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**A GUIDE TO BIOLOGICAL
AND FISHERIES RESEARCH
ON YELLOWFIN TUNA IN
EASTERN AUSTRALIA**

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SUMMARY

Biological and fisheries research on yellowfin tuna in Australia is increasing as the species grows in importance to commercial fishermen and recreational anglers. Various fisheries research agencies are, or have been, involved in research on yellowfin tuna. In particular, the CSIRO Division of Fisheries, New South Wales Fisheries Research Institute, Queensland Department of Primary Industries and Bureau of Rural Resources have been active.

Many exploratory and feasibility fishing surveys were conducted off eastern Australia during the late-1960s and 1970s. Fishing methods included pole-and-line and trolling. Such surveys were largely unsuccessful.

Biological research on yellowfin tuna in Australia has concentrated on stock structure and movement. Investigations indicated little likelihood of mixing of post-recruit yellowfin tuna of eastern Australian waters with those of distant Pacific regions. Tag-recapture studies have shown that yellowfin tuna mix throughout coastal waters of eastern Australia. Electrophoresis and morphometric studies suggested a degree of variability and possible sub-structuring of the yellowfin tuna population within the south-eastern Australian fishing zone (AFZ). Further investigations of yellowfin tuna stock structure, using tag-recapture, genetic and microchemical techniques, are under way.

Yellowfin tuna are believed to spawn throughout the tropical Pacific. Research has confirmed that yellowfin tuna spawn in the north-western and central-western Coral Sea during the summer.

Estimates of yellowfin tuna length at age by modal analysis, counts of vertebral annuli and tag-recapture were comparable. Preliminary estimates of age suggested that growth rates of east coast yellowfin tuna were similar to those published for yellowfin tuna of other Pacific regions.

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INTRODUCTION

Yellowfin tuna has become an important commercial and recreational species in Australia during the 1980s. Accordingly, research and most monitoring programs in Australia dealing with yellowfin tuna have been established during the late-1980s. This report provides a guide to biological and fisheries research directed at yellowfin tuna in Australia's 200 mile fishing zone (AFZ). The reader is urged to consult scientific papers and reports for details on results of research. A list of published literature is in Appendix 1. 'Grey literature' may be important to scientists charged with the immediate responsibility of assessing the condition of yellowfin tuna. Internal reports and other reports that have not been published are listed in Appendix 2.

The Japanese, using longlines, have fished for yellowfin tuna off eastern Australia since the early 1950s. Over the years Japanese scientists have published many papers on the fisheries biology of yellowfin tuna. Some, like Hisada (1973) specifically dealt with yellowfin tuna off eastern Australia. However, this guide does not cover research on yellowfin tuna in Australian waters conducted by Japanese scientists. A list of Japanese literature on the biology of tunas and billfishes in the south-western Pacific was provided by Green (1988).

FUNDING AND RESEARCH AGENCIES

This guide focuses on Australian research on yellowfin tuna and research that has been conducted in the past or is under way. The yellowfin tuna fisheries is managed by the Commonwealth Government of Australia under the Offshore Constitutional Settlement. Many agencies have been involved in research on yellowfin tuna, notably the CSIRO Division of Fisheries, New South Wales Fisheries Research Institute, Queensland Department of Primary Industries and Bureau of Rural Resources. Apart from 'core funding' by the agencies involved, research projects have been funded by grants from bodies such as the Fisheries Research Trust Account (FIRTA) and the Fisheries Development Trust Account (FDTA). In 1990 and 1991 research funds have been available from a levy on Australian longline fishermen and foreign access fees.

A workshop on tuna and billfish research in 1990 (Ward, in prep.) provided an overview of past and current research, funding arrangements, and identified directions for future work. Recent support for several research and monitoring projects reflects the main priority areas for research and monitoring related to management of the Australian yellowfin tuna fishery:

- establish monitoring programs;
- analyse existing data;
- investigate stock structure.

FISHERIES SURVEYS

An exploratory survey of yellowfin tuna resources of the Coral Sea off Queensland was conducted in 1965 (Hynd 1968). The survey was disappointing, catching only 130 yellowfin tuna by trolling and poling. A further survey by air revealed several sightings of large schools of yellowfin tuna.

Using pole-and-line, the *Catriona B* conducted an exploratory survey of yellowfin tuna off north Queensland in 1977 and 1978 (Carrick unpub.). Further trials in the area (Anon. 1982) suggested potential for commercial fishing, but no major Australian fishery for yellowfin tuna developed in the area.

As part of a survey of skipjack tuna resources off eastern Australia the South Pacific Commission (SPC) sighted and poled several schools of yellowfin tuna (mixed and pure) during 1979 (SPC 1984). Three-hundred and sixteen yellowfin tuna were tagged and released and biological data and information was collected from several specimens.

Queensland Department of Primary Industries conducted a feasibility survey of longlining for yellowfin tuna off south-east Queensland in 1986 (Goodrick and Brown 1987a, 1987b). The survey stimulated development of small-scale longline fishing for yellowfin tuna in the area.

COLLECTION AND ANALYSIS OF DATA

Observer Data

Australian fisheries officers and scientists are regularly placed on board Japanese longliners operating in the AFZ to collect biological data and verify logbooks. The Bureau of Rural Resources (BRR) is responsible for coordinating scientific aspects of the AFZ Observer Program. Following the establishment of several research projects in 1991 the Bureau placed high priority on observers collecting biological data and samples from yellowfin tuna.

Many projects mentioned in this report rely on the Observer Program for information and samples. The program is also significant in assembling data and samples that may be required for future research. Appendix 3 is an excerpt from observer instructions on yellowfin tuna. Yellowfin tuna data or samples routinely collected by observers include:

- lengths (fork length, length of second dorsal fin, length of anal fin);
- weight (whole and dressed for the same specimen);
- otoliths and vertebrae;
- gill-raker counts;
- sex.

The Bureau of Rural Resources is compiling a bibliography of cruise reports produced by observers. The Australian Fisheries Service recently developed a database system for data collected by observers on Japanese longliners. The Bureau is assembling historical data from observers for inclusion in the database.

Analysis of Japanese Catch and Effort Data

The Bureau of Rural Resources in collaboration with CSIRO Division of Fisheries are analysing the Japanese longline fishery in eastern Australian waters. The work involves compilation of relevant data sets and descriptions of annual, seasonal, and spatial distributions of fishing effort and catches of commercially important species, particularly yellowfin tuna. Other components of the project include descriptions of access restrictions, fishing campaigns, and fishing practices of Japanese longliners in eastern Australian waters. The report of the project will be available in 1992.

STOCK STRUCTURE AND MOVEMENT

Tagging Programs

Recreational Tagging

Several voluntary programs tagging and releasing various fish species have been conducted in Australia since the 1960s. The New South Wales Cooperative Gamefish Tagging Program, established in 1973, is the largest of such programs. Under the New South Wales program, anglers tag and release many pelagic species, including yellowfin tuna. The program has increased in popularity each year and is now the largest voluntary tagging program in the world (Pepperell, in prep.). As at June 1990, anglers had reported tagging and releasing over 7468 yellowfin tuna, mainly off the east coast of Australia. Over 129 tagged yellowfin tuna have been recaptured (J. Mathews, Fisheries Research Institute, 13 June, 1991).

Tag and recapture data are provided on request to the New South Wales Fisheries Research Institute (FRI). FRI is upgrading the computer database holding records of releases and recaptures to facilitate access to data by researchers.

Analyses of tagging data have been presented in several reports dealing with movement patterns Pepperell and Diplock (unpub.), fisheries interaction (Anon. 1989) and comparison of tag types (Pepperell, unpub.).

FIRTA Program

During the late-1980s the Fishing Industry Research Trust Account (FIRTA) funded the East Coast Tunas and Billfishes Research Program.

The FIRTA program examined many aspects of the biology of yellowfin tuna. Movement patterns of yellowfin tuna were investigated in a tag-recapture study. The following summary of the tagging project has been extracted from Anonymous (1989).

In December 1986 360 yellowfin tuna were caught by pole-and-line, tagged and released in the north-western Coral Sea handline fishery. A further 97 and 944 yellowfin tuna were caught by longline and pole-and-line, respectively, tagged and released off the coast of New South Wales during February-March 1987. Recapture data were combined with data from the New South Wales Cooperative Program in an analysis by Pepperell and Diplock (unpub.).

Tagged yellowfin tuna displayed low rates of movement in eastern Australian waters. Most recaptures of tagged yellowfin tuna were made over a period of 2 years within 200 nautical miles of the sites of release. Tag-recapture results showed that yellowfin tuna mixed throughout coastal waters of south-eastern Australia.

Although detailed analysis of tag-recapture results was not possible without comprehensive catch and effort data series for the fisheries, results indicated interaction between the various domestic fisheries of the eastern AFZ. Interaction between domestic yellowfin tuna fisheries and the Japanese longline fishery appeared to be low.

SPC/CSIRO Tagging Project

The Australian Fisheries Service (AFS) is finalising arrangements for extending the South Pacific Commission's (SPC's) Regional Tuna Tagging Programme. The programme will tag yellowfin tuna in the Coral Sea. The project was proposed by CSIRO Division of Fisheries in collaboration with SPC. It is planned that the charter vessels, *Te Tautai*, will spend one month tagging yellowfin tuna in the north-western Coral Sea during October, 1991.

The project will yield important information on the relationship between yellowfin tuna in the eastern AFZ and yellowfin tuna of the wider south-western Pacific. The work will also provide information on levels of interaction between fisheries for yellowfin tuna.

Population Genetics and Environmental Markers

Allozyme Electrophoresis

An electrophoresis study by Smith *et al.* (1988) distinguished four loci exhibiting polymorphic enzymes suitable for yellowfin tuna population analyses. Preliminary results suggested that yellowfin tuna from eastern Australian waters were different from yellowfin tuna sampled from other areas of the Pacific Ocean (Caroline Islands, Hawaii) as well as the Indian Ocean (Seychelles).

Morphometrics

Under the FIRTA Program scientists collaborated in a wider study of the meristics and morphometrics of yellowfin tuna, conducted by Dr Kurt Schaefer, Inter-American Tropical Tuna Commission. Dr Schaefer's study indicated significant differences in the meristics (gill raker counts) and morphometrics of yellowfin tuna from five Pacific sites (Australia, Japan, Hawaii, Ecuador, Mexico).

Preliminary morphometric analyses of the relative lengths of the anal and second dorsal fins of yellowfin tuna within the AFZ (Diplock and Reid, unpub.) suggested that two morphological types of yellowfin tuna may occur in the eastern AFZ. Further research is necessary on the possible sub-structuring of yellowfin tuna within the eastern AFZ.

Discrimination of Yellowfin Tuna Sub-Populations

CSIRO Division of Fisheries is involved in developing techniques for investigating yellowfin tuna stock structure. The project will test techniques and develop a sampling strategy necessary for a detailed study of yellowfin tuna stock structure in the eastern AFZ. Techniques include analysis of otolith microchemistry, mitochondrial DNA (mtDNA) and allozyme electrophoresis. The work will provide information on genetic and otolith variability in yellowfin tuna from various parts of the Pacific and Indian Oceans. Samples of yellowfin tuna larvae and juveniles will be collected from three areas of the Western Pacific and the Indian Ocean. The project will also provide a genetics-based key for identifying larval and juvenile tunas (yellowfin tuna, bigeye tuna, albacore, southern bluefin tuna, skipjack tuna).

REPRODUCTION

Spawning and reproductive development of yellowfin tuna in the Coral Sea were examined by McPherson (1988b, 1988b, 1988c) as part of the FIRTA Program. Yellowfin tuna are believed to spawn throughout the tropical Western Pacific. McPherson's work confirmed that yellowfin tuna spawn in the north-western and central-western Coral Sea during the summer. Spawning frequency was particularly high in the Japanese handline fishery, near the Great Barrier Reef off north Queensland. Spawning was not evident in yellowfin tuna taken south of 30°S (Diplock 1989).

In samples collected from the handline fishery 50% of female yellowfin tuna were mature at 101 cm (fork length). There was no significant difference between the ratios of males to females in either the Australian longline or Japanese handline or longline fisheries off north Queensland.

AGE, GROWTH AND RECRUITMENT

A description and appraisal of the ageing techniques for yellowfin tuna was presented Diplock and Watkins (unpublished). They estimated ages of yellowfin tuna through counts of growth rings apparent on hard parts (vertebrae, otoliths and dorsal fin spines). Estimates of growth parameters based on hard parts were compared with growth estimates derived by analysis of modal progressions and tag-recaptures. Growth rings on vertebrae were shown to be laid down annually. Counts of daily rings on otoliths corroborated the age estimates determined from vertebrae.

Using catch data Diplock and Watkins (unpub.) proposed that in any one year the domestic longline yellowfin tuna fishery was dependent on one or two size modes of yellowfin tuna. In 1986 and 1987, for example, the domestic longliners did not locate any new size classes, and catch rates were consequently low. The erratic annual appearance of small yellowfin tuna in the catch may result from intermittent recruitment to the fishery.

SCIENTIFIC LITERATURE

The FIRTA program compiled bibliographies of literature related to the biology of the tunas and billfishes taken by the east coast fisheries. Green's 1988 *Bibliography of Japanese Literature on the tunas (excluding southern bluefin tuna) and billfishes of the Coral and Tasman Seas* comprises 82 annotated citations. English translations of three significant articles written in Japanese were also produced by the project. More than 230 citations, many of which are annotated, are presented in *An annotated bibliography of tuna and billfish stocks occurring in eastern Australian waters* (Stewart 1990).

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Anon. 1982. Trials show Coral Sea Tuna Fishery has potential. *Australian Fisheries*. 41(2): 7.

Anon. 1989. A biological study of east coast tunas and billfishes, with particular emphasis on yellowfin tuna (*Thunnus albacares*). Review of Results and Recommendations for Research. Bureau of Rural Resources Working Paper No. 11/89. Revised Edition, Canberra.

Carrick, N. (unpub.). Commercial development of the striped tuna (*Katsuwonus pelamis*) resource in eastern Australian waters: Report of Phase 1. [not seen, cited in SPC (1984) *An Assessment of the Skipjack and Baitfish Resources of Eastern Australia*. Skipjack Survey and Assessment Programme. Final Country Report No. 16.]

Diplock, J.H. (1989) Reproductive activity of yellowfin tuna off south eastern Australia. New South Wales Department of Agriculture and Fisheries, Fisheries Research Institute internal paper.

Diplock, J.H. & Watkins, D. (unpub.) Ageing techniques for yellowfin tuna off eastern Australia. Draft of a New South Wales Department of Agriculture and Fisheries, Fisheries Research Institute Internal Report.

Goodrick, B. and Brown, I. (1987a) Report says tuna fishing "promising" but urges caution. *The Queensland Fisherman* 5(9): 29-31.

Goodrick, B. and Brown, I. (1987b) Results of tuna survey. *The Queensland Fisherman* 5(10): 35-41.

Green, R. 1988. **Bibliography of Japanese literature on the tuna (excluding southern bluefin tuna) and billfishes of the Coral and Tasman Seas.** CSIRO Marine Laboratories Report No. 194.

Hynd, J.S. 1968. **Report on a Survey for Yellowfin Tuna, *Thunnus albacares* (Bonnaterre) in Queensland Waters.** CSIRO Division of Fisheries and Oceanography Technical Paper No. 26.

McPherson, G.R. (1988a) A possible mechanism for the aggregation of yellowfin and bigeye tuna in the north western Coral Sea. Queensland Department of Primary Industries, Northern Fisheries Research Centre, Fisheries Research Branch Technical Report No. FRB 88/8.

McPherson, G.R. (1988b) Validation of the post-ovulatory follicle method for establishing the spawning frequency of yellowfin, bigeye and skipjack tuna in the Coral Sea. Queensland Department of Primary Industries, Northern Fisheries Research Centre, Fisheries Research Branch Technical Report No. FRB 88/9.

McPherson, G.R. (1988c) Reproductive biology of yellowfin and bigeye tuna in the eastern Australian Fishing Zone, with special reference to the north western Coral Sea. Queensland Department of Primary Industries, Northern Fisheries Research Centre, Fisheries Research Branch Technical Report No. FRB 88/10.

Pepperell, J.G. (in prep.). A review of tuna and billfish tagging in the eastern Australian fishing zone. In Ward, P.J. (Ed.) **East Coast Tuna & Billfish Research and Monitoring Priorities.** Bureau of Rural Resources Proceedings, Canberra.

Smith, A.K., Dixon, P.I., & Black, M. (1988) Population structure of yellowfin tuna (*Thunnus albacares*) in eastern Australian waters. University of New South Wales, Centre for Marine Science Technical Report. Revised Edition.

SPC (1984) **An Assessment of the Skipjack and Baitfish Resources of Eastern Australia.** Skipjack Survey and Assessment Programme. Final Country Report No. 16.

Stewart, P. 1990. **A Selected Bibliography of Tuna and Billfish Species occurring in Eastern Australian Waters.** Bureau of Rural Resources Working Paper No. WP5/90.

Ward, P.J. (Ed) (in prep.). **East Coast Tuna & Billfish Research and Monitoring Priorities.** Bureau of Rural Resources Proceedings, Canberra.

APPENDIX 1: SOME RECENT AUSTRALIAN PAPERS AND REPORTS ON THE FISHERIES BIOLOGY OF YELLOWFIN TUNA IN THE EASTERN AFZ

The following list includes publications, papers submitted for publication, reports and (unpublished) internal papers produced by Australian scientists on yellowfin tuna in the eastern AFZ.

Caton, A. & Ward, P. (1987) Yellowfin tuna: the nature and extent of the resource. *Australian Fisheries*. 46(12): 40-4.

Diplock, J. (1987) Clues to changing New South Wales longline catches. *Australian Fisheries*. 46(12): 16-18.

Diplock, J.H. (1989) Reproductive activity of yellowfin tuna off south eastern Australia. New South Wales Department of Agriculture and Fisheries, Fisheries Research Institute internal paper.

Diplock, J.H. (unpub.) Feeding ecology of yellowfin tuna in the eastern Australian Fishing Zone. Paper submitted for publication in *Australian Fisheries*.

Diplock, J.H. & Reid, D.D. (unpub.) Variation in fin lengths of eastern Australian yellowfin tuna: a suggestion of separate stocks. Draft of a New South Wales Department of Agriculture and Fisheries, Fisheries Research Institute Internal Report.

Diplock, J.H. & Watkins, D. (1987) Catch statistics of the N.S.W. longline tuna fishery 1985-1987. New South Wales Department of Agriculture and Fisheries, Fisheries Research Institute Internal Report, No. 42.

Diplock, J.H. & Watkins, D. (1988) Yellowfin tagging operation 1986/87. New South Wales Department of Agriculture and Fisheries, Fisheries Research Institute Internal Report No. 45.

Diplock, J.H. & Watkins, D. (unpub.) Ageing techniques for yellowfin tuna off eastern Australia. Draft of a New South Wales Department of Agriculture and Fisheries, Fisheries Research Institute Internal Report.

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tuna in the Coral Sea. Queensland Department of Primary Industries, Northern Fisheries Research Centre, Fisheries Research Branch Technical Report No. FRB 88/9.

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Smith, A.K., Dixon, P.I., & Black, M. (1988) Population structure of yellowfin tuna (*Thunnus albacares*) in eastern Australian waters. University of New South Wales, Centre for Marine Science Technical Report. Revised Edition.

Stewart, P. (1990.) A selected bibliography of tuna and billfish species occurring in eastern Australian waters. Bureau of Rural Resources Working Paper No. WP/5/90.

Pepperell, J.G. & Diplock, J.H. (unpub.) Seasonal migration of yellowfin tuna (*Thunnus albacares*) off south eastern Australia. Evidence for a possible localised stock. Draft of a New South Wales Department of Agriculture and Fisheries, Fisheries Research Institute Internal Report.

Ward, P.J. (1987) Scientists study east coast tuna and billfish. *Australian Fisheries*. 46(12): 16-18.

Watkins, D. (1987) Tuna tagging update. *Australian Fisheries*. 46(12): 46-8.

Williams, D. (1988) AIMS research into baitfish resources of North Queensland. Australian Institute of Marine Sciences internal paper.

TRANSLATIONS:

Abe, S. & Dotsu, Y. (1977) Research report of the T.S. 'Kakuto Maru', Nagasaki University. 1. A note on yellowfin tuna fishing with handline in the northwestern Coral Sea in October, 1976. *Bulletin of the Japanese Society of Scientific Fisheries*. 31: 7-11. [Translation by R. Green, CSIRO Marine Laboratories, 1988.]

Hisada, K. (1973) Investigation of tuna hand-line fishing ground and some biological observations on yellowfin and bigeye tunas in the northwestern Coral Sea. *Bulletin of the Far Seas Fisheries Research Laboratory*. 8: 35-69. [Published translation by Green, R. (1988) CSIRO Marine Laboratories Report 194.]

Nakagome, J. (1961) Seasonal variation of yellowfin tuna by area of different currents in mid-western and south-western parts of the Pacific Ocean. *Bulletin of the Japanese Society of Scientific Fisheries*. 27: 302-6. [Translation by R. Green, CSIRO Marine Laboratories 1988.]

APPENDIX 2: EXCERPT FROM OBSERVER INSTRUCTIONS RELEVANT TO YELLOWFIN TUNA

BIOLOGICAL DATA REQUIREMENTS

- Be sure to always note the type of measurements (e.g., total length, fork length, whole weight, dressed weight) recorded in your data sheets and what measuring device (tape, ruler, etc.) you used.
- Tagged tunas, billfishes and shark might be encountered by the operations. Ensure that the Japanese are aware of tag-recapture programs, and collect any tags and relevant details (location and date of capture, size) if tagged fish are caught while you are aboard or if they are holding tags. Also watch out for any wounds under the second dorsal fin which might be the result of a lost tag. Note the procedure described below for marlin with orange, 'double-length' tags.

The following biological requirements are listed in order of priority....

Yellowfin Tuna

- (1) **Length** (fork length, nearest cm), **dressed weight** (nearest kg) and **sex** of all yellowfin tuna caught during the monitoring period. Record **whole** and dressed weights where possible.
- (2) **Otoliths, caudal vertebrae**¹ (with flesh and skin removed, frozen in sealed plastic bags), from not more than 10 specimens, from each 20 cm length class (store caudal centra frozen).
- (3) **Second dorsal and anal fin** measurements for *as many* specimens as possible.
- (4) **Gill raker counts** (distinguish upper from lower limb) for the right-hand-side first gill arch of *as many* specimens as possible.
- (5) If any 'ripe' females are encountered, collect 2 cm thick **gonad sample** (stored frozen) from not more than 12 female specimens.
- (6) **Gut contents** where possible (other tuna and billfish are of particular interest).

¹Check that crew are not retaining tail stocks for 'pocket money'; if so, be diplomatic about tail stock collection.