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BIGEYE TUNA AGE, GROWTH AND REPRODUCTIVE BIOLOGY – PROGRESS REPORT

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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 has been finalized with sampling of bigeye expected to occur in the period October 2009 to January 2010, laboratory analysis in February 2010 to May 2010, data analysis and modeling in June 2010 and pilot project reporting in July 2010 with presentation of results and recommendations for phase 2 at the 6th Regular Session of the Western and Central Pacific Scientific Committee.

Sampling protocols, preliminary training of technicians in Palau and Federated States of Micronesia and the appointment of a sampling coordinator has been completed. Protocols for laboratory analysis have been drafted and preliminary arrangements for laboratory analysis organized.

TABLE OF CONTENTS

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 (Nicol et al. 2008) 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.

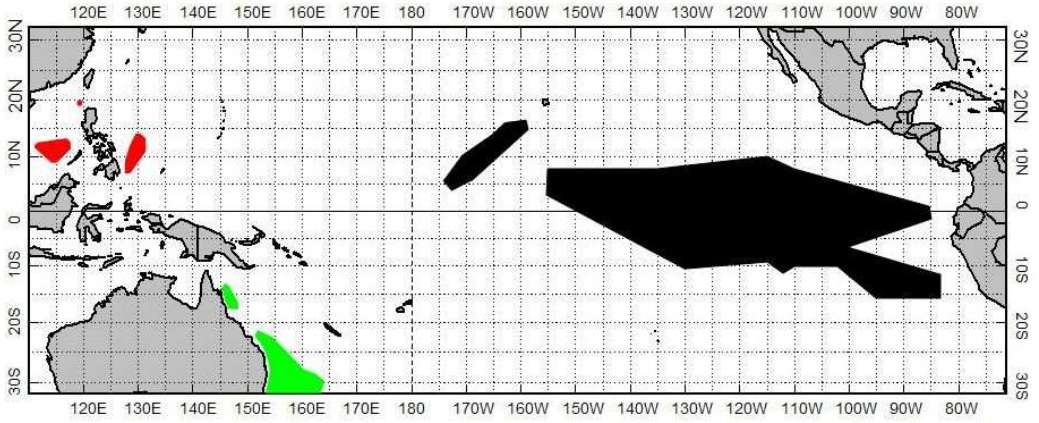

Figure 1. Location of recent studies on bigeye where reproductive parameters have been estimated; Schaefer et al. 2005 (black); Farley et al. 2006 (green); Sun et al. 2006 (red).

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).

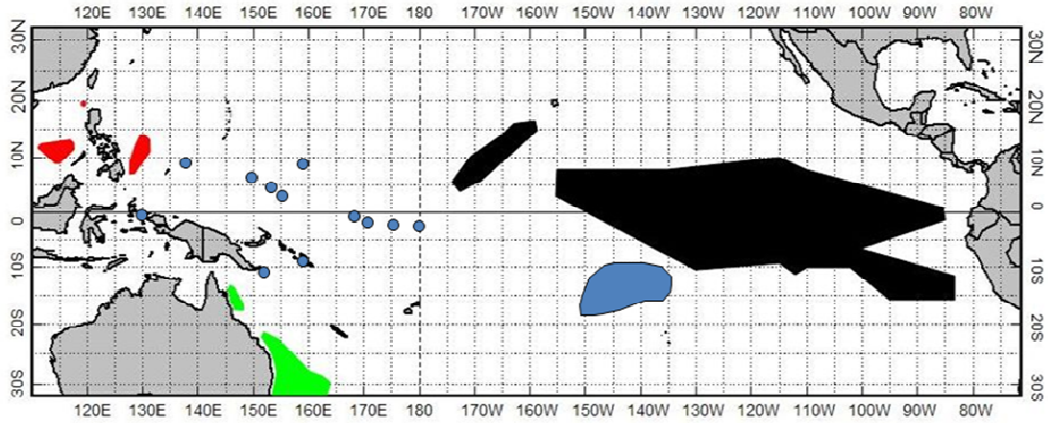

Figure 2. Location of recent studies on bigeye where age-growth have been estimated; Schaefer et al. 2005 (black); Farley et al. 2006 (green); Sun et al. 2006 (red); Leroy 2001 (blue).

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.

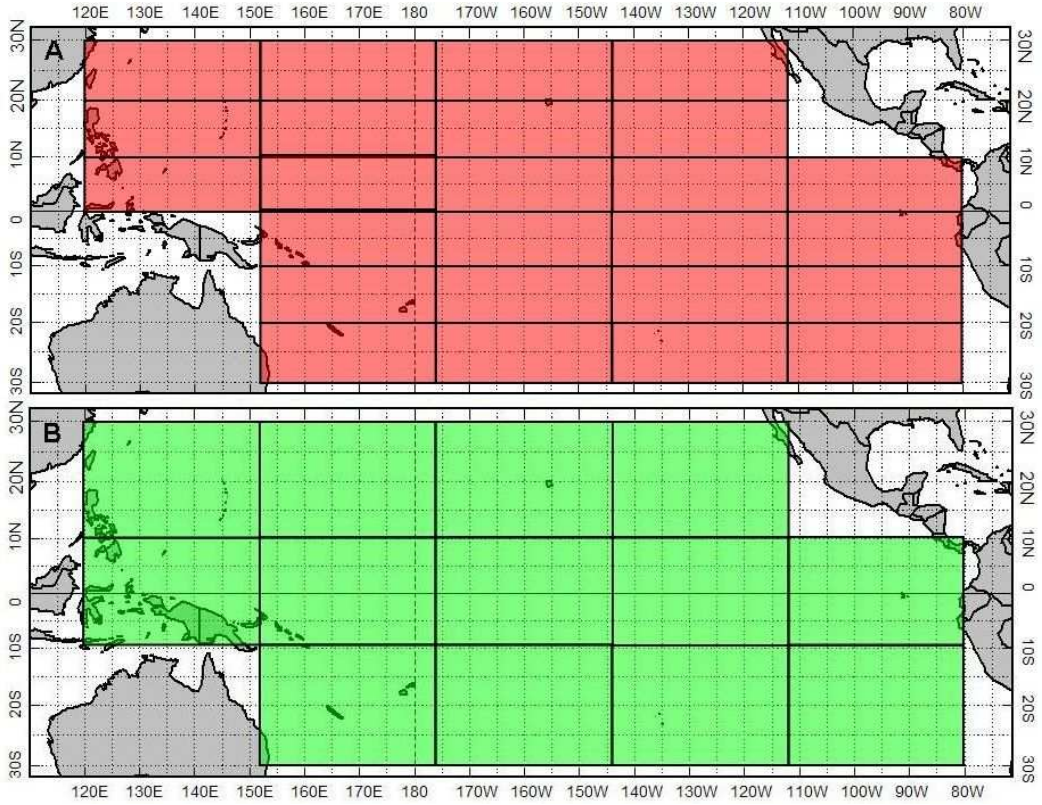

Figure 3 Proposed blocking designs for the collection of samples for the study on bigeye reproductive and growth biology. (A) Fine scale resolution; (B) Coarse scale resolution

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); whole migratory nucleus hydrated ovary sampling (for batch fecundity); sagittal otoliths and 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). 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.

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.
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	
September 2009	Training and provisioning of Palau and FSM observer and port samplers with extraction equipment and data records.	
October 2009	Data collection.	
November 2009	Data collection.	
December 2009	Data collection.	
January 2010	Data collection.	
February 2010	Histology & ageing.	
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 results to SC6.	

2.2 Progress

Sampling protocols have been prepared. Where possible gonads are to be collected fresh and preserved in 10% buffered formalin. When preservation cannot occur at the time of sampling, the gonads are to be frozen and then preserved in 10% buffered formalin in their frozen state when feasible. Otoliths are to be extracted, cleaned, dried and stored in vials along with the first spinoform ray of the first dorsal fin. Capture data to be recorded are: fork length of fish (nearest cm); weight of fish (nearest g); capture location (longitude and latitude); capture time; vessel name and flag; where it was sampled (Port, vessel or both); fishing method and set information

(eg. hook/net depth); and sea surface temperature (SST) when available. At sea observer sampling of large fish is likely to be problematic (time constraints and access to fish for otolith extraction from potentially high value individuals). To help resolve these difficulties, at sea observers, to treat every third set as a biological sampling set and not undertake other observer tasks on these sets. For larger specimens that have not been graded at sea, gonads and length to be collected at sea when gutted and the fish tagged so that the fish can be identified when grading occurs. The otoliths are to be extracted after grading if the individual is graded B or lower. Preliminary training of technicians/observers in Palau and Federated States of Micronesia in sampling methods and the appointment of a sampling coordinator has been completed. Protocols for laboratory analysis have been drafted and preliminary arrangements for laboratory analysis organized. CSIRO to prepare and read gonads and read otolith annual increments and SPC will undertake reading of daily increments.

3.0 References

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