operation. Sampling was also extended to include yellowfin to fill the knowledge gaps identified in SC5-BI-WP-03. The analysis of the samples collected for Phase 2 or yellowfin are not planned within this project.

The numbers of samples collected to date for each component are provided in Table 3, distribution of bigeye samples in Figure 5 and size frequency of bigeye samples in Figure 6. The distribution of yellowfin samples and size frequency of yellowfin samples are provided in Figure 7 and Figure 8 respectively.

Table 3. Numbers of bigeye otoliths and gonads sampled for the pilot and phase 2 studies and the number of otoliths and gonads sampled from yellowfin

	BET Pilot		**BET Phase 2**		**YFT**	
Country - EEZ	**Otoliths**	**Gonads**	**Otoliths**	**Gonads**	**Otoliths**	**Gonads**
FSM	58	20			45	3
Indonesia					4	0
International waters			15	4	57	6
Kiribati			21	5	41	5
Marshall Islands	47	17			38	26
Nauru			10	10	58	27
New Caledonia					4	0
Palau	6	7			47	3
Solomon Islands			0	3	2	2
Tokelau			2	14	0	1
Tuvalu			0	24	22	24
Total	**111**	**44**	**48**	**60**	**318**	**97**

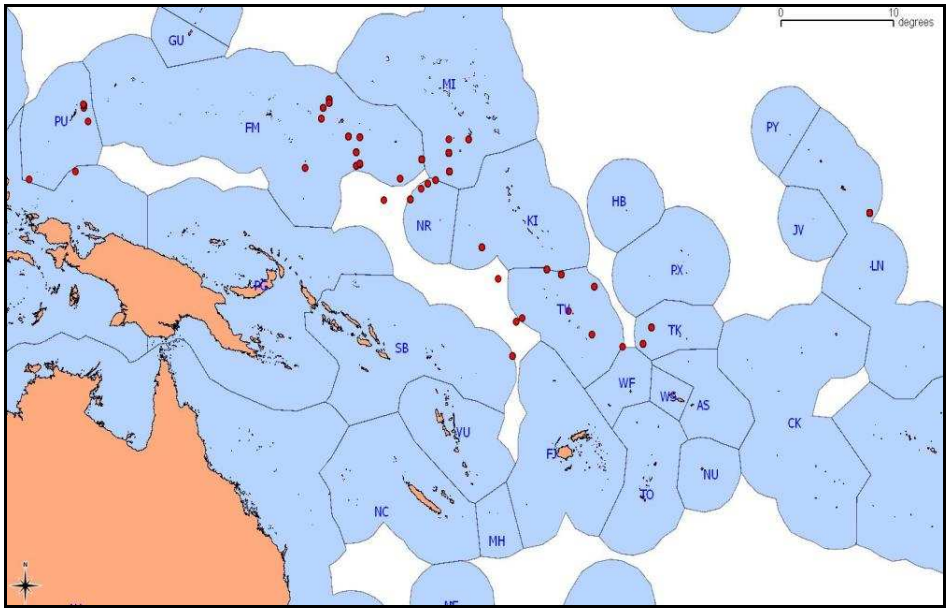
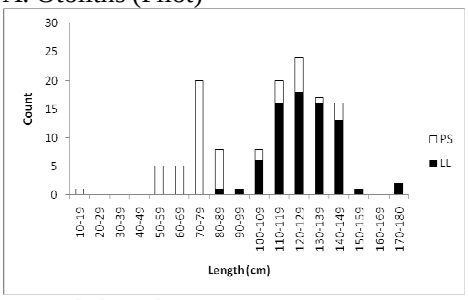
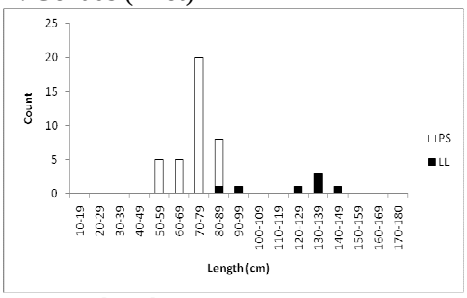


Figure 5. Spatial distribution of biological samples collected from Bigeye tunas

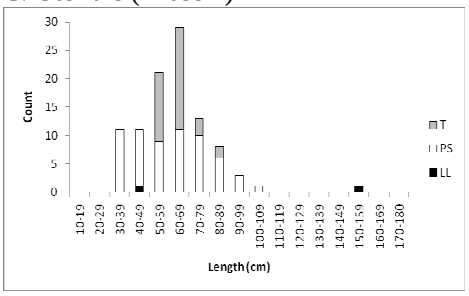
A. Otoliths (Pilot)



B. Gonads (Pilot)



C. Otoliths (Phase 2)



D. Gonads (Phase 2)

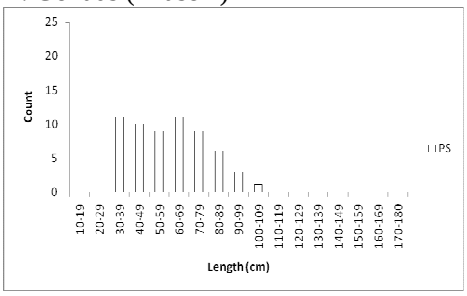


Figure 6. Length frequencies for Bigeye (T=Troll, PS=Purse Seine, LL= Longline)

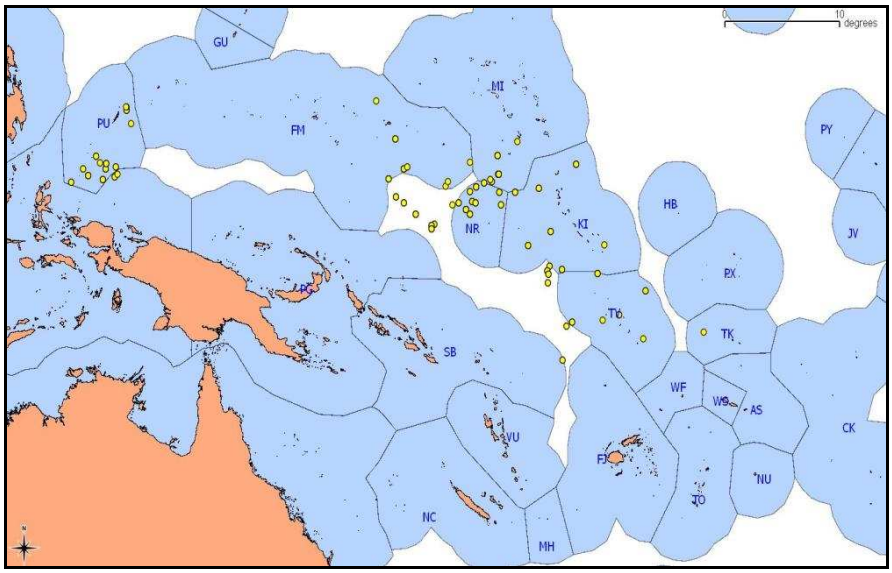


Figure 7. Spatial distribution of biological samples collected from Yellowfin tunas

A. Otoliths **B. Gonads**

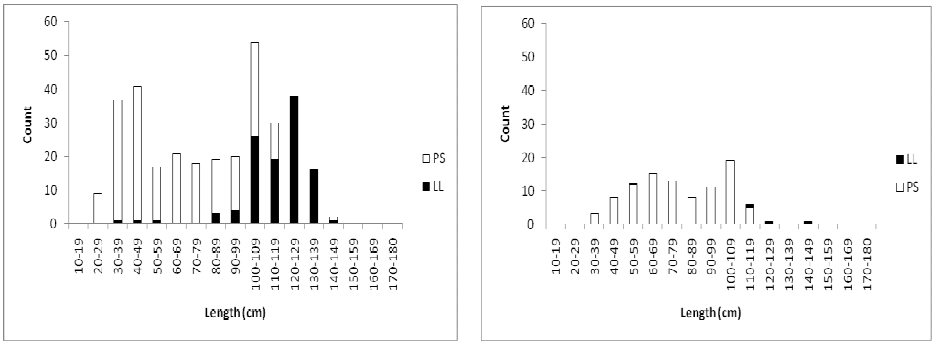


Figure 8. Length frequencies for yellowfin (PS=Purse Seine, LL= Longline)

Laboratory analysis is now scheduled for September to November 2010, with analysis completed by December 2010. Results of Phase 1 and recommendations for Phase 2 will be presented to the SC in 2011.

3.0 References

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