SOUTHERN BLUEFIN TUNA RECRUITMENT MONITORING PROGRAM – 2000/2001

FINAL REPORT

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AFMA/STBMAC Partially Funded Research Project

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The AFMA/STBMAC Southern Bluefin Tuna (SBT) Recruitment Monitoring Project for 2000/01 was part of the longer-term collaborative research project involving CSIRO and The National Research Institute of Far Seas Fisheries (NRIFSF) of Japan. Funding for the research in 2000/01 came from a variety of sources including JAMARC (Japan), CSIRO, FRDC and AFMA. The long-term objective of the collaborative research work is the monitoring of the abundance of juvenile SBT including the development of a fishery independent index of juvenile abundance for use in the assessment of the SBT resource. In 2000/01 the collaborative research project was comprised of four inter-related sub-projects. These were:

- Aerial survey
- Archival tagging
- Conventional tagging
- Integrated analysis
- Acoustic monitoring experiments.

In 2000/01 partial funding of the archival tagging, conventional tagging, integrated analysis and acoustic monitoring experiments were provided for in the AFMA/STBMAC research grant covered in this report.

Aerial survey

The analytical work for the 2000-2001 involved:

1. Undertaking a full analysis of existing data using new methods agreed by the Pt Lincoln Specialist workshop.

2. Undertaking a full analysis of the existing data using “old” methods.

3. Comparison of the results produced by the old and new methods, with particular reference to the error/variance fields indicated by each method.

4. Developing a method for and complete examination of the effect of using data from trainee spotters in 1999 and 2000 in both methods.

5. Incorporating environmental data in to the models as indicated by results of the Integrated Analysis Project.

6. Completing the critical evaluation of the use of aerial surveys for estimating the abundance of 1-4 year old SBT in the GAB.

7. Preparation of a report for the next RMPWS with recommendations for future aerial survey work, if any. Any recommendation for continued work would include recommendations on the appropriate interval between surveys, the likely level of effort require to achieve a given level of precision and a realistic plan to deal with the logistical requirements.

The results of this work were presented at the 13th Southern Bluefin Tuna Recruitment Monitoring and Tagging Program Workshop held in Hobart on 18-20 December 2001, a copy of which is attached to this report, including all the documents reporting this work in detail. Two documents, RMWS/01/1 and RMWS/01/2 were presented. The first document described a series of new analyses conducted over the course of the last 12 months. The first issues addressed by this paper were some technical questions regarding the most appropriate analytical approaches. From the work conducted it was concluded that:

- The most appropriate data unit for the aerial survey analysis was the 1/4 line truncated at 6 nm.

- The appropriate modeling units were the inshore/offshore components of each of the 5 survey lines.

- The major issue addressed in the body of this report was the choice of an index, and in particular the choice between a presence/absence index and one based on biomass estimates. The conclusion reached by the report was that a presence/absence index should be recommended for the following reasons:

- It fluctuated less than a biomass index and has less appearance of noise.

- It had a lower CV in all years.

- It did not use the spotter's estimates of biomass, which in the past have been shown to be imprecise.

- If surveys were to continue it is the least expensive option and one prone to the least potential problems in terms of protocols.

For the first time, the analyses incorporated data on both the environmental factors affecting surface abundance and surfacing behaviour of SBT produced by the Integrated Analysis project. These data indicate that surfacing probabilities vary among areas on the Great Australian Bight and that environmental factors do significantly affect surface abundance. The report recommends that these factors should be incorporated into the indices.

The final conclusion of the report was that there was evidence from the presence/absence index for a significant decline in the abundance of SBT in the survey area over the period 1993-2000.

Archival tagging

It was planned to deploy up to 40 archival tags on 1+ SBT in January-February 2001. These would include new tags as well as serviceable tags returned to us over the past 12 months (6-12, depending on appraisal by the manufacturers). The tags would be deployed in conjunction with the conventional tagging and acoustic monitoring work.

The tags on 1+ fish would most likely be recaptured in one of three fisheries; the domestic fishery in South Australia, the Japanese longline fishery in the SE Indian Ocean, and the Taiwanese longline fishery in the central Indian Ocean. All three would be targeted with tag promotion material.

While field activities in 2000-01 would focus on Western Australia, analysis of data collected over the last six years from fish released in South Australia would continue. The principle objectives for this work were analyze the links between feeding and surfacing, links between large-scale movements and oceanographic conditions, determine the queues for movement into and out of the GAB, and examine for how long fish released in the same school exhibit similar behaviour that may indicate school integrity.

The results of this work were presented at the workshop in document RMWS/01/04 where the difficulties encountered in deploying archival tags in Western Australia over the summer field season were discussed. The Wildlife Computers Mk7 tags available this season were too large to use on 1-year old SBT, and as 2-year old fish were rare, only 5 of the 30 tags available were deployed. Intensive analyses of archival tag data continued throughout the year. These included completion of the geolocation estimates for all fish released in the summer of 1998 (the year for which we have analysed environment: surfacing behaviour relationships), estimates of the frequency of feeding and food intake volume for fish while they are in the GAB, and improvements to the software used to display and analyse the archival tag data.

Conventional tagging

Tagging was to be conducted off West Australia 2000/2001 in order to:

1. Provide comparative estimates of year-class strength based on the tag returns obtained in the Australian surface fishery in the Great Australian Bight.

2. Estimate fishing mortality rates for juvenile SBT contingent on the estimates of natural mortality rates.

3. Compare SBT growth rates in the 2000s with those from previous decades.

4. Obtain quantitative information on SBT movements.

5. Obtain information on the age composition of SBT in the West Australian area.

Two approaches were to be used for obtaining information on recruitment from the tag releases in 2001. In the first approach, the recovery rate of tagged fish from a cohort as a fraction of the fish harvested in the South Australian surface fishery would be used to compare the relative strength of the cohorts tagged in 2000/2001 with those tagged in the 1990s. The second approach was based on estimating the fishing mortality rates after the first year of released based on the tag returns in the second year and assuming a natural mortality rate.

A suitable Western Australian fishing vessel would be chartered for up to 29 days in order to tag at least 5,000 fish. The charter period would also include sea time for the acoustic and archival tagging proposals. The target for the number of fish to be tagged consisted of a minimum of 3,500 fish in the 50 to 60cm range and 1,500 larger fish. The area within which tagging would be conducted was bounded in the west by Cape Leeuwin (115 degrees East) and in the east by the Eastern Group Islands (124 degrees East). The tagging procedures would be the same as those used during the 1990s tagging experiments.

Tag recovery, including the ongoing liaison activities with long line and surface fleets, would continue along with data entry of recovered tags, and publicising of tag recovery processes through the distribution of material to the various fleets.

The results of this work were reported at the workshop in document RMWS/01/3. A further 2156 one and two year old fish were tagged in Western Australia between January and March 2001. Fish availability in areas previously fished was low, and the majority of fish tagged were found near the Eastern Group of Islands east of the normal areas of occurrence. Numbers of reported recaptures continue to decrease, only 12 being reported from Australian waters, 18 from the Japanese fleet and 3 from the New Zealand domestic fishery.

Integrated analysis

The objective of this project was to reduce uncertainty in the aerial survey estimates of surface abundance of juvenile SBT in the GAB through incorporation of environmental and behavioural data and models into the aerial survey analyses. It was planned to continue the development of the statistical models linking environmental and biological data with data on surfacing behaviour (archival tags) and surface abundance (aerial survey). These models

would then be applied to estimate the surface distribution of SBT incorporating the environmental data (by each replicate if possible). This would enable evaluation of which environmental variables affect detectability and surface abundance and would be incoporated into aerial survey abundance estimates.

The results of this work were reported at the workshop in documents RMWS/01/6 and RMWS/01/12.

The Integrated Analysis Project covered three major areas of research:

- Estimation of geo-position using light, bathymetry and sea surface temperature, and the use of these estimates to describe the movements of SBT in the GAB during summer,

- Environment: surface abundance relationships, and

- Environment: surfacing behaviour relationships.

The analysis of daily position of fish while they are in the GAB involved an integration of light, bathymetry and sea surface temperature to derive a "best estimate" of geolocation for each day. Although a significant improvement over estimates using only light data, it is clear that the best estimates still contain a number of "outliers" (defined by any estimates that involve the fish moving more than 120 Nm in a day). In these cases interpolation was used to derive a daily position and track of the movement. The conclusions regarding movement remain as in previous years – i.e. 2-4 year old SBT move into the GAB in late November – early December and leave sometime between mid March and mid April; during their time in the GAB fish tend to spend almost 100% of their time in the aerial survey area, and when they leave tend to do so through the south east corner of this area.

Depth and location information from archival tags deployed and recovered from juvenile southern bluefin tuna (SBT) in the Great Australian Bight (GAB) were used to investigate the relationship between surfacing, and hence detectability in an aerial survey, and environmental conditions. Several methods for classifying depth information into behavioural definitions related to surfacing were considered for four time-scales in different areas of the GAB. Generalized linear models were developed to explore the relationship between the surfacing measure (response) and environmental (covariates) variables in each of three areas covered by the aerial survey. The surface-oriented behavioural definition and the whole-day time-scale were chosen for final model selection based on preliminary analysis of the data. The important environmental covariates in the final models included the atmospheric variables cloud cover, wind direction, barometric pressure and air temperature in Area 2, moon phase and chlorophyll in Area 3, and water temperature and chlorophyll in Area 4. The final models explained between 26.9% and 51.2% of the null deviance, although compared with bootstrapped models this was reduced to 19-25%. There was a significant difference in the SBT surfacing rates in the three areas examined; the range in the proportion of time at the surface was highest in Area 2 (55.3%) and lowest in Area 4 (35.9%).

Juvenile southern bluefin tuna (*Thunnus maccoyii*, SBT) are surface-orientated and non-randomly distributed in the Great Australian Bight (GAB) during the austral summer. In particular, SBT are clustered around the shelf break and inshore reefs, islands and rises, collectively known as lumps. The presence of SBT observed during an aerial survey in the GAB (1991-2000) was analyzed with regard to the topographic characters of these features and local environmental variables. A SBT attraction region around these features was derived and related to feature-specific topographic characters. The attraction region at the shelf break spanned an average distance of 23 km to the north and south of the break, and in total covered 11% of the survey area and contained 20% of all SBT sightings. Shelf break topographic characters were not significantly related to the attraction distances. Eighteen of 36 lumps examined were attractive to SBT, with an average attraction radius of 5.2 km. Fifteen percent of all sightings were inside the lump attraction areas which covered just 1.2% of the survey area. There were no significant differences between the topographic characters of attractive and unattractive lumps; however, depth and isolation were significant terms in a multiple linear regression explaining 55% of the variation in the size of the attraction region for attractive lumps. Generalized linear models indicated non-linear relationships between the presence of SBT at topographic features and environmental and topographic variables, and models incorporating topography and the environment explained 40% and 28% of the deviance at the lumps and shelf break respectively.

Acoustic monitoring experiments

This pilot study would evaluate the utility of using acoustic tags and fixed listening stations to provide information about habitat use and migration patterns of age 1 SBT. In addition it would provide information on short-term school fidelity, residence times around particular features or regions, and direction of movements within and between the topographic features. These data would be combined with data from the concurrent short-term traditional tagging and archival tagging programs (these should see fish captured in the GAB fishery in subsequent years), and would be incorporated in models on population size and movement. In particular movement across the WA region would allow development of a migration model to be used in interpreting results from the RMP acoustic survey.

Stations would be deployed between January and March 2000, after an initial period of conventional tagging had determined locations of high SBT abundance in southern WA. Tags have an individual code and would be attached externally to the dorsal surface of the fish. Listening stations would be located at several topographic features, either in clusters at the heads of several canyons (Bremer, Esperence, Albany, Starr or Cuttoff) or around lumps (Polacks, Lukin), or in a north-south line to the west of Bremer canyon. Listening stations would be separated by 500 m as the tags have a detection range of 300-500 m. Each listening station would consist of an acoustic receiver (tag reader), and a thermister array (one per cluster), to measure the vertical temperature profile. Tagging several individuals in the same school would provide information on school integrity through the detection of these individuals at the same or different times at the listening stations.

The results of the acoustic monitoring experiments were presented in RMWS/01/5. Internally implanted acoustic tags and moored acoustic receivers were used to investigate movements of juvenile southern bluefin tuna (SBT) near Esperance, Western Australia from January to

March 2001. A total of 32 juvenile SBT (mean length 66 cm) were acoustically tagged and ten receivers deployed, tested, and recovered after 38 days. The tag detection radius of receivers during validation experiments was approximately 350 meters. The receivers detected 20 of 32 (62.5%) tagged SBT during the deployment period. Tuna were detected at seven of the ten receivers, and on 61.5% of days. Individual tuna were detected at a maximum of six stations, and the maximum period between tagging and the last detection event was 38 days (mean 11.5 days). There was little variation in water temperature or currents at the receivers during the deployment period, thus no changes in habitat characters could be related to the tuna patterns observed. A total of 61 individual detection events lasted an average of 123 seconds, while the mean interval between detection events was 28 hours. There were 23 overlapping detection events, and the detection partners often changed between events involving one of the same individuals, indicating that school fidelity was low or that detection was not absolute. A mean daily residence area of 2704 km^2 (circle of radius 29.3 km) was estimated for these juvenile SBT during their total detection period at the receivers.

The results of this work were presented at the 13th Southern Bluefin Tuna Recruitment Monitoring and Tagging Program Workshop held in Hobart on 18-20 December 2001. This report appends these detailed sub-project reports presented as working papers at the Recruitment Monitoring And Tagging Program Workshop. The eight appendices are:

1. Southern Bluefin Tuna Recruitment Monitoring and Tagging Program. Report of the Thirteenth Workshop, 18-20 December 2001.

2. Cowling, A.M. *Further Data Analyses of the Aerial Surveys (1993-2000) for Juvenile SBT in the Great Australian Bight.* RMWS/01/1.

3. Cowling, A.M. *Issues in the Design and Implementation of an Aerial Survey of a Pelagic Species*. RMWS/01/2.

4. Gunn, J.S. and Patterson, T. *Archival tagging of juvenile SBT in the Great Australian Bight – Update on 2000-01 field work and analyses.* RMWS/01/4.

5. Stanley, C. *Tag and Sample Recovery from the 1990-2002 CSIRO/NRIFSF Tagging Program.* RMWS/01/3.

6. Hobday, Alistair. *The influence of topography and environment on presence of juvenile southern bluefin tuna,* Thunnus maccoyii*, in the Great Australian Bight*. RMWS/01/6.

7. Jeremy O'Reilly, Alistair Hobday, John Gunn, Ann Cowling. *Surfacing behavior of juvenile southern bluefin tuna, Thunnus maccoyii, in the Great Australian Bight.* RMWS/01/12.

8. Hobday, Alistair. *Determination of SBT Residence Time via Acoustic Monitoring Along the Southern WA Coast.* RMWS/01/5.