744

NOAA Technical Report NMFS SSRF—744

Tunas, Oceanography and Meteorology of the Pacific, An Annotated Bibliography, 1950–78

Paul N. Sund

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U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Marine Fisheries Service

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722. Gulf menhaden, *Brevoortia patronus*, purse seine fishery: Catch, fishing activity, and age and size composition, 1964–73. By William R. Nicholson. March 1978, iii + 8 p., 1 fig., 12 tables.

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724. Estimated average daily instantaneous numbers of recreational and commercial fishermen and boaters in the St. Andrew Bay system, Florida, and adjacent coastal waters, 1973. By Doyle F. Sutherland. May 1978, iv + 23 p., 31 figs., 11 tables.

725. Seasonal bottom-water temperature trends in the Gulf of Maine and on Georges Bank, 1963–75. By Clarence W. Davis. May 1978, iv + 17 p., 22 figs., 5 tables.

726. The Gulf of Maine temperature structure between Bar Harbor, Maine, and Yarmouth, Nova Scotia, June 1975–November 1976. By Robert J. Pawlowski. December 1978, iii + 10 p., 14 figs., 1 table.

727. Expendable bathythermograph observations from the NMFS/MARAD Ship of Opportunity Program for 1975. By Steven K. Cook, Barclay P. Collins, and Christine S. Carty. January 1979, iv + 93 p., 2 figs., 13 tables, 54 app. figs.

728. Vertical sections of semimonthly mean temperature on the San Francisco–Honolulu route: From expendable bathythermograph observations, June 1966–December 1974. By J. F. T. Saur, L. E. Eber, D. R. McLain, and C. E. Dorman. January 1979, iii + 35 p., 4 figs., 1 table. For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402, Stock No. 003-017-00438-4.

729. References for the identification of marine invertebrates on the southern Atlantic coast of the United States. By Richard E. Dowds. April 1979, iv + 37 p. For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402, Stock No. 003-017-00454-6.

730. Surface circulation in the northwestern Gulf of Mexico as deduced from drift bottles. By Robert F. Temple and John A. Martin. May 1979, iii + 13 p., 8 figs., 4 tables. For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402, Stock No. 003-017-00456-2.

731. Annotated bibliography and subject index on the shortnose sturgeon, *Acipenser brevirostrum*. By James G. Hoff. April 1979, iii + 16 p. For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402, Stock No. 003-017-00452-0.

732. Assessment of the Northwest Atlantic mackerel, *Scomber scombrus*, stock. By Emory D. Anderson. April 1979, iv + 13 p., 9 figs., 15 tables. For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402, Stock No. 003-017-00450-3.

733. Possible management procedures for increasing production of sockeye salmon smolts in the Naknek River system, Bristol Bay, Alaska. By Robert J. Ellis and William J. McNeil. April 1979, iii + 9 p., 4 figs., 11 tables. For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402, Stock No. 003-017-00451-1.

734. Escape of king crab, *Paralithodes camtschatica*, from derelict pots. By William L. High and Donald D. Worlund. May 1979, iii + 11 p., 5 figs., 6 tables.

735. History of the fishery and summary statistics of the sockeye salmon, *Oncorhynchus nerka*, runs to the Chignik Lakes, Alaska, 1888–1966. By Michael L. Dahlberg. August 1979, iv + 16 p., 15 figs., 11 tables. For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402, Stock No. 003-017-00459-7.

736. A historical and descriptive account of Pacific coast anadromous salmonid rearing facilities and a summary of their releases by region, 1960–76. By Roy J. Wahle and Robert Z. Smith. September 1979, iv + 40 p., 15 figs., 25 tables. For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402, Stock No. 003-017-00460-1.

737. Movements of pelagic dolphins (*Stenella* spp.) in the eastern tropical Pacific as indicated by results of tagging, with summary of tagging operations, 1969–76. By W. F. Perrin, W. E. Evans, and D. B. Holts. September 1979, iii + 14 p., 9 figs., 8 tables. For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402, Stock No. 003-017-00462-7.

738. Environmental baselines in Long Island Sound, 1972–73. By R. N. Reid, A. B. Frame, and A. F. Draxler. December 1979, iv + 31 p., 40 figs., 6 tables. For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402, Stock No. 003-017-00466-0.

739. Bottom-water temperature trends in the Middle Atlantic Bight during spring and autumn, 1964–76. By Clarence W. Davis. December 1979, iii + 13 p., 10 figs., 9 tables. For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402, Stock No. 003-017-00467-8.

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U.S. DEPARTMENT OF COMMERCE
Philip M. Klutznick, Secretary

National Oceanic and Atmospheric Administration
Richard A. Frank, Administrator

National Marine Fisheries Service
Terry L. Leitzell, Assistant Administrator for Fisheries

CONTENTS

Tunas, Oceanography and Meteorology of the Pacific, An Annotated Bibliography, 1950–78

PAUL N. SUND[1]

ABSTRACT

Annotated references are presented on papers published between 1950 and 1978 about Pacific tunas and about environmental subjects pertaining to tuna distributions and / or ecology. Key words are included and cross-referenced for each citation to aid in selecting specific topics of interest.

INTRODUCTION

This bibliography presents a listing of publications pertinent to the subject of Pacific tuna-oceanography. The list is not intended to include all articles published on the subject, but to provide a selection that samples areas of both biological and physical aspects. Articles were selected for inclusion because they address in some manner: 1) the relationship between the fish and their environment, particularly how the latter influences the former in time and space; and 2) the dynamic oceanographic and/or atmospheric processes involved in fish-environment interrelationships. Papers on other tuna-related topics are excluded. Investigation of the literature emphasized the Pacific region but was not restricted to that ocean in spite of the title. Articles concerning other ocean regions are included due to the subject matter being of pertinence to fish-enrivonmental relations irrespective of geography, or due to the inclusion of subject matter of such a nature that geography has no specific relation to the discussion. Further selection of references was made which excluded numerous articles published prior to the 1950's. From reading earlier articles, it became evident that they contained few substantive references to environmental factors influencing fish. And, a number of major works published since the above arbitrary cut-off date include a thorough review of the older literature, so there is no need to duplicate those efforts. The most recent articles included have a publication date of 1978; but, due to peculiarities of certain publication series, it is possible that some papers dated 1978 are not included. Sources for a portion of the articles listed here have been various bibliographies on tunas and on oceanography. These are listed separately prior to the annotated references. The reader is referred to those bibliographies for other than fish-environment topics. A selection of oceanographic atlases follows the bibliographies.

An attempt was made to read each article listed. However, in some cases of foreign literature, only the English abstract or resume, figures, tables, or captions were studied. Those articles not read or read in abstract only are so indicated.

Annotations are necessarily brief, but they are intended to highlight the contents and substance of the article, particularly with respect to fish-environment considerations. In some cases the title alone was considered adequate for that purpose, so no annotations were made. Key words are included at the end of most citations. A cross-index of key words and authors follows the annotated bibliography. Entries are listed alphabetically by author and chronologically by author.

Tunas are a valuable and important resource of the world ocean. The catch of tuna species constitutes the most valuable resource among high-seas fisheries areas of national jurisdiction (Klawe 1978). The tuna species, as a group, have been defined and discussed by Klawe (1977). The species of concern in articles included in this bibliography principally are those of commercial interest. Some articles discussing other species are included because information on environmental influences is presented. The currently accepted scientific and vernacular names of tuna species covered by papers listed in this bibliography are the following:

Scientific name	*Vernacular name*
Thunus alalunga	Albacore
Thunnus albacares	Yellowfin tuna
Thunnus maccoyii	Southern bluefin tuna
Thunnus obesus	Bigeye tuna
Thunnus thynnus orientalis	Bluefin tuna, Northern Pacific
Katsuwonus pelamis	Skipjack tuna
Auxis spp. *Auxis thazard* *Auxis rochei*	Frigate and bullet tunas
Euthynnus linneatus	Black skipjack
Euthynnus affinis	Kawakawa

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dividuals who assisted in procuring materials include Witold L. Klawe, Forest Miller, Tamio Otsu, and Shoji Ueyanagi. The citations were proofed for format in draft by Lee Thorson and Mary Fukuyama of the NMFS Scientific Publications Office. Certain persons kindly provided me with articles in various stages of prepublication preparation. I am indebted to all the above and to my colleagues at the Pacific Environmental Group, who provided assistance and constructive comment and criticism.

LITERATURE CITED

KLAWE, W. L.
1977. What is tuna? Mar. Fish. Rev. 39(11):1-5.
1978. World catches of tunas and tuna-like fishes in 1975. Inter-Am. Trop. Tuna Comm., Int. Rep. 11, 191 p.

Anonymous. 1965. Collected bibliographies on physical oceanography (1953-1964. Documentation Associates Information Services, Inc. 2430 Pennsylvania Avenue, Suite 215, Washington, D.C. 20037. Spec. bibliogr. oceanogr. Contr. No. 1, 1121 p.

Bernabei, H. 1964. Bibliogrpahy. Proceedings of the world scientific meeting on the biology of tunas and related species, La Jolla, California, U.S.A., 2-14 July 1962, p. 1853-2272.

Blackburn, M. 1976. Review of existing information on fishes in the Deep Ocean Mixing Environmental Study (DOMES) area of the tropical Pacific. Inst. Mar. Res., Univ. Calif., La Jolla. IMR Ref. No. 76-1, 76 p. (Mimeo.)

Documentation Associates Information Services, Inc. 1977. Deep Ocean Mining Environmental Study (DOMES) literature survey. 231 p. (Mimeo.) NMFS Southwest Fisheries Center La Jolla Laboratory, National Marine Fisheries Service, NOAA, P.O. Box 271, La Jolla, CA 92037.

Klawe, W.L., and M.P. Miyaki. 1967. An annotated bibliography on the biology and fishery of the skipjack tuna, Katsuwonus pelamis, of the Pacific Ocean. Inter-Am. Trop. Tuna Comm. Bull. 12:139-363.

Shimada, B.M. 1951. An annotated bibliography on the biology of Pacific tunas. U.S. Fish Wildl. Serv., Fish. Bull. 52:1-58.

Stevenson, M.R., and H.R. Wicks. 1975. Bibliography of El Nino and associated publications. [In Engl. and Span.] Inter-Am. Trop. Tuna Comm. Bull. 16:451-501.

Van Campen, W.G., and E.E. Hoven. 1956. Tunas and tuna fisheries of the world. An annotated bibliography, 1930-53. U.S. Fish Wildl. Serv., Fish. Bull. 111:173-249.

Barkley, R.A. 1968. Oceanographic atlas of the Pacific Ocean. University of Hawaii Press, Honolulu, 20 p. + 156 figs.

Bennett, E.B. 1963. An oceanographic atlas of the eastern tropical Pacific Ocean, based on data from EASTROPIC expedition, October-December 1955. Inter-Am. Trop. Tuna Comm. Bull, 8:33-165.

Burkov, V.A. 1972. The Pacific Ocean; general circulation of the Pacific Ocean water. [In Russ.] Nauka Press, Moscow, 195 p.

Eber, L.E., J.F.T. Saur, and O.E. Sette. 1968. Monthly mean charts of sea surface temperature, North Pacific Ocean, 1949-1962. U.S. Fish Wildl. Serv., Circ. 258, 168 p.

Johnson, J.H. 1961. Sea surface temperature monthly average and anomaly charts northeastern Pacific Ocean, 1947-58. U.S. Fish Wildl. Serv., Spec. Sci. Rep. Fish. 385, 56 p.

Love, C.M. 1970-1975. EASTROPAC Atlases. Data from participating ships, v. 1-10. U.S. Dep. Commer., NOAA Tech. Rep. NMFS Circ. 330.

Renner, J.A. 1963. Sea surface temperature monthly average and anomaly charts eastern tropical Pacific Ocean, 1947-58. U.S. Fish Wildl. Serv., Spec. Sci. Rep. Fish. 442, 57 p.

Robinson, M.K. 1976. Atlas of North Pacific Ocean monthly mean temperatures and mean salinities of the surface layer. U.S. Nav. Oceanogr. Off., Ref. Publ. 2(NOO RP-2).

Robinson, M.K., and R.A. Bauer. 1971. Atlas of monthly mean sea surface and subsurface temperature and depth of the top of the thermocline North Pacific Ocean. Fleet Numer. Weather Cent., Monterey, Calif., 24 p.

Stevenson, M.R., O.G. Guillen, and J. Santoro. 1970. Marine atlas of the Pacific coastal waters of South America. [In Engl. and Span.] Univ. Calif. Press, Berkely and Los Angeles, 23 p. plus charts.

Wooster, W.S., and T. Cromwell. 1958. An oceanographic description of the eastern tropical Pacific. Bull. Scripps Inst. Oceanogr. 7(3):169-282.

Alverson, D.L. 1961. Ocean temperatures and their relationship to albacore tuna (Thunnus germo) distribution in waters off the coast of the states of Oregon, Washington, and the province of British Columbia. J. Fish. Res. Board Can. 18:1145-1152.

Discussed American coastal fishery for albacore tuna in relation to temperature features. Fish concentrations occur along the interface of warm oceanic waters and cooler waters adjacent to the coast. Highest catch rates were recorded in water temperatures between 58° and 61°F. The author felt the fish were above the thermocline, in warm oceanic-type water.

KEY WORDS: tuna, albacore, temperature, catch, thermocline, discontinuity, season, distribution.

Alverson, F.G. 1959. Geographical distribution of yellowfin tuna and skipjack catches from the eastern tropical Pacific Ocean, by quarters of the year, 1952-1955. Inter-Am. Trop. Tuna Comm. Bull. 3:167-213.

Average quarterly distribution of purse seine and baitboat catches. Annual fluctuations in catch by quarter and area. Indications of fish movement from catch distribution. Mentioned unusual oceanographic conditions in the region during 1953 which may have been responsible for the large catches in 1954. Postulated that both yellowfin and skipjack movements into and out of the waters off Baja California were related to the temperature regime of that area.

KEY WORDS: tuna, yellowfin, skipjack, geography, distribution, catch, migration, oceanography, season.

Alverson, F.G., and C.L. Peterson. 1963. Synopsis of biological data on bigeye tuna Parathunnus sibi (Temminck and Schlegel) 1844. Species Synopsis No. 14. FAO Fish. Biol. Synop. 57. FAO Fish. Rep. 6:482-514.

Mapped the distribution of bigeye. Seasonal differences in distribution were not shown and that the relations between the distribution of the fish and various oceanographic changes are obscure was pointed out. Further, that nothing is known of the size of the bigeye tuna population in the Pacific. Summarized the depth, temperature and geographic ranges of the species and currents in which it is found. Speculated that distribution within the currents is no doubt related to temperature, food supply, and other factors.

KEY WORDS: tuna, bigeye, distribution, currents, temperature, food.

Anonymous. 1962. Present status of tuna research in Japan. Second Japan-United States Tuna Conference, Oct. 9, 1962, Tokyo, Rep. 2, 57 p.

A review of research of the Nankai Regional Fisheries Research Laboratory to 1962. Includes catch by season and region; contains maps and tables. The center of distribution differed for each species with respect to ocean currents. Within a species the size composition varied with currents, suggesting separate ecological existence in different current systems. The fishing grounds mainly were homogeneous in an east to west direction within a current. Migrations were of two types: 1) within a current and 2) across currents. The first is subject to seasonal change of distribution within a current itself and the second is an active movement of the fish with a change in their stage of life. The second is more rapid than the first. There were size changes within the current, large fish being found in the east and small in the west. Spawning areas were given for all species discussed.

KEY WORDS: tuna, albacore, yellowfin, bigeye, bluefin, catch, distribution, season, currents, size, migration, spawning.

Barkley, R.A., W.H. Neill, and R.M. Gooding. 1978. Skipjack tuna, Katsuwonus pelamis, habitat based on temperature and oxygen requirements. Fish. Bull., U.S. 76:653-662.

Defined and mapped the habitat of skipjack in the Pacific using averaged oceanographic data. Habitat features used were based on experiments on Hawaiian skipjack. The vertical and areal habitat were described by limits of temperature and oxygen. Habitat varied with size/age of fish.

KEY WORDS: tuna, skipjack, habitat, distribution, depth, oceanography, temperature, oxygen.

Beardsley, G.L., Jr. 1969. Distribution and apparent relative abundance of yellowfin tuna (Thunnus albacares) in the eastern tropical Atlantic in relation to oceanographic features. Bull. Mar. Sci. 19:48-56.

Yellowfin tuna caught by Japanese longline were noted to be distributed around and downstream from thermal domes. The proposed reasoning was that upwelling and enrichment processes are associated with the domes. Frontal zones noted to concentrate yellowfin at the surface apparently had little effect on the distribution of fish taken by longline.

KEY WORDS: tuna, yellowfin, thermal domes, upwelling, enrichment.

Berlage, H.P. 1966. The Southern Oscillation and world weather. K. Ned. Meterol. Inst. Meded in Verh. 88, 152 p.

Described mechanisms of atmospheric pressure differences influencing the strength of Peru and Equatorial Current systems, and an impact on sea surface temperatures. Stated that the strength of the Peru Current depends on the pressure difference between Easter Island and Santiago.

KEY WORDS: atmospheric pressure, temperature, currents.

Berlage, H.P., and H.J. DeBoer. 1959. On the extension of the Southern Oscillation throughout the world during the period July 1, 1949 up to July 1, 1957. Geofis. Pura. Appl. Milano 43:287-295.

Correlated the Southern Oscillation values with pressure data from numerous points over the globe. Found a high correlation of other points with Easter Island. They postulated that the Southern Oscillation operates principally as a stationary wave in its effects on the earth's atmosphere.

KEY WORDS: atmospheric pressure, Southern Oscillation.

Berlage, H.P, and H.J. DeBoer. 1960. On the Southern Oscillation, its way of operation and how it affects pressure patterns in the higher latitudes. Geofis. Pura. Appl. Milano 46:329-351.

Presented arguments that Southern Oscillation influences weather patterns over the globe; that there are periods of weather types running for several years which are due to fluctuations in the Southern Oscillation.

KEY WORDS: atmosphere, atmospheric pressure, Southern Oscillation, distribution.

Bini, G. 1952. Osservazioni sulla fauna marina delle coste del Chile e del Perù con speciale riguardo alle specie ittiche in generale ed ai tonni in particolare. Boll. Pesca Piscic. Idrobiol. 7(1):11-60.

In Italian, not read. Considered possibilities for commercial fishery development for tunas and bonito off Chile and Peru.

KEY WORDS: tunas, temperatures, oceanography.

Bjerknes, J. 1961. "El Nino" study based on analysis of ocean surface temperatures 1935 to 1957. Inter-Am. Trop. Tuna Comm. Bull. 5:219-303.

Discussed the seasonal variation reflected in winds and sea surface temperatures as related to atmospheric and oceanographic changes, all pertaining to the development of El Nino. Compared 1935 to 1957 sea surface temperatures with data in the Hydrographic Office Atlas and presented evidence of a general warming trend in the open sea area south of the equator, a cooler tendency in coastal and equatorial upwelling zones. El Nino results from ocean-wide weakening of northern trade winds, permitting abnormally large volumes of warm water to accumulate in the eastern tropical Pacific. A weakness in the southern trade winds plus a possible south equatorial countercurrent add to the above phenomena.

KEY WORDS: winds, currents, season, pressure, upwelling, thermocline depths, El Nino.

Blackburn, M. 1959. Scripps Tuna Oceanography Research (STOR) Program - Quarterly Progress Report No. 6. Univ. Calif. SIO Ref. (59-22), 17 p.

Comparison of tuna catches and zooplankton volumes off Baja California.

KEY WORDS: tuna, feed.

Blackburn, M. 1959. Analysis of tuna availability in relation to oceanographic variables. In M. Blackburn (editor), Scripps Tuna Oceanographic Research (STOR) Program - Quarterly Progress Report No. 7. Univ. Calif. SIO Ref. 59-31:4, 8.

Comparison of tuna catches with abundance of zooplankton and micronekton.

KEY WORDS: tuna, feed.

Blackburn, M. 1960. Analysis of tuna availability in relation to oceanographic variables. *In* M. Blackburn (editor), Scripps Tuna Oceanographic Research (STOR) Program - Quarterly Progress Report No. 10. Univ. Calif. SIO Ref. (60-15):8-9.

Tuna distributions correlated with temperature. Tuna were displaced poleward of normal distributions in the warm years 1957-58.

KEY WORDS: tuna, temperature, distribution.

Blackburn, M. 1960. Tuna ecology. *In* M. Blackburn (editor), Scripps Tuna Oceanographic Research (STOR) Program - Final Report. June 21, 1957-June 30, 1960. Univ. Calif. SIO Ref. 60-50:65-71.

Isotherms of 20° and 21°C coincided with yellowfin and skipjack distributions off Baja California for the 1951 to 1959 period. Zooplankton did not relate well with tuna distributions. Skipjack avoided temperatures over 28°C. Yellowfin seemed to aggregate on food.

KEY WORDS: tuna, yellowfin, skipjack, temperature, food, distribution.

Blackburn, M. 1961. Tuna ecology. *In* M. Blackburn (editor), Scripps Tuna Oceanography Research (STOR) Program - Report for the Year. July 1, 1960 - June 30, 1961. Univ. Calif. SIO Ref. 61-26:29-33.

Correlation analyses of tuna abundance and zooplankton and micronekton abundance and surface temperature. Within the temperature-controlled limits of distribution the abundance of tunas was determined by the abundance of the biota in their food chain, and not by temperature.

KEY WORDS: tuna, temperature, food, distribution.

Blackburn, M. 1962. Tuna ecology. In Blackburn and associates, Tuna oceanography in the eastern tropical Pacific. U.S. Fish. Wildl. Serv., Spec. Sci. Rep. Fish. 400, p. 36-42.

Review of the STOR program. An hypothesis is presented that: "the countercurrent exercises a moderating influence on anomalous temperature regimes in general, both low and high, in the region between 5° and 10°N, where it approaches the coast." The summary section considers several hypotheses and relations between tunas and oceanography.

KEY WORDS: tuna, skipjack, yellowfin, oceanography, currents, temperature, depth.

Blackburn, M. 1962. Distribution and abundance of eastern tropical Pacific tunas in relation to ocean properties and features. [Abstr.] In J.C. Marr (editor), Pacific Tuna Biology Conference, August 14-19, 1961, Honolulu, Hawaii. U.S. Fish. Wildl. Serv., Spec. Sci. Rep. Fish. 415, p. 21-22.

Abstract only. The distributions of yellowfin and skipjack tuna corresponded, at the extremes of the eastern tropical Pacific region, to the seasonal march of surface isotherms, particularly the 21°C isotherm in the north area. In the central region, the surface temperature almost always exceeded 21°C. Yellowfin and skipjack occurred in most areas at most seasons, and skipjack may have been excluded at sea surface temperatures over 28°C. The author suggested an association between the deep themocline, biological productivity of surface waters, and tuna. In offshore island areas tunas were more abundant near islands than in the adjacent waters.

KEY WORDS: tuna, yellowfin, skipjack, temperature, distribution, season, thermocline, enrichment.

Blackburn, M. 1962. Tuna ecology. In M. Blackburn (editor). Scripps Tuna Oceanography Research (STOR) Program - Half-yearly progress report No. 1. Univ. Calif., SIO Ref. 62-14 (originally numbered as 62-50):16.

Influence of temperature on tuna abundance in the Gulf of Tehuantepec.

KEY WORDS: tuna, temperature, abundance.

Blackburn, M. 1962. Tuna ecology. In M. Blackburn (editor). Scripps Tuna Oceanography Research (STOR) Program - Report for the year July 1, 1961-June 30, 1962. Univ. Calif. Ref. 62-25:21-24.

Distribution and abundance of tuna in the Gulf of Tehuantepec. Yellowfin lagged zooplankton by three months in the area. Yellowfin were seasonal with interyear similarities; skipjack were seasonal with large interyear variance.

KEY WORDS: tuna, yellowfin, skipjack, distribution, feed, season, temperature.

Blackburn, M. 1963. Distribution and abundance of tuna related to wind and ocean conditions in the Gulf of Tehuantapec, Mexico. In H. Rosa (editor), Proceedings of the world scientific meeting on the biology of tunas and related species, La Jolla, California, U.S.A., 2-14 July 1962, p. 1559-1582. FAO Fish. Rep. 6.

An hypothesis is stated wherein yellowfin are more abundant in the Gulf of Tehuantapec area and in seasons where and when they aggregate upon the expected high concentrations of their forage. (Eutrophication resulted from wind mixing of the shallow pycnocline.) The hypothesis was tested and confirmed when assumptions were made of an average lag of three months between wind action and the resulting crop of forage. Yellowfin were distributed according to the distribution of their food in space in time, and this distribution could be understood in some detail by reference to a series of oceanic phenomena connected with the annual weather cycle.

KEY WORDS: tuna, yellowfin, skipjack, distribution, abundance, oceanography, wind, season, enrichment, circulation, feed.

Blackburn, M. 1965. Oceanography and the ecology of tunas. Oceanogr. Mar. Biol. Annu. Rev., H. Barnes, Editor, 3:299-322.

A review article on the effects of the environment on the distribution and abundance of tunas. The paper considered all commerical species of tunas; and among oceanographic factors listed are temperature, salinity, oxygen, transperancy, nutrients, currents, water masses, fronts, thermocline, topography.

KEY WORDS: tunas, yellowfin, bluefin, bigeye, skipjack, distribution, geography, abundance, depth, temperature, salinity, oxygen, transparency, nutrients, currents, fronts, upwelling, discontinuities (convergence/divergence), thermocline, wind.

Blackburn, M. 1969. Conditions related to upwelling which determine distribution of tropical tunas off western Baja California. U.S. Fish Wildl. Serv., Fish. Bull. 61:147-176.

Presented results from six oceanographic cruises relating temperature, chlorophyll-a, forage and tuna distributions. An hypothesis was tested that tunas generally do not aggregate in waters less than 20°C even when suitable food is abundant.

KEY WORDS: tuna, yellowfin, skipjack, oceanography, temperature, nutrients, food, color, upwelling, bottom features.

Blackburn, M., and R.M. Laurs. 1972. Distribution of forage of skipjack tuna (*Euthynnus pelamis*) in the eastern tropical Pacific. U.S. Dep. Commer., NOAA Tech. Rep. NMFS SSRF 649, 16 p.

The authors related skipjack forage distribution and oceanographic features to their potential for indicating areas suited to skipjack habitation and fishing. Made use of EASTROPAC data for 1967-68. Areas with high concentrations of forage could offer fishing potential for skipjack.

KEY WORDS: tuna, skipjack, feed, season, distribution, upwelling, temperature.

Boersma, P.D. 1978. Breeding patterns of Galapagos penguins as an indicator of oceanographic conditions. Science (Wash., D.C.) 200:1481-1483.

A paper on breeding patterns of Galapagos penguins as influenced by oceanographic conditions. Oceanographic parameters were intimately related to the distribution, growth, reproductive timing, and reproductive success of Galapagos penguins. The breeding biology of seabirds may be a useful reflection of long-term environmental conditions.

KEY WORDS: seabirds, reproduction, distribution, environment.

Bozhkov, A.T. 1973. The effect of oceanological conditions on the distribution of tunas. [In Russ.] Tr. Atl. Nauchno-Issled. Inst. Rybn. Khoz. Okeanogr. 51:69-80.

Not read.

Brandhorst, W. 1958. Thermocline topography, zooplankton standing crop and mechanisms of fertilization in the eastern tropical Pacific. J. Cons. Perm. Int. Explor. Mer 24(1):16-31.

Compared thermocline topography with zooplankton distribution and found an inverse relationship between thermocline depth and size of zooplankton standing crop, which in some regions appeared related to abundance of tunas. A general description of oceanographic features in the eastern tropical Pacific. Availability of nutrients to phytoplankton was dependent upon depth of the thermocline.

KEY WORDS: tunas, yellowfin, skipjack, oceanography, thermocline, food, season, distribution, depth, temperature, salinity, oxygen, currents.

Broadhead, G.C., and I. Barrett. 1964. Some factors affecting the distribution and apparent abundance of yellowfin and skipjack tuna in the eastern Pacific Ocean. Inter-Am. Trop. Tuna Comm. Bull. 8:419-473.

Sea surface temperatures and thermocline topography were considered as possible regulating factors of tuna abundance and distribution. Abundance patterns were modified at the northern and southern extremes during major changes in the sea surface temperature. The coincidental movement of both isotherms and contours of skipjack abundance during spring and summer months was particularly evident off Baja California. Off Ecuador and Peru the seasonal warming and cooling had no pronounced effect on skipjack distribution. No relationship was evident between yellowfin tuna abundance and depth of the mixed layer.

KEY WORDS: tunas, yellowfin, skipjack, sea surface temperature, thermocline topography, abundance, season, distribution.

Brown, R.P., and K. Sherman. 1961. Oceanographic observations and skipjack distribution in the North Central Pacific. In J.C. Marr (editor), Pacific Tuna Biology Conference, August 14-19, 1961, Honolulu, Hawaii, p. 22. U.S. Fish Wildl. Serv., Spec. Sci. Rep. Fish. 415.

Abstract only. Results of five oceanographic cruises. The summer season skipjack appearances were concentrated in boundaries between two adjacent water types. Frequency of occurrence of skipjack schools suggested movement of large fish from the west into the Hawaiian Island area. Authors suggested a relation between skipjack larvae occurring in summer and zooplankton abundance, both attributable to the spawning periodicity of adult skipjack.

KEY WORDS: tuna, skipjack, season, area, migration, larvae, water types, current boundaries.

Calkins, T.P. 1961. Measures of population density and concentration of fishing effort for yellowfin and skipjack tuna in the eastern tropical Pacific Ocean, 1951-1959. Inter-Am. Trop. Tuna Comm. Bull. 6:69-152.

Tuna catch data were analyzed to demonstrate seasonal changes in the geographic distribution of catch per unit effort in the skipjack fishery. Pronounced seasonal fluctuations were noted in density with higher values in the third and fourth quarters of each year for skipjack. This pattern was not present in yellowfin indices. Mentioned unusual oceanographic conditions of 1957, 1958, and 1959 coinciding with abnormal range variations of the fishery with increased catches at the north and south extremes and decreased catches in the middle.

KEY WORDS: tuna, skipjack, yellowfin, catch, area, season, oceanography.

Caviedes, C.N. 1973. Secas and El Nino: Two simultaneous climatical hazards in South America. Proc. Assoc. Am. Geogr. 5:44-49.

El Ninos off Peru and Secas (droughts) off northeast Brazil appeared simultaneously and a linkage between them seems to exist. Both depend on the position of the intertropical convergence and the subtropical high pressure cells of the Pacific and Atlantic Oceans. Cloud analysis of satellite pictures of normal years suggested that a mechanism of linkage is the reason for the simultaneous occurrence of the two events.

KEY WORDS: oceanography, meteorology, atmosphere, sea surface temperature, season, currents.

Clemens, H.B., and W.L. Craig. 1965. An analysis of California's albacore fishery. Calif. Dep. Fish Game, Fish Bull. 128, 301 p.

Historical review of California's albacore fishery. Seasonal variation, size and age composition, migration, and relation to sea temperatures.

KEY WORDS: tuna, albacore, stock, size and age, migration, temperatures, catch, behavior.

Craig, W.L., and E.K. Dean. 1968. Scouting for albacore with surface salinity data. Undersea Technol., May 1968, p. 22.

Used surface salinity values to indicate boundaries between water bodies off the California coast. Showed that transition zones are complex and on a scale of hundreds of yards, not miles.

KEY WORDS: tuna, albacore, surface temperature, salinity, currents, habitat.

Creswell, G.R. 1976. A drifting bouy tracked by satellite in the Tasman Sea. Aust. J. Mar. Freshwater Res. 27:251-262.

Compared buoys tracked by satellites and sea surface temperature data from merchant ships. Successfully used satellites for locating the drifting buoys. Buoys followed the circulation pattern and tended to concentrate in frontal zones of current systems. Buoys could serve as indicators of tuna aggregation.

KEY WORDS: currents, temperature, convergence.

Cromwell, T. 1958. Thermocline topography, horizontal currents and "ridging" in the eastern tropical Pacific. Inter-Am. Trop. Tuna Comm. Bull. 3:135-164.

Seasonal charts of thermocline depth in eastern tropical Pacific. Observed series of east-to-west ridges and troughs. Discovered Costa Rican thermal dome; related currents to thermal structure; thermocline depth is related to enrichment of surface waters.

KEY WORDS: oceanography, temperature, thermocline, depth, season, currents, enrichment, convergence/divergence, upwelling.

Cushing, D.H., and R.R. Dickson. 1976. The biological response in the sea to climatic changes. Adv. Mar. Biol. 14:1-122.

Chapters on climate controls and characteristics, climate variation, warming in the 1930's and early 1940's, biological effects of climatic changes, biological response to climatic changes.

KEY WORDS: climate, oceanography, environment, season, temperature, upwelling, winds.

Davidoff, E.B. 1963. Size and year class composition of catch, age, and growth of yellowfin tuna in the eastern tropical Pacific Ocean. 1951-1961. Inter-Am. Trop. Tuna Comm. Bull. 8:201-250.

Compared surface water temperature data and yellowfin tuna year class growth rates; no relationship was shown. Differences in growth rates of individual year classes were attributed to environmental factors other than temperature.

KEY WORDS: tuna, yellowfin, temperature, environment, growth.

Davidoff, E.B. 1969. Variations in year class strength and estimates of the catchability coefficient of yellowfin tuna in the eastern Pacific Ocean. Inter-Am. Trop. Tuna Comm. Bull. 14:1-44.

Yellowfin catchability varied with age and time; age 2 most vulnerable to fishing, than age 3 and age 1. Influence of sea surface temperature on year class strength showed no correlation.

KEY WORDS: tuna, yellowfin, age, temperature, catch.

deBuen, F. 1955. Notas sobre un viaje de estudios de oceanografia aplicada en el extremo norte de la costa chilena. [In Span.] Bol. Cient. Cia. Adm. Guano 2:25-39.

[Not read.] Off Chile, blue waters contain tunas, billfishes, etc.; coastal waters do not. The latter contain anchovies, mackerel, etc.

KEY WORDS: tunas, billfishes, water color, temperature.

deBuen, F. 1957. Pelagic fishes and oceanographic conditions along the northern and central coast of Chile. [Fr. summ.] UNESCO Symposium on Physical Oceanography 1955 Tokyo, UNESCO, Tokyo, p. 153-155.

A general overview of tuna and billfish biology and related oceanographic observations for the central Chile coast.

KEY WORDS: tuna, billfishes, feed, water color, maturation, sea surface temperatures.

Dizon, A.E. 1977. Effect of dissolved oxygen concentration and salinity on swimming speed of two species of tuna. Fish. Bull., U.S. 75:649-653.

Yellowfin and skipjack held in tanks were tested against decreasing oxygen and salinity. No consistent swimming speed changes were observed when salinity was decreased from 34 to 29 ^{o}/oo. For oxygen decreases: a) at about 4 ppm skipjack abruptly increased swimming speed; b) yellowfin did not alter speed; c) some skipjack died at about 2.5 ppm. Hypothesized that increased swimming speed at low oxygen levels is a behavioral response to remove an animal from suboptimal areas.

KEY WORDS: tuna, yellowfin, skipjack, oxygen, salinity, habitat, behavior, distribution, depth.

Dizon, A.E., R.W. Brill, and H.S.N. Yuen. 1978. Correlations between environment, physiology, and activity and the effects on thermoregulation in skipjack tuna. <u>In</u> G.D. Sharp and A.E. Dizon (editors), The physiological ecology of tunas, p. 233-259. Acad. Press., N.Y.

Reviewed the physiological limitations imposed by the habitat on the fish. Discussed energetics of swimming and thermal regulation, and physiology of skipjack in relation to habitat occupied.

KEY WORDS: tuna, skipjack, yellowfin, behavior, habitat, temperature, oxygen, depth, thermocline, light.

Dizon, A.E., T.C. Byles, and E.D. Stevens. 1976. Perception of abrupt temperature decrease by restrained skipjack tuna (Katsuwonus pelamis). J. Therm. Biol. 1:185-187.

Decreasing temperature produced responses in fish with threshold values similar to those produced by increasing temperature stimuli in the previous study. Skipjack perceive abrupt temperature decrease (0.5°C per second) as small as 1° to 2°C.

KEY WORDS: tuna, skipjack, temperature, behavior.

Dizon, A.E., W.H. Neill, and J.J. Magnuson. 1977. Rapid temperature compensation of volitional swimming speeds and lethal temperatures in tropical tunas (Scombridae). Environ. Biol. Fishes 2:83-92.

Gave lower and upper lethal limits of temperature for skipjack of 15° and 33°C, respectively for 30 to 36 cm fish. Skipjack and kawakawa swimming speeds appeared remarkably unrelated to water temperatures changing at a rate of 1°C per day, from the lower to upper lethal temperatures both for falling and rising temperatures. At temperature changes of 5°C per hour skipjack swimming speed was constant. Kawakawa speed increased with increasing temperature, and yellowfin swimming speed showed no dependence on temperature. These behaviors were discussed with relation to the animals' habitat.

KEY WORDS: tuna, kawakawa, yellowfin, skipjack, temperature, behavior.

Dizon, A.E., E.D. Stevens, W.H. Neill, and J.J. Magnuson. 1974. Sensitivity of restrained skipjack tuna (Katsuwonus pelamis) to abrupt increases in temperature. Comp. Biochem. Physiol. 49A:291-299.

Skipjack can perceive temperature increases as small as 1°C.

KEY WORDS: tuna, skipjack, temperature, behavior.

Donguy, J.R., and C. Henin. 1976. Anomalous navi-facial salinities in the tropical Pacific Ocean. J. Mar. Res. 34:355-364.

Presented one-half yearly charts for the period 1956-73 and four quarterly charts since 1973 of surface salinity. Described the main features in normal years and abnormal years.

KEY WORDS: salinity, season, distribution.

Dotson, R.C. 1978. Fat deposition and utilization in albacore. In G.D. Sharp and A.E. Dizon (editors), The physiological ecology of tunas, p. 343-355. Acad. Press., N.Y.

Fat stores in muscle tissues of albacore are used for energy and migration into the American Pacific coast fishery. Fat content decreased as fish moved east. Some variation noted due to feeding enroute. Foraging enroute found to be associated with Transition Zone boundary (fronts) where fish stayed for several weeks. Fish are immature and therefore fat storage is not associated with gonad development but for utilization in migration.

KEY WORDS: tuna, albacore, migration, fronts, feed.

Dow, R.L. 1978. Effects of climate cycles on the relative abundance and availability of commerical market and estuarine species. J. Cons. 37:274-380.

Correlated higher than mean annual sea temperatures with higher numbers of species in commercial fish landings; in colder than mean years the number of species declined. Both extreme high and low years were associated with commercial extinction of several previously important species. "A highly significant coefficient of correlation between sea surface temperature and total annual catch indicates that sea temperature is probably the principle factor influencing the volumes, since neither changes in fishing effort or market conditions were adequate to account to the magnitude of annual fluctuations in volume." Author concluded that sea surface temperature had been a principle environmental regulator of species abundance and availability. Dependence on sea surface temperature, etc., cycles for abundance makes management of fisheries difficult.

KEY WORDS: temperature, environment, abundance, distribution, seasons.

Enami, S., and T. Toyotaka. 1954. On the fisheries of tuna and the oceanographical conditions in the Sawu Sea. Mem. Fac. Fish., Kagoshima Univ. 3(2):1-8.

A comparison of summer and winter fishing and oceanographic conditions in the titled area. Rates for yellowfin were lower in winter than in summer. For bigeye, rates were higher in winter than in summer. More large yellowfin were taken in summer than in winter. The sex ratios for yellowfin were 69% male in winter, 57% in summer. Optimum temperature values for catch were given as 20° to 23°C in winter, 23° to 25°C in summer.

KEY WORDS: tuna, yellowfin, bigeye, season, oceanography, temperature, size.

Favorite, F., and W.J. Ingraham, Jr. 1976. Sunspot activity and ocean conditions in the northern North Pacific Ocean. Oceanogr. Soc. Jpn. 32: 107-115.

The location of centers of the Aleutian Lows changes markedly over time in a relation to sunspot maximum periods.

KEY WORDS: meteorology, atmospheric pressure.

Forsbergh, E.D. 1969. On the climatology, oceanography and fisheries of the Panama Bight. Inter-Am. Trop. Tuna Comm. Bull. 14:49-385.

Considered fisheries for yellowfin and skipjack as compared to upwelling, temperature, salinity, osmotic presure, thermocline topography, dissolved oxygen, transparency, zooplankton, temperature and salinity fronts, tuna food, and bottom topography.

KEY WORDS: tunas, yellowfin, skipjack, climatology, oceanography, season, upwelling, temperature, salinity, density, oxygen, abundance, catch, distribution.

Fox, W.W. 1971. Temporal-spatial relationships among tunas and billfishes based on the Japanese longline fishery in the Atlantic Ocean, 1956-1965. Univ. of Miami, Sea Grant Tech. Bull. 12, 78 p.

Consideration of the degree of distributional overlap of tunas and billfishes and the degree to which the abundance of a pair of species coincides in time and space. Gave species groups of similar ecological preference. Concluded, on the basis of joint occurences, that within the sampling unit most species of tunas and billfishes may be caught together.

KEY WORDS: tunas, billfishes, yellowfin, albacore, bigeye, bluefin, skipjack, temperature, depth, distribution, abundance.

Garvine, R.W. 1974. Dynamics of small scale oceanic fronts. J. Phys. Oceanogr. 4:557-569.

Developed a model explaining features of fronts such as confrontation of lighter and denser water, surface convergence, and related sinking motions. Presented a characterization of fronts and frontal features plus a description of their dynamics.

KEY WORDS: fronts, density, convergence/discontinuity.

Grandperrin, R. 1976. Structures trophiques aboutissant aux thons de longue ligne dans Le Pacifique Sud-ouest tropical. [In Fr. abstr., Engl. summ.] J. Rech. Oceanogr. 1(2):43-48.

Comparison of tuna food and standing crop of zooplankton and nekton plus vertical distribution of tuna and pelagic fauna. Tuna feeding was limited to upper layers (0-450 m) and to daytime. Concluded that trophic structures leading to longline tuna in the southwest Pacific appeared to depend on surface mechanisms.

KEY WORDS: tuna, yellowfin, bigeye, temperature, depth, time of day, feeding.

Green, R. 1967. Relation of the thermocline to success of purse seining for tuna. Trans. Am. Fish. Soc. 96:126-130.

Compared rates of success of catch in the eastern tropical Pacific in relation to the thickness of the mixed layer and average temperature gradient within the thermocline. Rates of success of purse seining were clearly related to both thermocline depth and the gradient within it. Also noted the relation of an oxygen minimum and temperature in some areas and proposed an influence on purse seining success.

KEY WORDS: thermocline, temperature, oxygen, depth, catch.

Hanamoto, E. 1974. Fishery oceanography of bigeye tuna - I Depth of capture by tuna longline gear in the eastern tropical Pacific Ocean. La Mer (Bull. Soc. Fr.-Jpn. Océanogr.) 12(3):128-136.

Shallow longline hooking depths between lat. 3^{o}N and 3^{o}S were believed to be influenced by the Equatorial Undercurrent. The swimming layer of bigeye was deeper than the capture depth indicated by longline depth data.

KEY WORDS: tuna, bigeye, catch, depth, currents, habitat.

Hanamoto, E. 1975. Fishery oceanography of bigeye tuna - II Thermocline and dissolved oxygen content in relation to tuna longline fishing grounds in the eastern tropical Pacific Ocean. La Mer (Bull. Soc. Fr.-Jpn. Océanogr.) 13(2):58-71.

Areas of high bigeye catch were found in shallow thermocline areas such as off Ecuador and along the equator. Catch rates were low in areas where the top of the thermocline was below 100 m. Depths of capture of bigeye were principally within or below the thermocline.

KEY WORDS: tuna, bigeye, thermocline, oxygen, concentration, temperature, catch, depth.

Hanamoto, E. 1976. The swimming layer of bigeye tuna. Bull. Jpn. Soc. Fish. Océanogr. 29:41-44. [Transl. 21 by T. Otsu, SWFC Honolulu Lab. May 1977.]

Bigeye catch rates varied with depth. Some latitudinal differences were noted, but those were attributed to water structure (currents).

KEY WORDS: tuna, bigeye, depth, habitat, catch, currents, geography, distribution.

Hester, F.J. 1961. A method of predicting tuna catch by using coastal sea-surface temperatures. Calif. Fish Game 47:313-326.

Described the seasonal and areal variation in albacore and bluefin catch in southern California and Baja waters. Developed a correlation between sea surface temperature at two southern California shore stations and bluefin and albacore catch from selected areas. It was possible to forecast tuna catch using winter water temperatures prior to the fishing season.

KEY WORDS: tunas, albacore, bluefin, catch, distribution, temperature, season, food, enrichment, environment.

Howard, G.V. 1963. The matter of availability and the harvest of tunas. In H. Rosa, Jr. (editor), Proceedings of the world scientific meeting on the biology of tunas and related species, La Jolla, California, U.S.A., 2-14 July 1962, p. 1041-1055. FAO Fish. Rep. 6.

Discussed evidence for a cause-effect relationship between temperature and tuna distributions. States that ". . . most researchers agree that surface temperature does not directly influence the distribution and availability in tropical waters except near the upper and lower limits of tolerence." Noted also that temperature values for a given species varied with geography.

KEY WORDS: tuna, albacore, yellowfin, bluefin, bigeye, skipjack, currents, distribution, environment, oceanography, temperature, food, enrichment, upwelling, fronts, water mass.

Hubbs, C.L., and G.I. Roden. 1964. Oceanography and marine life along the Pacific coast of middle America. In Natural environment and early cultures, p. 143-186. Handb. Mid. Am. Indians, vol. 1, Univ. Texas Press, Austin.

Reviews the impact of the sea on man in the Pacific area throughout history. For example: food, clothes, climate, trade goods, and articles. Described the ocean environment: currents, winds, and temporal-spatial features of them. Coastal Indian middens are the record of history of man and his use and the importance of the sea to him.

KEY WORDS: oceanography, meteorology, distribution, temperature, salinity, oxygen, winds, season.

Igeta, Y. 1965. A consideration on the relation between skipjack and albacore fishing grounds and vertical distribution of water temperature determined by bathythermograph. [In Jpn.] In Summary of proceedings of tuna fisheries research, Tuna Fishing (34 & 35):63.

[Not read.]

Ingham, M.C., S.K. Cook, and K.A. Hausknecht. 1977. Oxycline characteristics and skipjack tuna distribution in the southeastern tropical Atlantic. Fish. Bull., U.S. 75:857-865.

Reviewed possible mechanisms for oxygen minimum layers in the ocean. Showed an inverse relationship between the sighting of skipjack schools and the depth to the oxygen minimum layer.

KEY WORDS: tuna, skipjack, oxygen, distribution.

Inoue, M. 1958. Studies on movements of albacore fishing grounds in the northwest Pacific Ocean. I. Adaptability of water temperatures for albacores in the winter season from observations of records on catches and optimum water temperatures by fishing boats. [In Jpn., Engl. summ.] Bull Jpn. Soc. Sci. Fish. 23:673-679.

Noted a tendency for higher temperatures to be associated with larger fish; lower temperatures for small ones. Temperatures below 16.3° and over 22.8°C were considered "barriers" to albacore migration. Described seasonal movements of fish by size.

KEY WORDS: tuna, albacore, season, migration, size, distribution, temperature, depth.

Inoue, M. 1959. Studies on the movements of albacore fishing grounds in the northwest Pacific Ocean. 2. Influence of fluctuations of the oceanographical conditions upon the migration and distribution of albacore in winter-summer season and its fishing ground in the southern waters off Japan. [In Jpn., Engl. summ.] Bull. Jpn. Soc. Sci. Fish. 25:424-430

Described three patterns of albacore distribution based on seasonal isotherm distributions. Albacore distributions conformed to the distribution of isotherms within each pattern type. Winter and summer migrations were controlled by warm- and cold-water masses which acted as barriers to fish movements, which also influenced the timing of the fishing season.

KEY WORDS: tuna, albacore, oceanography, temperature, season, habitat, migration.

Inoue, M. 1960. Studies of movements of albacore fishing grounds in the northwest Pacific Ocean. III. Influence of fluctuations of the oceanographical conditions upon the fishing grounds of albacore in the summer period and its fishery conditions in the eastern waters off Japan. Bull. Jpn. Soc. Sci. Fish. 26:1152-1161.

Albacore accumulated at frontal edges against cold water. Fronts provided a barrier to movement and warm tongues provided a mechanism of "environmental inductance." Patterns of sea surface temperature distribution were plotted, showing meanders in edge of Kuroshio. Albacore occurred in warm-water pockets which intruded into cooler water.

KEY WORDS: tuna, albacore, seasons, catch, distribution, migration, oceanography, fronts, temperature, convergence, season.

Inoue, M. 1961. Relation of sea condition and ecology of albacore in northwest Pacific Ocean, Parts 1 and 2. In J.C. Marr (editor), Pacific Tuna Biology Conference, August 14-19, 1961, Honolulu, Hawaii, p. 25-26. U.S. Fish Wildl. Serv., Spec. Sci. Rep. Fish. 415.

Abstract only. Defined and used three classes of temperature distributions to predict the success of the summer albacore fishery. Fluctuations of the previous winter ocean conditions influenced the albacore migrations relative to the fishery.

KEY WORDS: tuna, albacore, distribution, season, migration, oceanography, catch.

Inter-American Tropical Tuna Commission. 1973. Report of the Inter-American Tropical Tuna Commission for the year 1972. [In Engl. and Span.]. Inter-Am. Trop. Tuna Comm., Annu. Rep. 1972, 166 p.

Discussed a hypothesis that sea surface temperatures in the spawning areas are related to skipjack abundance in fishing areas. The consistency of results supported the hypothesis that there is a relationship between skipjack abundance in the eastern tropical Pacific and sea surface temperatures in the central equatorial Pacific spawning area. Temperature itself was considered not to be the principle causal factor, but merely reflected the character of equatorial currents and associated zones of convergence and divergence. Considering correlations of yellowfin catch and sea surface temperatures, none of the correlations were significant.

KEY WORDS: tunas, yellowfin, skipjack, abundance, sea surface temperature, currents, convergence/divergence, spawning.

Inter-American Tropical Tuna Commission. 1974. Report of the Inter-American Tropical Tuna Commission for the year 1973. [In Engl. and Span.] Inter-Am. Trop. Tuna Comm., Annu. Rep. 1973, 150 p.

Using the Southern Oscillation index, about one-half the variation in skipjack abundance could be explained by fluctuations in temperature and pressure anomalies. A prediction capability was suggested with the best predictor thought to be the change in temperature along the equator between long. 180° and 130°W.

KEY WORDS: tuna, yellowfin, skipjack, season, abundance, Southern Oscillation index, temperature, pressure.

Inter-American Tropical Tuna Commission. 1975. Report of the Inter-American Tropical Tuna Commission for the year 1974. [In Engl. and Span.] Inter-Am. Trop. Tuna Comm., Annu. Rep. 1974, 169 p.

See annotations for 1973 and 1975 annual reports.

Inter-American Tropical Tuna Commission. 1976. Report of the Inter-American Tropical Tuna Commission for the year 1975. [In Engl. and Span.] Inter-Am. Trop. Tuna Comm., Annu. Rep. 1975, 176 p.

The Southern Oscillation index was favored as a predictor of the apparent abundance of part of the skipjack in the eastern tropical Pacific fisheries. Correlations ran high, but predictions on abundance often failed.

KEY WORDS: tuna, skipjack, Southern Oscillation index, catch, abundance.

Inter-American Tropical Tuna Commission. 1977. Report of the Inter-American Tropical Tuna Commission for the year 1976. [In Engl. and Span.] Inter-Am. Trop. Tuna Comm., Annu. Rep. 1976, 180 p.

Predictions for skipjack catches based on Southern Oscillation index being discontinued due to failures in the prediction.

KEY WORDS: tuna, skipjack, Southern Oscillation index, catch, abundance.

Inter-American Tropical Tuna Commission. 1978. Report of the Inter-American Tropical Tuna Commission for the year 1977. [In Engl. and Span.] Inter-Am. Trop. Tuna Comm., Annu. Rep. 1977, 180 p.

Skipjack larvae captures were highly correlated with sea surface temperatures suggesting that the area of warm water might be a good index of skipjack spawning or survival of larvae, which could be related to year class abundance of adult fish. Compared the use of atmospheric pressure and sea surface temperature differences as indicators of skipjack year class abundance.

KEY WORDS: tuna, skipjack, spawning, abundance, temperature, Southern Oscillation index.

Jerlov, N.G. 1953. Studies of the equatorial currents in the Pacific. Tellus 5:308-14.

> Noted changes in intensity and north-south location of divergence and convergence zones at boundaries of the countercurrent (lat. 5°N and 10°N).
>
> KEY WORDS: oceanography, currents, season, distribution, convergence/divergence.

Jerlov, N.G. 1956. The equatorial currents in the Pacific Ocean. Rep. Swed. Deep-Sea Exped. 3(6): 129-154.

> Presented plan view and vertical sections of oceanographic data from four crossings of the equator in 1947. Pointed out major features and seasonal variations. Concluded that "the mechanism of the equatorial currents may principally be understood from the action of prevailing winds."
>
> KEY WORDS: oceanography, temperature, salinity, density, depth, season, currents, discontinuity, divergence, winds.

Johnson, J. H. 1961. Sea temperatures and the availability of albacore (*Thunnus germo*) off the coast of Oregon and Washington. *In* J.C. Marr (editor), Pacific Tuna Biology Conference, August 14-19, 1961, Honolulu, Hawaii, p. 26. U.S. Fish Wildl. Serv., Spec. Sci. Rep. Fish. 415.

> Abstract only. In years with above normal sea surface temperatures, albacore landings in general were greater than in years of below normal temperatures. Whereas warm waters did not ensure a good fishery, widespread cold waters were detrimental to fishing success.
>
> KEY WORDS: tuna, albacore, temperatures, catch.

Johnson, J.H. 1962. Sea temperatures and the availability of albacore off the coasts of Oregon and Washington. Trans. Am. Fish. Soc. 91:269-274.

Studied sea surface temperatures and albacore landings for the period 1947 to 1960. Warm-water years were better for catch but did not ensure good fishing. Cold-water years were detriminal to fishing success. Fluctuations in landings were results of yearly variation in abundance and variability and were not related to fishing.

KEY WORDS: tuna, albacore, temperature, catch, season.

Johnson, J.H. 1963. Changes in availability of albacore in the eastern Pacific Ocean 1952 and 1958. In H. Rosa (editor), Proceedings of the world scientific meeting on the biology of tunas and related species, La Jolla, California, U.S.A., 2-14 July 1962, p. 1227-1235. FAO Fish. Rep. 6.

California current influenced the distribution of albacore: when the flow was strong albacores' southern limit was farther south, when weak the southern limit was farther north. Isotherms coincided with the fishery at its north and south limits. Atmospheric changes influenced sea conditions and produced temperature anomalies which were reflected in albacore distributions.

KEY WORDS: tuna, albacore, environment, oceanography, climate, temperature, currents, catch, distribution.

Johnson, J.H., and G.R. Seckel. 1976. Use of marine meteorological observations in fishery research and management. Paper presented at the World Meteorological Organization's Technical Conference on the Applications of Marine Meteorology to the High Seas and Coastal Zone Development, 22-26 Nov. 1976, Geneva, Switzerland.

Related changes in fisheries with changes in environmental conditions.

KEY WORDS: tuna, catch, spawning, migration, wind, temperature, currents, upwelling, convergence.

Kamimura, T., and M. Honma. 1963. Distribution of the yellowfin tuna (Neothunnus macropterus [Temminck and Schlegel]) in the tuna longline fishing grounds of the Pacific Ocean. [In Jpn., Engl. abstr.] Rep. Nankai Fish. Res. Lab. 17:31-53.

Longline hooking rate for yellowfin attained a maximum near the equator in the west and central Pacific and decreased toward higher latitudes. Yellowfin were found principally in the South Equatorial Current, bigeye in North Equatorial Current suggesting environmental differences to which each is sensitive. Temperature did not seem to be a controlling factor. Yellowfin distribution showed only a small seasonal variation in the equatorial region. Seasonal peaks did appear in the catch at higher latitudes in the west Pacific. Noted a west-to-east gradient of increasing size of yellowfin across the Pacific. Young fish were in high densities around islands and near land.

KEY WORDS: tuna, yellowfin, bigeye, season, size, catch, temperature, currents, distribution, population.

Kanagawa Prefectural Fisheries Experimental Station. 1952-1956. Table of survey of tuna catches by months and by fishing area. [In Jpn.] Kanagawa-ken Suisan Shikenjo Geppo (Mon. Rep. Kanagawa Pref. Fish. Exp. Stn.) Nos. 1-43.

World-wide catch data from Japanese longline boats; include data on effort, sampling coverage, and water temperature.

KEY WORDS: tuna, catch, distribution, season, temperature.

Kanagawa Prefectural Fisheries Experimental Station. 1961. Analysis of hook rate of pelagic tuna fishing boats in Japan, 1958. [In Jpn.] Kanagawa Suishi Shiryō (Rep. Kanagawa Pref. Fish. Exp. Stn.) 3, 47 p.

Catch and efforts statistics of Japanese longline boats by month, area, and species. Includes water temperature data.

KEY WORDS: tuna, catch, distribution, season, temperature.

Kawai, H. 1959. On the polar frontal zone and its fluctuation in the waters to the northeast of Japan (III). Fluctuation of the water mass distribution during the period 1946-1950 and hydrographic conditions in the fishing grounds of skipjack and albacore. [In Jpn., Engl. summ.] Bull. Tohoku Reg. Fish. Res. Lab. 13:13-59.

Seasonal changes in skipjack concentrations relative to oceanographic conditions. Concluded that size of fish differed in accordance with temperature and chlorinity on the albacore grounded.

KEY WORDS: tuna, skipjack, albacore, oceanography, temperature, salinity, depth, fronts, water masses, season.

Kawai, H., and M. Sasaki. 1962. On the hydrographic condition accelerating the skipjack's northward movement across the Kuroshio Front. [In Jpn., Engl. summ.] Bull. Tohoku Fish. Res. Lab. 20:1-27.

The primary Kuroshio front and the sharp thermal gradient along it prevented skipjack from moving northward. Both the primary and a secondary front influenced the movement of the main body of skipjack into the Japanese fishery.

KEY WORDS: tuna, skipjack, migration, season, front, currents.

Kawasaki, T. 1952. On the populations of skipjack, Katsuwonus pelamis (Linnaeus), migrating to the north-eastern sea along the Pacific coast of Japan [In Jpn., Engl. summ.] Bull. Tohoku Reg. Fish. Res. Lab. 1:1-14.

Compared population structure and fish condition factor by areas (coastal vs. offshore). Areas occupied overlapped and fluctuated with variations in strength of the Kuroshio Current. Availability was postulated to be related to the current system.

KEY WORDS: tuna, skipjack, distribution, migration, season, oceanography, currents.

Kawasaki, T. 1957. Relation between the live-bait fishery of albacore and the oceanographical conditions in waters adjacent to Japan. 1. The fishing ground south of the Kuroshio Front. [In Jpn.] Bull. Tohoku Fish. Res. Lab. 9:69-109.

Albacore live bait fishing grounds formed in the transition area north of the Kuroshio front. The fishing ground was within an isolated warm-water mass associated with an anticyclonic eddy. The grounds formed only when temperatures at the surface were greater than 17°C and chlorinity greater than 19°/oo.

KEY WORDS: tuna, albacore, oceanography, front, water mass, currents, temperatures, salinity.

Kawasaki, T. 1957. On the fluctuation of the fisheries conditions in the live-bait fishery of skipjack in waters adjacent to Japan. 1. [In Jpn., Engl. summ.] Bull. Tohoku Reg. Fish. Res. Lab. 10:17-28.

Analyzed catch statistics for skipjack from 1905 to 1956. Indicated a trend for large fish in good years, small fish in poor years. Oceanographic conditions for skipjack fishery were favorable in 1951 and 1956, but not in 1953.

KEY WORDS: tuna, skipjack, catch, season, oceanography.

Kawasaki, T. 1957. Relation between the live-bait fishery of albacore and the oceanographical conditions in waters adjacent to Japan. 1. The fishing ground south of the Kuroshio Front. [In Jpn.] Bull. Tohoku Fish. Res. Lab. 9:69-109.

Studied the relation between live bait albacore fishery and state of the sea. Listed conditions for appearance of the albacore fishing ground relative to the Kuroshio front waters and their surroundings.

KEY WORDS: albacore, distribution, catch, oceanography, currents, fronts, convergence.

Kawasaki, T. 1957. Relation between the live-bait fishery of albacore and the oceanographical conditions in waters adjacent to Japan. 2. The fishing grounds north of the Kuroshio Front. [In Jpn.] Bull. Tohoku Fish. Res. Lab. 10:29-45.

Described albacore live bait fishing ground in the transition zone north of the Kuroshio front in 1947, 1948, and 1950. The ground was formed within an isolated water mass accompanied by an anticyclonic eddy. The warm-water mass was formed by a meander of the Kuroshio front.

KEY WORDS: tuna, albacore, temperature, salinity, currents, front, season.

Kawasaki, T. 1965. Ecology and dynamics of the skipjack population (I), (II). [In Jpn.] Nihon Suisan Shigen Hogo Kyōkai, Suisan Kenkyū Sōsho (Study Ser. Jpn. Fish. Resour. Conserv. Assoc.) 8-1:1-48, 8-2:49-108. [Engl. transl., 1967, by M.P. Miyake (Part I) and by U.S. Joint Publications Research Service (Part II). Inter-Am. Trop. Tuna Comm. and U.S. Bur. Commer. Fish., Calif., 54 p. and 79 p.]

Described three Pacific areas for fishery: Japanese, Hawaiian, and eastern Pacific waters. Gave methods of fishing, and general trends in catch over the history of fisheries. Reviewed fluctuations in catch per unit of effort, changes due to year class strength which were due to environmental changes.

KEY WORDS: tuna, skipjack, catch, distribution, history, season, stock.

Kawasaki, T. 1967. Ecology and dynamics of the skipjack population (II). Resources and fishing conditions. Japan Fishery Resources Protection Association. [Translated by U.S. Joint Publications Research Service (66 typed pages).]

General history of Japanese, Hawaiian, and United States fisheries; methods and catch trends. Presented a population catch structure based on size-frequency modes, growth differential, and behavior. Listed numerous "groups" in various areas. Compared trends among the areas over time. Presented a model of the skipjack population in the central and North Pacific; basically a migration of large spawners into the central Pacific with young fish moving to the peripheral regions to feed and mature; these then--once they reach large size--move offshore to the central area again. Author gave little credence to serological subgroups such as described by Sprague. Discussed environmental/oceanographic influences on fishing skipjack near Japan which were strongly associated with fronts and edges of water masses where two masses meet; migratory skipjack fishing grounds occurred mainly at current boundaries; skipjack grounds were formed in boundaries where warm waters thinly covered the surface.

KEY WORDS: tuna, skipjack, catch, population, migration, currents, front, season, spawning, stock.

Kawasaki, T., and Y. Aizawa. 1956. On the ecology of the albacore in waters adjacent to the northeast of Japan. [In Jpn., Engl. summ.] Bull. Tohoku Fish. Res. Lab. 6:81-92.

Study of the migration of albacore by age- and length-group and temperature. Migrations were led by old fish during westward movement; during eastward movement younger fish took the lead. Considered relations between age and season and sea surface temperatures.

KEY WORDS: tuna, albacore, age, season, temperature, habitat.

Kawasaki, T., M. Yao, M. Anraku, A. Naganuma, and M. Asano. 1962. On the structure and the fluctuation mechanism of the piscivorous fish community distributed in the subsurface layer of the Tohoku Sea region. I. [In Jpn., Engl. summ.] Bull. Tohoku Reg. Fish Res. Lab. 22:1-44.

[Not read.]

Kearney, R.E. 1978. Some hypotheses on skipjack (Katsuwonnus pelamis in the Pacific Ocean. South Pac. Comm., Noumea, New Caledonia, Occas. Pap. 7:1-23.

Distribution of larvae, juveniles and young, and adults in relation to the environment; physiological limitations with regard to environment; population-subpopulation-stock definition, description, and distribution. Discussion on stock assessment.

KEY WORDS: tuna, skipjack, distribution, population, stock, growth, environment, larvae, migration.

Kikawa, S. 1957. The concentrated spawning area of bigeye tuna in the western Pacific. [In Jpn., Engl. abstr.] Rep. Nankai Reg. Fish. Res. Lab. 5:145-157

A study based on gonad indexes in different areas. Relative abundance curves of three groups appeared to coincide with ocean current basins, with curves crossing at points which coincided with current boundaries. Ocean currents were considered to have definite ecological significance to tunas: bigeye being found in the North Pacific Current in the resting stage; bluefin in the North Equatorial Current were recent spawners. The most mature group was dominant in the Equatorial Countercurrent so that spawning areas of bigeye lay in that current. Fish were recruited from north to south in the North Pacific with the reverse in the South Pacific. No good data were available for yellowfin, but spawning seemed to occur in the South Equatorial Current area.

KEY WORDS: tuna, yellowfin, bigeye, bluefin, distribution, spawning, age, migration, season, currents, boundaries.

Kikawa, S., T. Shiohama, Y. Morita, and S. Kume. 1977. Preliminary study on the movement of the North Pacific albacore based on the tagging. Bull. Far Seas Fish. Res. Lab. (Shimizu) 15:101-113.

Described location and timing of Japanese local albacore fishery. Albacore tagged in the Kuroshio front grounds moved east; one was recovered in the U.S. fishery. Some fish moved north to leave the frontal zone early in the season. Long-term recoveries occurred throughout the pole and line area, suggesting a regular seasonal movement which is repeated yearly. Most fish did not go to the U.S. area, but entered the longline fishery. It was considered unlikely that albacore in the west were supported only by recruits from the eastern Pacific.

KEY WORDS: tuna, albacore, migration, fronts.

Klawe, W.L. 1963. Observations on the spawning of four species of tuna (*Neothunnus macropoterus*, *Katsuwonus pelamis*, *Auxis thazard* and *Euthynnus lineatus*) in the eastern Pacific Ocean, based on the distribution of their larvae and juveniles. [In Engl. and Span.] Inter-Am. Trop. Tuna Comm. Bull 6:449-540.

Examined vertical distribution of larvae and found they were limited to layers above the thermocline. Gave areas and seasons of principle spawning.

KEY WORDS: tuna, yellowfin, skipjack, black skipjack, *Auxis*, larvae, distribution, spawning, oceanography, bullet tuna, frigate tuna.

Klawe, W.L., J.J. Pella, and W.S. Leet. 1970. The distribution, abundance and ecology of larval tunas from the entrance to the Gulf of California. [In Engl. and Span.] Inter-Am. Trop. Tuna Comm. Bull. 14:507-544.

Paper deals mostly with Auxis. The geographic distribution of larvae catches were strongly influenced by the distribution of oceanographic properties. Temperature clearly was a very important variable for Auxis sp., the optimum temperature for the species being around 27°C. Authors noted a marked increase in the proportion of plankton tows containing larval. Thunnus albacares and Euthynnus lineatus occurring at stations where surface temperatures exceeded 26° or 27°C. They also listed water masses within which larvae were taken at various months. No relation per se was made with the distribution of larval tunas and water masses.

KEY WORDS: tunas, Auxis, yellowfin, skipjack, larvae, spawning, temperature, season, distribution, oceanography, bullet tuna, frigate tuna.

Knudsen, P.F. 1977. Spawning of yellowfin tuna and the description of subpopulations. [In Engl. and Span.] Inter-Am. Trop. Tuna Comm. Bull. 17:119-169.

Biochemical genetics indicated a number of genetically distinct groups of yellowfin in the eastern Pacific, and two recruitment groups of a mixture of the above enter the eastern tropical Pacific fishery. Coastal fish showed at least two spawning periods per year which vary in time and extent. Offshore fish did not show this variable pattern of spawning. Spawning time differences were not an isolation factor for maintaining the genetic differences; but data were insufficient to determine if spatial isolation was occurring. Author proposed that the environment in inshore and offshore areas caused the observed differences in spawning behavior.

KEY WORDS: tuna, yellowfin, population, spawning, season, geography, oceanography.

Kume, S. 1963. Ecologial studies on bigeye. I. On the distributon of bigeye tuna in the eastern Pacific. Rep. Nankai Reg. Fish. Lab. 17:121-131.

Described distributional patterns of bigeye in the eastern Pacific. Speculated that accumulations of bigeye were associated with discontinuities of the oceanographic structure. Abundance and density were influenced by the Transition Zone and the subtropical convergence. In the eastern equatorial Pacific, areas of a high density occurred in two east-west zones along the north and south margins of upwellings of cooler water at or near the equator, and seasonal movements of the fish reflected seasonal extensions of the upwelling area. In periods of development of the upwelling area sexually mature bluefin occurred just in the upwelling area.

KEY WORDS: tuna, bigeye, distribution, season, currents, discontinuity, upwelling, abundance, migration.

Kume, S. 1969. Ecological studies on bigeye tuna - VI. A review on distribution and size composition of bigeye tuna in the Equatorial and South Pacific Ocean. Bull. Far Seas Fish. Res. Lab. (Shimizu) 1:77-98.

Seasonal variation in distribution of longline catch was related fairly well to that of upwelling strength along the equator. Spawning occurred throughout the entire equatorial region. A size gradient, with increases from east-to-west, suggested a growth migration. Simultaneous year class appearance in different areas indicated an internal association of the stock. He therefore concluded the presence of a single stock.

KEY WORDS: bigeye, stock, season, catch, temperature, spawning, distribution, age/size.

Laevastu, T., and I. Hela. 1970. Fisheries oceanography. Fish. News (Books) Ltd., Lond., 238 p.

A compilation of fish-environmental relations, summarizing the state of knowledge in the field and giving examples of the interactions between fish and their environment. Wide geographic coverage considering several types of fishes.

KEY WORDS: tuna, distribution, environment.

Laevastu, T., and H. Rosa, Jr. 1963. Distribution and relative abundance of tunas in relation to their environment. In H. Rosa, Jr. (editor), Proceedings of the world scientific meeting on the biology of tunas and related species, La Jolla, California, U.S.A., 2-14 July 1962, p. 1835-1851. FAO Fish. Rep. 6.

Tabulated the temperature range of each species of tuna and indicated the optimum temperature range for fisheries. Temperate water species (albacore and bluefin) seasonally migrate according to temperature control, food, or both. High concentrations occurred when there were high surface temperature gradients and where the optimum temperature zone was narrow. Also a vertical temperature gradient could act as a barrier and cause aggregation. Thermocline ridges were preferred areas for aggregation. They noted that Japanese work indicated that several species usually remain within a given current or water mass for a season, then migrate from one water mass to another during seasonal changes. Within a water mass or current tunas tended to aggregate at boundaries. Eddies were preferred sights for aggregation along with frontal zones. Transparency values of 25-35 m were optimal for best fishing. Fishing areas coincided with productive areas. Migrations were discussed.

KEY WORDS: tunas, bluefin, yellowfin, skipjack, bigeye, albacore, distribution, temperature, depth, currents, transparency, food.

Laurs, R.M., and R.J. Lynn. 1975. The association of ocean boundary features and albacore tuna in the northeast Pacific. In Proceedings: Third S/T/D Conference and Workshop, February 12-14, 1975, p. 23-30. Plessey Environmental Systems, San Diego, Calif.

Migration of albacore into the U.S. fishery and distribution were related to oceanographic conditions of the Transition Zone and associated frontal structure. Albacore were more available within the Transition Zone than outside of it. Interannual variations in the ocean structure were reflected in albacore distributions.

KEY WORDS: tuna, albacore, sea surface temperature, discontinuity, distribution, migration, fronts.

Laurs, R.M., and R.J. Lynn. 1977. Seasonal migration of North Pacific albacore, Thunnus alalunga, into North American coastal waters: Distribution, relative abundance, and association with Transition Zone waters. Fish. Bull., U.S. 75:795-822.

Concluded that the shoreward migration of albacore is linked to the Transition Zone (T.Z.) and that variations in the pattern of migration occurred in response to variations in the character and development of the T.Z. and its frontal structure. When the T.Z. was narrow and the fronts well developed, the migration was narrow and well defined; when broad, the migration was broad and less well defined. Gave speeds of albacore migration as 48 k per day for 78-80 cm size fish. Forage availability was likely an important factor influencing the route of the migration. The albacore migratory route during spring was thought to be determined by ocean temperatures, and the limiting temperatures were found near the northern boundary of the T.Z. While temperature may play a role in determining the southern limit of the albacore distribution and migratory route, the major factor is the abundance and availability of forage organisms which drop off sharply near the southern boundary of the T.Z. Evidence was given for two groups taking separate routes into the American Pacific fishery.

KEY WORDS: tuna, albacore, migration, stock, distribution, food, season, temperature, fronts, oceanography.

Laurs, R.M., H.S.H. Yuen, and J.H. Johnson. 1977. Small-scale movements of albacore, *Thunnus alalunga*, in relation to ocean features as indicated by ultrasonic tracking and oceanographic sampling. Fish. Bull., U.S. 75:347-355.

Gave average swimming speeds of 1.6 kn; during day 1.7 kn, at night 1.3 kn. Movements were influenced by sea surface temperature; fish avoided low temperature water, fish stayed on the warm side of local upwelling fronts. Results suggested that 1) albacore concentrate in the vicinity of upwelling fronts presumably to feed and 2) the fish move away from the immediate area when upwelling ceases and the front is no longer present at the surface.

KEY WORDS: tuna, albacore, oceanography, migration, temperature, upwelling, fronts, feed.

LeGuen, J.C., J.R. Donguy, and C. Henin. 1977. Perspectives on the tuna fishery in the South Pacific. [In Fr.] Marit. Fish. 56(1186):20-28.

A brief history of the Japanese, Korean, and Taiwanese fisheries in the South Pacific. A summary of Japanese activities for 1975 and 1976 based on Japanese data atlases. Statistics of catch per area revealed the importance of hydrological perterbations connected with islands and of the equatorial and tropical current systems. A very active fishery centered on the convergence between the Equatorial Current and the North Equatorial Countercurrent. Near island groups, skipjack schools concentrated on the interior of large reefs; also in island wakes. The authors promoted the idea of the use of airborne or satellite thermal sensors to delimit water masses and large current systems.

KEY WORDS: tunas, billfishes, currents, convergence, island wakes, temperature, water mass, fronts.

LeGuen, J.C., F. Poinsard, and J.P. Troadec. 1965. The yellowfin tuna fishery in the eastern tropical Atlantic (preliminary study). Commer. Fish. Rev. 27(8):7-18.

Described characteristics of the Point Noire live-bait tuna fishery. Fish concentrations were related to the location of a thermal front which shifts north and south seasonally. Tunas occur close to the front on the warm side. Highest concentrations of yellowfin were found in waters with temperatures from 24° to 25°C which characterized the boundary between warm and cold water.

KEY WORDS: tuna, skipjack, yellowfin, bigeye, temperature, front, season, catch, distribution.

Magnier, Y., H. Rotschi, P. Rual, and C. Colin. 1973. Equatorial circulation in the western Pacific (170°E). Progr. Oceanogr. 6:29-46.

Presented a new nomenclature for currents. Characteristics of the currents are tabulated.

KEY WORDS: currents.

Manar, T.A. (editor). 1966. Proceedings of the Governor's Conference on Central Pacific Fishery Resources, Honolulu-Hilo, February 28 - March 12, 1966. State of Hawaii, Honolulu, 266 p.

Includes papers on tuna biology, fisheries, economics, etc. by various participants with emphasis on skipjack. Reviewed history of catch and research until 1965.

KEY WORDS: tuna, yellowfin, bigeye, bluefin, skipjack, albacore, catch, distribution, abundance, size, larvae, spawning.

Marr, J.C. (editor). 1962. Pacific Tuna Biology Conference, August 14-19, 1961. U.S. Fish Wildl. Serv., Spec. Sci. Rep. Fish. 415, 45 p.

A review of the status of tuna-environment information to 1962. Characterized skipjack habitat in geographic and thermal terms for the eastern tropical Pacific.

KEY WORDS: tuna, skipjack, environment, fronts, upwelling, temperature, feed.

Matsumoto, W.M., and R.A. Skillman. Synopsis of biological data on skipjack tuna, _Katsuwonus pelamis_ (Linnaeus). Unpubl. manuscr. Southwest Fisheries Center Honolulu Laboratory, National Marine Fisheries Service, NOAA, P.O. Box 3830, Honolulu, HI 96812.

Matsumoto, W.M., and R.A. Skillman. Biology, ecology, and resource of the skipjack tuna, Katsuwonus pelamis. Unpubl. manuscr. Southwest Fisheries Center Honolulu Laboratory, National Marine Fisheries Service, NOAA, P.O. Box 3830, Honolulu, HI 96812.

Description of skipjack habitat. Skipjack inhabit the upper mixed layer having uniform temperatures and salinities with oxygen being near or at saturation. Greatest concentrations were limited to temperature range of 18^{o}-21^{o}C. Major water masses and currents influenced the distribution both through drift of larvae and possibly of the adults as well. Described larval distribution and geography and adult distribution. Discussed migration routes.

KEY WORDS: tuna, skipjack, yellowfin, albacore, bigeye, habitat, temperature, salinity, oxygen, water mass, currents, discontinuities, upwelling, food, larvae, spawning, distribution, season, depth, migration.

McCreary, J. 1976. Eastern tropical ocean response to changing wind systems: with application to El Nino. Phys. Oceanogr. 6(5):632-645.

A mathematical model describes the mechanism of the oceans' response to wind changes. He produced a description of the mechanics leading up to El Nino; and the event also expands poleward from the equator to include the Davidson Current area.

KEY WORDS: oceanography, equatorial, currents, winds, El Nino.

McGary, J.W., J.J. Graham, and T. Otsu. 1960. Oceanography and north Pacific albacore. Calif. Coop. Oceanic Fish. Invest. Rep. 8:45-53.

A report on surveys to define distribution and abundance of albacore in relation to oceanographic environment. Migrations and seasonal fluctuations were considered along with temperature-salinity characteristics of water masses and their boundaries and shifts in the latter with seasons.

KEY WORDS: tuna, albacore, distribution, abundance, geography, season, migration, oceanography, water mass, temperature, salinity, fronts, season, enrichment.

McGowan, J.A. 1974. The nature of oceanic ecosystems. In Charles B. Miller (editor), The biology of the oceanic Pacific, p. 9-28. Oreg. State Univ. Press, Corvallis.

Described a number of ecotones exemplifying the habitats of a wide range of types of organisms; gave a general description of the features of each province. Variations in biological events related better to climate-scale than weather-scale events.

KEY WORDS: tunas, weather, climate, habitat, distribution, geography.

McKenzie, M.K. [1964?]. The distribution of tuna in relation to oceanographic conditions. N.Z. Ecol. Soc. 11:6-10.

Coastal areas of New Zealand and Australia were compared with other fishing areas. Greatest concentrations of fish occurred near current convergences and upwellings where there usually was abundant food. Thermocline acted as a barrier to feed-fish. Water clarity was important because of optical selectivity in feeding by tunas. Discussed seasonal changes in the position of convergences formed from local current systems and described local fishery's seasonality.

KEY WORDS: tuna, yellowfin, skipjack, albacore, southern bluefin, currents, convergence, temperature, thermocline, transparency, fronts, season, distribution, feed.

Meehan, J.M. 1965. First occurrence of bigeye tuna on the Oregon coast. Oreg. Res. Briefs 11(1):53-54.

KEY WORDS: tuna, bigeye, temperature, range, distribution.

Merle, J., H. Rotschi, and B. Voituriez. 1969. Zonal circulation in the tropical western South Pacific at 170° E. Bull. Jpn. Soc. Fish. Oceanogr., Spec. No., p. 91-97.

Renamed the equatorial/tropical currents and countercurrents. Discussed southern hemisphere divergence, convergence and doming at current boundaries and the impact on nutrients and enrichment near the surface.

KEY WORDS: currents, discontinuities, enrichment.

Miller, F.R. Sea surface temperatures in the eastern tropical Pacific during 1974 and the tropical fishery. Unpubl. manuscr. Southwest Fisheries Center La Jolla Laboratory, National Marine Fisheries Service, NOAA, P.O. Box 271, La Jolla, CA 92038.

Reviewed published sea surface temperature data and tuna distribution. The 79°F isotherms in the eastern tropical Pacific enveloped areas where most yellowfin were captured in 1974. Composited annual negative SST anomalies of 2°F and greater coincided with areas of poor tuna fishing in 1974. Most active tuna fishing was found where seasonal temperatures remained in the range of 79° to 84°F.

KEY WORDS: tuna, sea surface temperature, season, catch, distribution.

Miller, F.R., and E.D. Forsbergh. 1978. North Equatorial Countercurrent, a possible path for skipjack migration in the eastern tropical Pacific. Proceedings of the 29th Tuna Conference May 22-24, 1978, p. 3-5.

Sea surface temperature, zonal current strength and Southern Oscillation index all were correlated; and significant correlation existed between skipjack abundance, the index and sea surface temperatures in the spawning area as well as the Southern Oscillation index at earlier times. They hypothesized: 1) more spawning occurs in warm years; 2) more larvae survive in warm years; 3) migration of young skipjack from the spawning areas to fishing areas is influenced by the strength of the eastward flow of the North Equatorial Countercurrent and the South Equatorial Countercurrent.

KEY WORDS: tuna, oceanography, skipjack, sea surface temperature, currents, Southern Oscillation index, spawning, migration, season, abundance.

Miller, F.R., and R.M. Laurs. 1975. The El Nino of 1972-73 in the eastern tropical Pacific Ocean. [In Span. and Engl.] Inter-Am. Trop. Tuna Comm. Bull. 16:403-448.

Reviewed the hypothesis on the origin of El Nino. The 1972-73 El Nino was analyzed from the aspect of ocean temperature anomalies and then similarities in ocean temperatures in recent ones were compared.

KEY WORDS: atmosphere, wind, oceanography, sea surface temperatures, El Nino.

Miyake, M.P. 1968. Distribution of skipjack in the Pacific Ocean, based on records of incidental catches by the Japanese longline tuna fishery. Inter-Am. Trop. Tuna Comm. Bull. 12:511-608.

Charted the catch of skipjack per thousand hooks by longliners by quarter by 5° square for 1949-65, 1961-64, 1956-60. Considered all available Japanese longline data on Pacific Ocean skipjack taken incidental to the longline fishery; temperature, depth of capture, etc.

KEY WORDS: tuna, skipjack, catch, distribution, depth, season, spawning, temperatures.

Morita, T. 1959. On the constitutional state of fishing ground over the waters near the Goto Rettō. [In Jpn., Engl. summ.] Mem. Fac. Fish, Kagoshima Univ. 7:161-167.

Related seasonal variation in fishing to oceanographic conditions off southern Japan. Charted annual temperature and salinity variation with skipjack catch.

KEY WORDS: tuna, skipjack, catch, season, currents, temperature, salinity.

Morita, T. 1960. Studies on the constitutional state of skipjack fishing ground over the waters near Tokara Retto (I). On the relation between the water-temperature and the catching condition in the fishing ground. [In Jpn., Engl. summ.] Mem. Fac. Fish, Kagoshima Univ. 8:121-129.

Seasonal changes in fishing grounds off Japan were related to vertical oceanographic structure and seasonal stock migrations.

KEY WORDS: tuna, skipjack, oceanography, catch, season, temperature, depth.

Murphy, G.I., and R.S. Shomura. 1972. Pre-exploitation abundance of tunas in the equatorial central Pacific. Fish. Bull., U.S. 70:875-913.

Related temperature, upwelling, nutrients, and forage to ocean processes and to tuna distributions. Considered the hypothesis that variations in yellowfin are influenced by variations in the wind-driven ocean circulation that affects the food supply of the species.

KEY WORDS: tunas, yellowfin, skipjack, bigeye, albacore, temperature, enrichment, fronts, wind, convergence, currents, oceanography.

Nakagome, J. 1958. On the seasonal variation of swimming layers of yellowfin tuna, big eyed tuna and black marlin in the area of Caroline and Marshall Islands. 1. On the seasonal variation of swimming layer. [In Jpn., Engl. summ.] Bull. Jpn. Soc. Sci. Fish. 23:518-522.

Swimming layer depths of yellowfin were shallower (115 m) in late spring and deeper (150 m) in autumn, changing seasonally. The bigeye zone was shallower (110-120 m) in late spring and from November to December, and deeper (140-150 m) in the autumn and January, changing seasonally.

KEY WORDS: tuna, yellowfin, bigeye, depth, habitat.

Nakagome, J. 1958. Relation between seasonal variation of swimming layer of yellowfin tuna and big eyed tuna and vertical distribution of chlorinity. [In Jpn., Engl. summ.] Bull. Jpn. Soc. Sci. Fish. 23:523-524.

No relation was found between the swimming layer and vertical distribution of chlorinity.

KEY WORDS: tuna, yellowfin, bigeye, season, depth, habitat, chlorinity (salinity).

Nakagome J. 1958. On the seasonal variation of swimming layers of yellowfin tuna, big eyed tuna and black marlin in the area of Caroline and Marshall Islands. 2. Relation between seasonal variation of swimming layer and vertical distribution of water-temperature. [In Jpn., Engl. summ.] Bull. Jpn. Soc. Sci. Fish. 24:169-172.

Variation of the swimming layer of yellowfin and bigeye was not related to variations in water temperature. Therefore, the author supposed that the swimming layer was independent of temperature.

KEY WORDS: tuna, yellowfin, bigeye, habitat, depth, temperature.

Nakagome, J. 1958. On the seasonal variation of swimming layers of yellowfin tuna, big eyed tuna and black marlin in the area of Caroline and Marshall Islands. 3. On the relationship between seasonal variation of swimming layer and rate-of-catch. [In Jpn., Engl. summ.] Bull. Jpn. Soc. Sci. Fish. 24:173-175.

Variation of catch rate of yellowfin and bigeye correlated with depth of the swimming layer. When the depth from the surface to the swimming layer was shallow catch rate was high; when deep it was low.

KEY WORDS: tuna, yellowfin, bigeye, catch, habitat, depth.

Nakagome, J. 1960. On the cause of annual variation of fishing condition of bigeye tuna in the area from Marshall Islands to Palmyra Island. 3. Relation between monthly and annual variations of fishing condition and those of surface water temperature of the fishing ground. [In Jpn., Engl. summ.] Bull. Jpn. Soc. Sci. Fish. 26:406-407.

Monthly and annual variations of fishing conditions for bigeye and sea surface temperatures were considered. A direct relation between sea surface temperatures and the annual variations in catch could not be found.

KEY WORDS: temperature, bigeye, season, catch, oceanography, temperature.

Nakagome, J. 1960. On the cause of annual variation of fishing condition of bigeyed tuna in the area from Marshall Islands to Palmyra Island. 5. Relation between appearance of dominant age group of bigeyed tuna and surface water temperature in spawning and larvae cultivated area. [In Jpn., Engl. summ.] Bull. Jpn. Soc. Sci. Fish. 26:472-475.

Discussed the variation in annual sea surface temperature and age frequency of bigeye caught on lingline. Observed different periods of high and low temperatures on the fishing grounds between years and seasons.

KEY WORDS: tuna, season, bigeye, temperature, catch, age.

Nakagome, J. 1961. Seasonal variation of swimming layer of yellowfin tuna by area of different currents in mid-western and southwestern parts of the Pacific Ocean. Bull. Jpn., Soc. Sci. Fish. 27:302-306.

Compared the seasonal variation in the swimming layer and among areas of the fisheries off northeast Australia and New Guinea.

KEY WORDS: tuna, yellowfin, habitat, depth, convergence, currents, season.

Nakagome, J. 1965. On the seasonal variation of swimming layer of yellowfin tuna, big-eyed tuna and blue marlin in the area of Caroline and Marshall Islands - IV. Seasonal variation of water temperature by depth. [In Jpn.] Bull. Jpn. Soc. Sci. Fish. 31:781-784.

Seasonal variations in water temperatures at the surface and 50 m were different than those of 150, 200, and 300 m. Compared values among years.

KEY WORDS: tuna, bigeye, season, depth, temperature, habitat.

Nakagome, J. 1965. On the seasonal variation of swimming layer of yellowfin tuna, bigeye tuna and blue marlin in the area of Caroline and Marshall Islands - V. Relation between seasonal variation of depth of swimming layer and that of depth of water temperature layer. [In Jpn., Engl. summ.] Bull. Jpn. Soc. Sci. Fish. 31:785-788.

Swimming depths of yellowfin and bigeye seemed related to the seasonal variation of the depth of 28°C water. Swimming layers were presumed to be 50 to 70 m deep for yellowfin and bigeye. Presented charts of the seasonal variation in the depth of the layers for the species considered.

KEY WORDS: tuna, yellowfin, bigeye, temperature, depth, habitat, season.

Nakagome, J. 1969. On the cause of annual variation of albacore catch in the Coral and Tasman Seas - III. Monthly and annual variation of distribution of sea surface temperature. Bull. Jpn. Soc. Sci. Fish. 35:50-54.

Showed annual fluctuations of surface isotherms and from these inferred water mass locations.

KEY WORDS: tuna, albacore, distribution, season, temperature, water mass.

Nakagome, J., H. Tsuchiya, S. Suzuki, S. Tanaka, T. Sakakibara, and H. Honda. 1965. Age composition of Atlantic tunas related with distribution of water temperature and distance from land - I. Yellowfin tuna. Bull. Jpn. Soc. Sci. Fish. 31:97-100.

Age composition of fish was related to water temperature at the surface and at 500 m and to the distance from the continent.

KEY WORDS: tuna, yellowfin, age, temperature, depth.

Nakagome, J., H. Tsuchiya, S. Suzuki, S. Tanaka, T. Sakakibara and H. Honda. 1965. Age composition of Atlantic tunas related with distribution of water temperature and distance from land - II. Albacore. Bull. Jpn. Soc. Sci. Fish. 31:101-104.

Age composition was found to be related to water temperatures at the surface, 50 and 100 m, and to the distance from continents. Age of fish was younger in lower temperatures or near land; those in higher temperatures and farther offshore were older.

KEY WORDS: tuna, albacore, temperature, depth, age.

Nakamura, H. 1952. The tunas and their fisheries. U.S. Fish. Wildl. Serv., Spec. Sci. Rep. Fish. 82, 115 p. [Translated from Japanese by W.G. Van Campen.]

Contrasted waters of two currents with respect to tunas and billfishes. Separated areas at lat. 5°N, which is the approximate border between the North Equatorial Current and Equatorial Countercurrent. Catch rates for bigeye and spearfishes was hardly different in the two currents. Yellowfin catch rate in the north area was less than one-half that of the south area.

KEY WORDS: tuna, bigeye, yellowfin, oceanography, currents, catch.

Nakamura, H., and H. Yamanaka. 1959. Relation between the distribution of tunas and the ocean structure. [In Jpn., Engl. summ.] J. Oceanogr. Soc. Jpn. 15:143-149.

Hypothesized that the fishing grounds of different characters were formed with a close relation to the ocean current systems. Paper related the distribution and migration of tunas and ocean structure and found that tuna distributions could be used as an indicator of seasonal and annual variations of the ocean conditions.

KEY WORDS: tuna, albacore, bigeye, yellowfin, bluefin, oceanography, currents, temperature, season, catch, distribution.

Namias, J. 1973. Response of the equatorial countercurrent to the sub-tropical atmosphere. Science (Wash., D.C.) 181:1244-1245.

The strength of the Equatorial Countercurrent of the North Pacific and associated variations in sea surface temperatures at its eastern extremity off central America were related to the zonal wind flow in the remote subtropical atmosphere with lags of as much as eight months between the wind and temperature.

KEY WORDS: atmosphere, wind, temperature, currents.

Neill, W.H., R.K.C. Chang, and A. Dizon. 1976. Magnitude and ecological implications of thermal inertia in skipjack tuna, Katsuwonus pelamis (Linnaeus). Environ. Biol. Fish. 1:61-80.

Suggested that large thermal inertia and high rates of metabolism may pose ecological problems for skipjack tuna as they grow in body mass. This means that as size increases with age there are temperature areas that the fish can no longer tolerate. Authors hypothesized that an increased thermal inertia may be important in the perception of the weak horizontal gradients of temperature that characterize the high-seas habitat of skipjack tuna.

KEY WORDS: tuna, skipjack, thermal regulation, temperature, environment, behavior, fronts, migration.

Neill, W.H., E.D. Stevens, F.G. Carey, K.D. Lawson, N. Mrosovsky, and W. Frair. 1974. Thermal inertia versus thermoregulation in "Warm" turtles and tunas. Science (Wash., D.C.) 184:1005-1010.

Bluefin tuna are capable of thermal regulation.

KEY WORDS: tuna, bluefin, temperature, behavior.

Nelson, C.S. 1977. Wind stress and wind stress curl over the California Current. U.S. Dep. Commer., NOAA Tech. Rep. NMFS SSRF 714, 87 p.

Discussed implications of the flow of currents on the biological resources.

KEY WORDS: meteorology, wind, currents.

Noel, J., and J.-M. Stretta. 1975. Télédetection aérienne et stratégie de pêche. Peche Marit. 1167:416-418.

Reported location of fish shoals by their relation to aerially detected sea surface fronts.

KEY WORDS: tuna, fronts, remote sensing, temperature.

Okachi, I. 1963. Studies on the distribution and structure of the fish fauna in the Japan Sea by catch statisitics. 2. Supplement of seasonal distribution and fishing condition of the bluefin tuna. [In Jpn., Engl. summ.] Bull. Jpn. Sea Fish. Res. Lab. 11:9-21.

Considered seasonal variation in catch. Attributed the fall increase in catch as being due to transportation by the current under the influence of westerly winds.

KEY WORDS: tuna, bluefin, season, catch, migration, size/age, currents, wind.

Okiyama, M. 1974. Occurrence of the postlarvae of bluefin tuna, Thunnus thynnus, in the Japan Sea. Bull. Jpn. Sea Reg. Fish. Res. Lab. 25:89-97.

Three post-larval bluefin were captured and presumed to have been spawned in the Japan Sea. Case was considered unique and related to unusually warm-water conditions, and of no significance to stock.

KEY WORDS: tuna, bluefin, larvae, spawning, temperatures, stock.

Okiyama, M., and S. Ueyanagi. 1977. Larvae and juvenile of the Indo-Pacific dog-tooth tuna, Gymnosarda unicolor (Rüppell). Bull. Far Seas Fish. Res. Lab. (Shimizu) 15:35-50.

Described the development of larval and juvenile tunas. Included data on depth and temperature at capture. Presented some evidence of diurnal vertical migration. Spawning was evidenced over most of year.

KEY WORDS: tuna, dog-toothed, temperature, depth, season.

Owen, R.W., Jr. 1968. Oceanographic conditions in the northeast Pacific Ocean and their relation to the albacore fishery. U.S. Fish Wildl. Serv., Fish Bull. 63:503-526.

Described the physical-chemical environment encountered by albacore as they entered the fishery off Oregon and Washington. Discussed which conditions influenced the availability of the fish to the fishery. Annual variations recurred regularly and were altered only in degree. Annual variations were attributable to changes in the wind field, water discharge from rivers, and advection.

KEY WORDS: tuna, albacore, season, oceanography, currents, wind, upwelling, gradients, temperature, salinity, transparency.

Patzert, W.C., and M. Tsuchiya. 1974. Some ideas concerning the mechanism for El Nino. [Abstr.] P.V. 13 IUGG, IAPSO First Spec. Assembly, Melbourne, Jan. 1974, p. 118.

Discussed atmospheric and oceanographic mechanisms possibly leading to El Nino.

KEY WORDS: oceanography, meteorology, winds, currents, El Nino.

Pearcy, W.G. 1973. Albacore oceanography off Oregon -- 1970. Fish. Bull., U.S. 71:489-504.

Sudden changes were noted in fishing success, not attributable to any obvious oceanographic events. Postulated that albacore stayed in subsurface layers to prey on saury and thus were less available to surface gear.

KEY WORDS: tuna, albacore, catch, season, feed, temperature, salinity.

Quinn, W.H. 1972. Use of the Southern Oscillation in weather prediction. Appl. Meteorol. 11:616-628.

Use of newly available Easter Island records improved the forecasting of weather and lead time of the forecast of abnormally heavy equatorial rainfall.

KEY WORDS: meteorology, wind, weather, currents, Southern Oscillation index.

Quinn, W.H. 1974. Monitoring and predicting El Nino invasions. J. Appl. Meteorol. 13:825-830.

By monitoring the atmospheric pressure between two points he was able to develop a forecasting scheme for predicting El Nino 3 months in advance, and could anticipate the occurrence of El Nino 9 to 13 months in advance.

KEY WORDS: atmospheric pressure, El Nino.

Quinn, W.H., D.O. Zopf, K.S. Short, and R.T.W. Yang. 1978. Historical trends and statistics of the Southern Oscillation, El Nino, and Indonesian droughts. Fish. Bull., U.S. 76:663-678.

Defined and described El Nino and anti-El Nino-type events; and gave their characteristics. He used monthly mean values and anomalies from a weather record of 116-year extent to detect major changes. He discussed forecasting potential for predicting El Nino events.

KEY WORDS: oceanography, atmospheric pressure, Southern Oscillation index, history.

Radovich, J. 1961. Relationships of some marine organisms of the northeast Pacific to water temperature, particularly during 1957 through 1959. Calif. Dep. Fish Game, Fish Bull. 112, 62 p.

American Pacific coast waters prior to 1957 were of subnormal temperatures; 1957 began a period of warming lasting through at least 1959. Many southern marine species appeared north of their usual range and some spawned off southern California. Similar species intrusions were recorded in the past. He listed several abnormal northward occurrences of marine mammals and other biological anomalies.

KEY WORDS: tuna, albacore, temperature, distribution, migration, movement.

Radovich, J. 1963. Effects of water temperature on the distribution of some scombrid fishes along the Pacific coast of North America. In H. Rosa, Jr. (editor), Proceedings of the world scientific meeting on the biology of tunas and related species, La Jolla, California, U.S.A., 2-14 July 1962, p. 1459-1475. FAO Fish. Rep. 6.

A history of references to anomalous fish distributions off California and speculations on environmental causes. He argued for a direct relation between temperature and fish distribution rather than temperature as an index of other factors.

KEY WORDS: tuna, temperature, distribution, environment, currents.

Reid, J.L., Jr. 1962. Distribution of dissolved oxygen in the summer thermocline. J. Mar. Res. 20:138-148.

A summer subsurface maximum in oxygen occurred which was in excess of surface values by over 1 ml per liter. Seasonal variations in temperature accounted for the formation of the subsurface maximum in summer.

KEY WORDS: oceanography, oxygen, depth, thermocline, temperature, season.

Richards, W.J. 1969. An hypothesis on yellowfin tuna migrations in the eastern Gulf of Guinea. Cah. O.R.S.T.O.M., Ser. Oceanogr. 7:3-7.

Presented a conceptual model of migration for tropical Atlantic yellowfin: Adult yellowfin enter the Gulf of Guinea to spawn during the warm season. Larvae and juveniles remain there for about one year. That year class moves south to Angola and subsequently returns north to warm water. The movement takes place annually until the fish are over two years old, at which time they move westward into the central tropical Atlantic. During the warm season adults return to the Gulf of Guinea to spawn.

KEY WORDS: tuna, yellowfin, bluefin, skipjack, migration, spawning, temperature.

Roberts, P.E. 1974. Albacore off the north-west coast of New Zealand, February 1972. N.Z. J. Mar. Freshwater Res. 8:455-472.

Albacore were taken where surface temperatures were between 18.5° and 21.3°C and usually in blue water with bottom depths between 45 and 180 m. Fish were mainly 2- to 3-year olds. In 1970 and 1971 fish were taken in warmer waters than in 1972, probably due to a southward extension of the West Auckland Current. Although catch rates increased with increasing temperatures they were not interpreted as being related to the subsurface temperature structure. Little or no difference in thermocline depth or intensity was observed.

KEY WORDS: tuna, albacore, temperature, color/transparency, depth, age, season, currents, upwelling, thermocline.

Roden, G.I., and J.L. Reid, Jr. 1961. Sea surface temperature, radiation, and wind anomalies in the North Pacific Ocean. Rec. Oceanogr. Works Jpn. 6:36-52.

They discussed nonseasonal variations in sea surface temperature occurring in the oceans. These covered large areas and persisted 3 to 6 months on the average. The relation of temperature anomalies to wind and radiation anomalies was examined by cross correlation. Significant values were found in some cases, but were best restricted to certain times of the year and certain areas.

KEY WORDS: oceanography, temperature, wind, season, geography.

Rosa, H., Jr. (editor). 1963. Proceedings of the world scientific meeting on the biology of tunas and related species, La Jolla, California, U.S.A., 2-14 July 1962. FAO Fish. Rep. 6(2), 975 p.

Synopsis of each species; covers gross characteristics of geographic range and sometimes includes oceanographic features of ecological relationships.

KEY WORDS: tunas, geography, temperature, thermocline.

Rosa, H., Jr., and T. Laevastu. 1961. World distribution of tunas and tuna fisheries in relation to environment. _In_ J.C. Marr (editor), Pacific Tuna Biology Conference, 14-19 August, 1961, Honolulu, Hawaii, p. 34-35. U.S. Fish Wildl. Serv., Spec. Sci. Rep. Fish. 415.

Tuna aggregations are found in shallow thermocline, upwelling, current boundary and enrichment areas generated by islands, sea mounts, etc. Atmospheric factors influence oceanic dynamics and enhance the fish habitat. Bluefin and albacore are temperate and subtropical species often found associated with frontal zones and have a narrow optimal temperature range. Bigeye and yellowfin are pelagic in the equatorial current systems. Skipjack are warm temperate subtropical and tropical widely ranging species.

KEY WORDS: tunas, yellowfin, skipjack, bigeye, bluefin, albacore, environment, thermocline, depth, upwelling, currents, discontinuities, enrichment, meteorology.

Rothschild, B.J. 1966. Major changes in the temporal-spatial distribution of catch and effort in the Japanese longline fleet. In T.A. Manar (editor), Proceedings of the Governor's Conference on Central Pacific Fishery Resources. Honolulu-Hilo, February 28-March 12, 1966:91-126.

Statistical area blocks were used in discussions of the number or spatial changes by time for species and were too coarse to allow correlations with the environmental features and changes. Some broad trends were observed.

KEY WORDS: tunas, distribution, environment.

Royer, T.C. 1978. Ocean eddies generated by seamounts in the north Pacific. Science (Wash., D.C.) 199:1063-1064.

Eddies were observed north of Hawaii, 37 km in diameter and over 1,000 m in depth. Eddies possibly resulted from interaction of the North Pacific Current and sea mounts.

KEY WORDS: oceanography, depth, currents, eddies.

Saito, S. 1973. Studies on fishing of albacore, Thunnus alalunga (Bonnaterre) by experimental deep-sea tuna longline. Hokkaido Daigaku, Sapporo, Jpn. Mem. Fac. Fish. 21(2):107-184.

Results of hook rate by depth experiments: Albacore were most dense between 200 and 260 m and sometimes more dense between 280 and 300 m than in layers above 200 m. The paper deals mostly with design and operation of longline gear intended to fish deeper layers than conventional gear. Albacore occurrences coincided with a "discontinuous" surface against the low salinity water mass of the 200 to 400 m level.

KEY WORDS: albacore, depth, season, discontinuity.

Saito, S., K. Ishii, and K. Yoneta. 1970. Swimming depths of large sized albacore in the South Pacific Ocean - I. Fishing of albacore by a newly designed vertical longline. Jpn. Soc. Sci. Fish. 36(6):578-584.

A study of the swimming depths of albacore using a vertical longline. Results confirmed the hypothesis that albacore are among the deeper swimming tunas. Hook rates approximated 4.7-5.4% at 200-300 m and even 3.4% at 380 m.

KEY WORDS: tuna, albacore, depth, habitat.

Saito, S, and S. Sasaki. 1974. Swimming depth of large sized albacore in the South Pacific Ocean - II. Vertical distribution of albacore catch by an improved vertical longline. Bull. Jpn. Soc. Sci. Fish. 40(7):643-649.

Experimented on depth of catch with a vertical longline west of the Fiji Islands. Albacore highest hook rates were at 200 to 300 m, and at the 380 m layer they were higher than that at 150 m. Bluefin greatest catch rates were at 300 m and deeper; yellowfin greatest catch rates were at less than 200 to 300 m.

KEY WORDS: tuna, albacore, bluefin, yellowfin, depth, distribution, catch, habitat.

Samaylenko, V.S. 1970. The effect of wind and solar radiation upon the ocean. (Nature of the Peru Current). Oceanology 10(1):1-12.

A description is given of the major oceanographic and meteorological features off Chile and the Peru Current areas. He noted the stability of oceanic and atmospheric conditions and the long-term sameness of the region. He concluded that the role of insolation is insignificant on water temperature due to the persistant cloud cover. He showed a cool surface water layer not being due to advection but to vertical advection/upwelling of deep water to the surface. The main reason for a cool Peru Current is the divergence responding to the southeast tradewinds.

KEY WORDS: oceanography, currents, temperature, meteorology, winds.

Sandoval, T.E. 1971. The summer distribution of tuna in relation to the general oceanographic conditions off Chile and Peru. Bull. Far Seas Fish. Res. Lab. 5:23-88.

A general descriptive review of southeastern Pacific oceanography, currents, etc. Shows the distribution of numerous properties along the South American coast, all in relation to the abundance of yellowfin, albacore, bigeye, and marlin.

KEY WORDS: tuna, albacore, bigeye, yellowfin, catch, distribution, season, migration, oceanography, upwelling, fronts, water mass, temperature, salinity.

Sasaki, T. 1952. Skipjack fishing grounds and oceanographic conditions in the Northeastern sea area. U.S. Fish Wildl. Serv. Spec., Sci. Rep. Fish. 83, p. 1-21 [Transl. from Japanese by W.G. Van Campen.]

A tabulation of the temperature range of tuna catches by month in the local Japanese fishery. The main fishing grounds were within the favorable water temperatures of 20^{o} to 24^{o}C at the surface and especially at marked current boundaries where the isotherms clump.

KEY WORDS: tuna, skipjack, oceanography, temperature, currents, isotherms, boundaries.

Sato, T., S. Mishima, K. Shimazaki, and S. Yamamoto. 1964. On the oceanographical condition and the distribution of tuna fish in the Coral Sea in December, 1962. [In Jpn., Engl. summ.] Bull. Fac. Fish. Hokkaido Univ. 15(2):89-102.

Results from a training ship cruise. Observed a relation between the catch of tunas and current systems. Catches were larger north of a convergence. The authors concluded that albacore were in a southward migration and part of a northern population which spawns later in the region.

KEY WORDS: tuna, albacore, catch, oceanography, currents, convergence, temperatures, depth, salinity.

Schaefer, M.B. 1961. Tuna oceanography programs in the tropical central and eastern Pacific. Calif. Coop. Oceanic Fish. Invest. Rep. 8:42-44.

A brief review of the knowledge to date of tuna-oceanography in the specified area. There was a good correspondence between the abundance of tunas and production of organisms lower in the food chain, related to enrichment of the euphotic zone from below. At the extremes of their ranges--at least in the eastern tropical Pacific--there appeared to be a direct effect of temperature on tropical tunas. On a small scale, the fishes associated with sea surface temperature discontinuities or fronts.

KEY WORDS: tuna, yellowfin, skipjack, bigeye, albacore, oceanography, food, fronts, temperature, enrichment, water mass, convergence.

Schaefer, M.B., G.C. Broadhead, and C.J. Orange. 1962. Synopsis on the biology of the yellowfin tuna, *Thunnus* *(Neothunnus)* *albacares* (Bonnaterre) 1788 (Pacific Ocean). *In* H. Rosa, Jr. (editor), Proceedings of the world scientific meeting on the biology of tunas and related species, La Jolla, California, U.S.A., 2-14 July 1962, p. 538-561. FAO Fish. Rep. 6.

Studies indicated that temperature is an important ecological factor determining the distribution of adult tunas at the extremes of their range. Seasonal appearances off Baja California and northern South America followed the march of the isotherms. Within the range of temperature occupied, the most important determinant of abundance appeared to be food.

KEY WORDS: tuna, yellowfin, temperature, distribution, range, season, food.

Schell, I.I. 1965. The origin of possible prediction of the fluctuations in the Peru Current and Upwelling. J. Geophys. Res. 70(22):5529-5540.

A correlation of atmospheric forces and the El Nino phenomenon. Results indicated that the major controls of sea surface temperature and the strength of the Peru Current and Cape Horn Current, as well as upwelling over long time intervals and the development of El Nino, lie in the strength and convergence of the westerlies between long. 135°W and 90°W and lat. 35°S to 50°S and in the strength of the southerlies and southeasterlies along and inland from the coast linked to the westerlies.

KEY WORDS: meteorology, oceanography, sea surface temperature, currents, El Nino.

Seckel, G.R. 1963. Climatic parameters and the Hawaiian skipjack fishery. In H. Rosa, Jr. (editor), Proceediings of the world scientific meeting on the biology of tunas and related species, La Jolla, California, U.S.A., 2-14 July 1962, p. 1201-1208. FAO. Fish. Rep. 6.

Hawaiian skipjack peak catch periods each year (1951-61) coincide with summer cold advection periods. The time of initial warming reflects intensified dynamic processes which relate to the displacement of the oceanographic climate, which in turn influence the fishery.

KEY WORDS: tuna, skipjack, oceanography, climatology, currents, temperature, season, catch.

Seckel, G.R. 1964. Climatic oceanography and its application to the Hawaiian skipjack fishery. [Abstr.] Proc. Hawaiian Acad. Sci.: 39th Annual Meeting 1963-1964, p. 26.

Oceanographic conditions were used to predict the relative success of the Hawaiian skipjack fishery.

KEY WORDS: tuna, skipjack, currents, boundaries, water mass, season, catch.

Seckel, G.R. 1972. Hawaiian-caught skipjack tuna and their physical environment. Fish. Bull., U.S. 72:763-787.

The author developed a numerical drift model to examine the contribution of currents to the travel (drift) of skipjack from the eastern North Pacific to Hawaii. He found that drift alone is a possible mode of travel in the North Equatorial Current; the time span of 21 to 23 months fits tagging data.

KEY WORDS: tuna, skipjack, larvae, currents, convergence/discontinuities.

Seckel, G.R., and M.Y.Y. Yong. 1977. Koko Head, Oahu, sea-surface temperatures and salinities, 1956-73, and Christmas Island sea-surface temperatures, 1954-73. Fish. Bull., U.S. 75:767-779.

A harmonic analysis of short and long-term variations in sea surface temperatures and sea surface salinities at the two stations.

KEY WORDS: oceanography, temperature, salinity, tuna, skipjack, distribution, migration.

Sette, O.E. 1955. Consideration of midocean fish production as related to oceanic circulatory systems. J. Mar. Res. 14(4):398-414.

A general discussion of mid-Pacific Ocean dynamics and bioproductivity climaxing with tunas. Divergence and convergence features provided the basic support for a persistant concentrated stock of yellowfin.

KEY WORDS: tuna, yellowfin, oceanography, upwelling, convergence, currents, depth, enrichment.

Sette, O.E. 1956. Nourishment of central Pacific stocks of tuna by the equatorial circulation system. Proc. Pac. Sci. Congr. 8(3):131-148.

An outline of hydrographic and exploratory fishing observations and preliminary results of Pacific Oceanic Fishery Investigations up to 1953. He described the effect of wind on ocean circulation in the tropcial band and presented a nonmathematical model of physical-dynamic processes leading to apex predators (tuna) production.

KEY WORDS: tuna, yellowfin, oceanography, wind, convergence/divergence, upwelling, nutrients, currents, food.

Sette, O.E. 1961. Problems in fish population fluctuations. Calif. Coop. Oceanic Fish. Invest. Rep. 8:21-24.

Discussed the philosophy of fisheries and oceanographic research.

KEY WORDS: oceanography, abundance, population.

Sharp, G.D. 1977. Potential vulnerability zones for skipjack and yellowfin in the Indian Ocean. Proc. 28th Tuna Conference. Lake Arrowhead, Calif. Oct. 3-4, 1977, p. 15-18.

Used monthly maps of the average distribution of "vulnerability zones" for yellowfin and skipjack in the Indian Ocean to examine the seasonal variation in location of potential zones to be occupied by the fish.

KEY WORDS: tuna, skipjack, yellowfin, distribution, habitat, oceanography, temperature, oxygen, depth.

Sharp, G.D. 1978. Behavioral and physiological properties of tunas and their effects on vulnerability to fishing gear. In G.D. Sharp and A.E. Dizon (editors), The physiological ecology of tunas, p. 397-449. Acad. Press, N.Y.

Using a background of physiological experimental data the oceanic environment suitable for the tuna habitat is described. Also considered is the effect of environment on susceptibility to capture.

KEY WORDS: tuna, yellowfin, albacore, skipjack, bigeye, bluefin, environment, habitat, oceanography, temperature, depth, fronts, distribution, migration, season, food, spawning, age/size, currents, wind.

Shimada, B.M. 1958. Geographical distribution of the annual catches of yellowfin and skipjack tuna from the eastern tropical Pacific Ocean from vessel logbook records, 1952-1955. Inter-Am. Trop. Tuna Comm. Bull. 2:289-363.

Discussed year to year variations in catch distributions in relation to oceanic circulation and nutrient supplies. Also considered the El Nino abnormal conditions and their influence on catch.

KEY WORDS: tuna, yellowfin, skipjack, oceanography, distribution, catch.

Shingu, C. 1970. Studies relevant to distribution and migration of southern bluefin. Bull. Far Seas Fish. Res. Lab. 3:57-114.

A history of the fishery, seasonal distribution and migration paths, and distribution by age class, with comments on stock and subgroup distribution. He described the fishes' distribution by month and area, and noted the spawning and migration grounds and catch relations to temperature-salinity diagrams for the different areas and ages of fish.

KEY WORDS: tuna, southern bluefin, catch, season, distribution, migration, spawning, temperature, salinity, age, environment.

Squire, J.L., Jr. Observations of albacore (Thunnus alalunga) fishing off California in relation to sea surface temperature isotherms as measured by an airborne infrared radiometer. Unpubl. manuscr. Southwest Fisheries Center La Jolla Laboratory, National Marine Fisheries Service, NOAA, P.O. Box 271, La Jolla, CA 92038.

Described the association discovered between albacore fishing and certain sea surface temperatures and temperature discontinuities.

KEY WORDS: tuna, albacore, catch, oceanography, temperature, color, transparency, fronts.

Steigner, J.M., and M.C. Ingham. 1971. Surface winds of the southeastern tropical Atlantic Ocean. U.S. Dep. Commer., NOAA Tech. Rep. NMFS SSRF-643, 20 p.

Authors infer that, given adequate information, wind data as a factor influencing the ocean surface layer can be used to predict the distribution of tuna schools. Wind speeds also directly impact fishing operations and can be used to generally outline potential areas and times of the year for fishing.

KEY WORDS: tuna, meteorology, winds, season, distribution.

Stevenson, M.R. 1970. On the physical and biological oceanography near the entrance of the Gulf of California, October 1966 - August 1967. [In Engl. and Span.] Inter-Am. Trop. Tuna Comm. Bull. 14:389-504.

Descriptive oceanography of the specified area based on data from "Mazatlan Project" (part of the EASTROPAC expedition series).

KEY WORDS: oceanography, temperature, salinity, depth, upwelling, currents, season.

Stretta, J.-M. 1977. Sea surface temperature measurements by aerial radiometry and tuna concentrations in the Gulf of Guinea. In G.H. Tomczak (editor), Environmental analyses in marine fisheries research--Fisheries Environmental Services, p. 62-65. FAO Fish. Tech. Pap. 170.

Described the operation for developing sea surface temperature and front maps from research vessels and aircraft for use in advisories to the tuna fleet. Used a mix of real-time data plus historical data and a model input for subsurface structure interpretations.

KEY WORDS: tuna, yellowfin, skipjack, oceanography, temperature, thermocline, depth, fronts, feed, enrichment.

Suda, A. 1956. Studies on albacore - III. Size compositions classified by ocean current. [In Jpn., Engl. abstr.] Bull. Jpn. Soc. Sci. Fish. 21(12):1194-1198.

Compared albacore size composition among several current areas and concluded that the evidence indicated that the various ocean currents presented an environment considerably different from each other for the tunas.

KEY WORDS: tuna, albacore, size, distribution, geography, oceanography, currents.

Suda, A. 1962. Studies on the albacore. 8. Ecological considerations on the albacore in the Philippine sea (Considerations on the movement of big sized albacore from distributing ground of immature group (North Pacific current area) to supposed spawning ground (North equatorial current area). [In Jpn., Engl. summ.]. Rep. Nankai Fish. Res. Lab. 16:127-34.

KEY WORDS: tuna, albacore, migration, spawning, geography, currents, season.

Suda, A., S. Kume, and T. Shiohama. 1969. An indicative note on a role of permanent thermocline as a factor controlling the longline fishing ground for bigeye tuna. Bull. Far Seas Fish. Res. Lab (Shimizu) 1:99-114.

This paper showed the important role of the permanent thermocline as a factor controlling the formation of longline grounds for bigeye tuna. Fishing success depended on whether the hooks reached the permanent thermocline in the tropics. An hypothesis was presented for catch locations of bigeye in tropical and temperate regions. Bigeye inhabited temperature zones within or just below the thermocline with no relation apparent to primary productivity. There was a notable increase in average size of fish from west to east.

KEY WORDS: tuna, yellowfin, bigeye, temperature, thermocline, depth, habitat, currents, water masses, enrichment, discontinuity.

Suda, A., and M.B. Schaefer. 1965. General review of the Japanese tuna longline fishery in the eastern Pacific Ocean, 1956-1962. Inter-Am. Trop. Tuna Comm. Bull. 9:307-462.

Considered Japanese longline catch data for the dated period with regard to fishing area and effort, catch, geographical and seasonal distributions, and indices of concentration. Apparent abundance was discussed in terms of seasonal changes, trends, and relation to fishing effort.

KEY WORDS: tuna, yellowfin, bigeye, albacore, catch, geography, season, abundance.

Suda, A., and T. Shiohama. 1962. Studies on the albacore. 7. Some considerations on the relationship between the distribution of albacore and the surface temperature in the longline fishing ground of the northwest Pacific. Rep. Nankai Fish. Res. Lab. 15:39-68.

Discussed the relation between the distribution of albacore and water temperatures on the longline grounds in the northwest Pacific.

KEY WORDS: tuna, albacore, season, catch, distribution, oceanography, temperature.

Suda, A., and T. Shiohama. 1964. Albacore studies - 7. Surface water temperature and the distribution of albacore in the longline fishing grounds of the northwestern Pacific Ocean. In Symposium on Scombroid Fishes. Mar. Biol. Assoc. India, Mandapam Camp, Part 1, p. 529-564.

Concluded that the relationship of albacore with sea surface temperature changed with age/size, time (season) and area in a complex manner and that a complex of factors determined the actual distributional relations of the fish.

KEY WORDS: tuna, albacore, distribution, season, age/size, sea surface temperature.

Sullivan, C.M. 1954. Temperature reception and responses in fish. J. Fish. Res. Board Can. 11:153-170.

Reviewed laboratory and field observations on the temperature response in fishes.

KEY WORDS: temperature, migration.

Suzuki, Z., P.K. Tomlinson, and M. Honma. 1978. Population structure of Pacific yellowfin tuna. [In Engl. and Span.] Inter-Am. Trop. Tuna Comm. Bull. 17:277-441.

Considered spawning activity migration, distribution, and habitat of yellowfin in the Pacific. Gave evidence for existence of three stocks: western, central, and eastern.

KEY WORDS: tuna, yellowfin, spawning, distribution, migration, stock, habitat.

Suzuki, Z., Y. Warashina, and M. Kishida. 1977. The comparison of catches by regular and deep tuna longline gears in the western and central equatorial Pacific. Bull. Far Seas. Fish. Res. Lab. (Shimizu) 15:51-90.

A comparison was made of catch by conventional gear versus deep gear and catch by species. The target species was bigeye tuna for which hook rates improved with deeper set hooks, while rates of other species declined.

KEY WORDS: yellowfin, albacore, bigeye, depth, season, distribution, catch, temperature, thermocline, habitat.

Symposium on Scombroid Fishes, Parts I-IV. 1964-1967. Mar. Biol. Assoc. India, Mandapam Camp, Jan. 12-15, 1962.

Papers presented at a 1962 meeting on subjects including systematics, stocks, early life history, food and feeding, parasites, fishing and fisheries, and environmental considerations.

KEY WORDS: see annotation.

Symposium on Tuna Resources and Oceanography, June 1963. Tokyo, Japan. Tuna Fishing 15(99), 33 p. Nat. Tuna Res. Counc. I. [Translated by James H. Shohara; Transl. No. 9. Bur. Comm. Fish. 1964.]

A conference of science and industry representatives to discuss their experiences regarding tuna resources and oceanogrpahy. No formal papers, but some graphic data were presented. Included the historical summary of Japanese tuna research.

KEY WORDS: tuna, albacore, yellowfin, skipjack, bigeye, bluefin, distribution, abundance, catch, size.

Titov, V.B. 1977. On meandering of the Cromwell Current. Oceanology 17(3):271-273.

Meandering of equatorial currents was investigated on the basis of the theory of inertial motions near the equator. New experimental data on the meandering of the Cromwell Current were presented. Author established the relationship between the phase of the meander and the change in the absolute value of current velocity.

KEY WORDS: currents.

Tomczak, G.H. 1977. Environmental advice to French albacore fishery in the North Atlantic Ocean. In G.H. Tomczak (editor), Environmental analysis in marine fisheries research--Fisheries Environmental Services, p. 56-61. FAO Fish. Tech. Pap. 170.

Described a service to the French albacore fishery of weather and sea state forecasts.

KEY WORDS: tuna, albacore, catch, season, distribution, temperature, fronts.

Troup, A.J. 1965. The "Southern Oscillation." Q. J. R. Meteorol. Soc. 91:490-506.

Described the Southern Oscillation, its operation in time and space, and the physical process by which it comes about.

KEY WORDS: meteorology, atmospheric pressure, Southern Oscillation index.

Tsuchiya, M. 1970. Equatorial Circulation of the South Pacific. In Scientific exploration of the South Pacific, p. 69-74. Stand. Book 309-01755-6.

Discussed and summarized each of several currents from the equator to the Antarctic convergence giving a description and characteristics for each one; geographic extent, transport, etc.

KEY WORDS: currents, oceanography, convergence/divergence.

Uda, M. 1952. On the relation between the variation of the important fisheries conditions and the oceanographical conditions in the adjacent waters of Japan, 1. J. Tokyo Univ. Fish. 38(3):363-389.

Discussed herring sardine, and tuna fishery variations in relation to variations in the interannual climatic environment. Cited historical events in the Japanese tuna fishery in relation to oceanographic features and events.

KEY WORDS: tuna, bluefin, yellowfin, oceanography, currents, boundaries, convergence/divergence, water mass, season, upwelling, temperature, atmosphere, wind.

Uda, M. 1961. Cyclical fluctuations of the Pacific tuna fisheries in response to cold and warm water intrusions. In J.C. Marr (editor), Pacific Tuna Biology Conference, August 14-19, 1961, Honolulu, Hawaii, p. 39. U.S. Fish Wildl. Serv., Spec. Sci. Rep. Fish. 415.

Abstract only. Related tuna fishing results to cold- and warm-water variations. Postulated an inverse relation between skipjack catch on the Japanese side and that on the American side of the Pacific. Catches varied as did temperature on the two sides of the ocean. Bluefin catches were noted to decline with cold-water intrusions and to increase with warming.

KEY WORDS: tuna, skipjack, bluefin, temperature, currents, upwelling, fronts, enrichment, meteorology, migration, catch.

Uda, M. 1961. Fisheries oceanography in Japan, especially on the principles of fish distribution, concentration, dispersal and fluctuation. Calif. Coop. Oceanic Fish. Invest. Rep. 8:25-31.

Described the range of temperature for a number of organisms and summarized the ecological principles which seem to influence or regulate localizations and processes which act to influence suitable or nonsuitable conditions for fishing.

KEY WORDS: tuna, bluefin, albacore, bigeye, skipjack, yellowfin, oceanography, temperature, fronts, convergences, enrichment, feed, migration, spawning, currents, wind.

Uda, M. 1974. Fishery oceanography of the western Pacific: application of oceanographic information to forecast natural fluctuations in the abundance of certain commercially important fish stocks. Proc. Indo-Pac. Fish Counc. 15(3):56-65.

Brief review of knowledge of several species of commerical importance in the western Pacific and a discussion of the effects of environmental changes and fishing intensity on the stocks.

KEY WORDS: tunas skipjack, yellowfin, albacore, bigeye, bluefin, catch, temperature.

Uda, M., and M. Ishino. 1958. Enrichment pattern resulting from eddy systems in relation to fishing grounds. J. Tokyo. Univ. Fish. 44(1+2):105-129.

Classified environmental patterns resulting from eddy systems into three types and related these to commercial fishing situations. Model experiements are described.

KEY WORDS: oceanography, discontinuity, eddies, fronts, currents, water masses, upwelling, enrichment, food.

Ueyanagi, S. 1969. Observations on the distribution of tuna larvae in the Indo-Pacific Ocean with emphasis on the delineation of the spawning areas of albacore, <u>Thunnus alalunga</u>. Bull. Far Seas Fish. Res. Lab. 2:177-219.

Described the morphology and the vertical and geographical distribution of larval tuna species; delineated spawning areas, and mentioned depth and temperature at which larvae were taken.

KEY WORDS: tuna, yellowfin, skipjack, bigeye, bluefin, southern bluefin, albacore, spawning, season, temperature, depth, thermocline.

Ueyanagi, S. 1974. Larvae and postlarvae of tunas and billfishes - Identification methods, distribution, occurrence. [In Jpn.] Far Seas Fish. Res. Lab. (Shimizu), p. 1-35.

Geographic occurrences of larval tunas. Some figures include isotherms and/or location or current boundaries.

KEY WORDS: tuna, yellowfin, skipjack, albacore, bluefin, southern bluefin, larvae, distribution, currents, temperature.

VanCampen, W.G. 1952. Oceanographic conditions and the albacore fishery east of Cape Nojima. U.S. Fish Wildl. Serv., Spec. Sci. Rep. Fish. 77, 18 p.

Translation of Japanese article describing tuna fishing conditions in the 1930's. An apparent close relationship existed between the movement of isotherms of approximately 18°C and the movements of the fishing grounds. Grounds mainly occurred along current boundaries.

KEY WORDS: tuna, albacore, season, currents, temperature, migration, environment.

Waldron, K.D. 1962. Synopsis of biological data on skipjack Katsuwonus pelamis (Linnaeas) 1758 (Pacific Ocean). In H. Rosa, Jr. (editor), Proceedings of the world scientific meeting on the biology of tunas and related species, La Jolla, California, U.S.A., p. 695-748. FAO Fish. Rep. 6.

A generalized review of skipjack habitat.

KEY WORDS: tuna, skipjack, distribution, currents, temperature, El Nino.

Walsh, J.J. 1978. The biological consequences of interaction of the climatic, El Nino, and event scales of variability in the eastern tropical Pacific. Rapp. P.-V. Reun. Cons. Int. Explor. Mer 173:182-192.

An analysis of biological response to climatic, El Nino, and event scales of variability for the eastern tropical Pacific. Suggested that marine communities respond to global oscillations at climatic time scales by geographic relocation of their centers of abundance. Man's impact is superimposed upon natural stresses.

KEY WORDS: oceanography, meteorology, wind, temperature, atmospheric pressure, enrichment, feed.

Williams, F. 1970. Sea surface temperature and the distribution and apparent abundance of skipjack (Katsuwonus pelamis) in the eastern Pacific Ocean, 1951-1968. [In Engl. and Span.] Inter-Am. Trop. Tuna Comm. Bull. 15:231-281.

The paper contains a 20-year continuous plot of selected isotherms and skipjack occurrences along the Pacific coast of the Americas. Author reviewed the coastal oceanographic annual regime, and anomalies from 1949-68, plus usual seasonal trends and outstanding/noteworthy events in that period.

KEY WORDS: tunas, skipjack, temperature, distribution, abundance, catch, season, oceanography.

Williams, F. 1972. Consideration of three proposed models of the migration of young skipjack tuna (Katsuwonus pelamis) into the eastern Pacific Ocean. Fish. Bull., U.S. 70:741-762.

Three models proposed are: 1) active migration, 2) passive migration, and 3) gyral migration. Mechanisms and timing in all three models are dependent on oceanographic conditions and events in the central-east Pacific, which thus have a controlling effect on migration success.

Williams, K.F. 1977. Sea surface temperature maps to assist tuna fisheries off New South Wales, Australia. In G.H. Tomczak (editor), Environmental analysis in marine fisheries research--Fisheries Environmental Services, p. 38-55. FAO Fish. Tech. Paper 70.

Described an operational sea surface temperature mapping-advisory service to tuna fisherman and aerial spotters. Southern bluefin apparently were regulated in their distribution by sea surface temperature and thermal fronts along the southeast Australian coast.

KEY WORDS: tuna, southern bluefin, oceanography, temperature, fronts, season, migration, catch.

Wyrtki, H. 1964. The thermal structure of the eastern Pacific Ocean. Ergänz. Reihe A(8°), 6 Deut. Hydrogr. Zeit.

An analysis of the thermal structure and its seasonal variation in the eastern tropical Pacific Ocean.

KEY WORDS: oceanography, temperature, depth, season, thermocline, gradient.

Wyrtki, K. 1965. The thermal structure of the eastern Pacific Ocean. Deut. Hydrogr. Z. Ergänzungsh., 84 p.

Analysis of thermal structure and seasonal variations in the eastern Pacific using BT data. Features and variability of thermal structure made evident by the charted data were discussed.

KEY WORDS: currents, temperature, depth, season.

Wyrtki, K. 1965. The annual and semi-annual variation of sea surface temperature in the North Pacific Ocean. Limnol. Oceanogr. 10:307-313.

Monthly averages of sea surface temperatures for the period 1947 to 1960 are used to determine the amplitude and phase of annual and semi-annual thermal variations.

KEY WORDS: sea surface temperature, season.

Wyrtki, K., E. Stroup, W. Patzert, R. Williams, and W. Quinn. 1976. Predicting and observing El Nino. Science (Wash., D.C.):343-346.

Defined Southern Oscillation and presented a theory for mechanisms leading to El Nino. Described the 1975 oceanographic situation as compared with 1967 and 1968 regarding significant changes from El Nino conditions in the former year as a return to "normal."

KEY WORDS: Southern Oscillation, atmospheric pressure, currents, El Nino.

Yabe, H., S. Ueyanagi, and H. Watanabe. 1966. Studies on the early life history of bluefin tuna, _Thunnus thynnus_, and on the larva of the southern bluefin tuna, _T. maccoyi_. [In Jpn., Engl. summ.] _Rep. Nankai Reg. Fish._ Res. Lab. 23:95-129.

Described larvae and distribution of their occurrence in the western Pacific and Indian Oceans. The area in which they were distributed corresponded to areas of the Kuroshio Current and Kuroshio Countercurrent.

KEY WORDS: tuna, bluefin, southern bluefin, spawning, season, migration, temperature, thermocline, depth.

Yamanaka, H. 1956. Vertical structure of the ocean relevant to fishing conditions for albacore adjacent to 10°S in the western South Pacific. [In Jpn., Engl. summ.] Bull. Jpn. Soc. Sci. Fish. 21(12):1187-1193.

Discussed the vertical structure from research cruise data compared to albacore catch distribution for the various seasons. Postulated that hydrological fluctuations between years and areas may be negligible for the general locality considered.

KEY WORDS: tuna, albacore, currents, discontinuity, season, distribution, depth, catch, boundaries.

Yamanaka, H. 1962. Tunas and oceanic conditions. [In Jpn., Eng. abstr.] J. Oceanogr. Soc. Jpn. 20th Annu.:663-678.

Lists institutions participating in tuna and oceanography studies and considers types of investigations needed.

KEY WORDS: color, transparency, salinity, currents, water masses, productivity.

Yamanaka, H. 1969. Relation between the fishing grounds of tuna and the equatorial current system. [In Jpn., Engl. abstr.] Bull. Jpn. Soc. Fish Oceanogr., Spec. No., p. 227-230.

Discussed the relation between tuna distributions and currents, water type and thermal structure, productivity and equatorial circulation and structure, fluctuations of fisheries and oceanographic conditions.

KEY WORDS: yellowfin, bigeye, oceanography, water type, currents, temperature.

Yamanaka, H. and N. Anraku. 1961. Relations between the distribution of tunas and water masses of the North and South Pacific oceans west of 160°W. In J.C. Marr (editor), Pacific Tuna Biology Conference, August 14-19, 1961, Honolulu, Hawaii, p. 41-42. U.S. Fish. Wildl. Serv., Spec. Sci. Rep. Fish. 415.

Water masses were defined by the T-S relation, and an approximate relation is shown between the occurences of tunas and surface water types.

KEY WORDS: tunas, albacore, bigeye, yellowfin, oceanography, water masses, temperature, salinity, season.

Yamanaka, H., Y. Kurohiji, and J. Morita. 1966. General results of the investigation in the South Western Pacific Ocean by the fish-finder. [In Jpn., Eng. summ.] Rep. Nankai Reg. Fish. Res. Lab. (24):115-127.

A report of research vessel data on hydrography, eggs and larvae of yellowfin, and deep scattering layer studies. Yellowfin shoals were found distributed in correspondence with oceanographic structures; the swimming layer of yellowfin was above the depth of the thermocline.

KEY WORDS: tuna, yellowfin, skipjack, depth, habitat, distribution, oceanography, currents, thermocline, feed.

Yamanaka, H., J. Morita, and N. Anraku. 1969. Relation between the distribution of tunas and water types of the north and south Pacific Ocean. Bull. Far Seas Fish. Res. Lab. (Shimizu) 2:257-273.

Used the temperature-chlorinity relation to map distributions of numerous water types and then related those to tuna distributions. Some patterns emerged, but several dilemmas appeared.

KEY WORDS: tunas, albacore, bigeye, water masses, currents, catch, distribution, temperature, salinity, migration.

Yamanaka, I. 1978. Oceanography in tuna research. Rapp. P-V. Réun. Cons. Int. Explor. Mer 173:203-211.

A brief historical review and summary of the role of oceanography in the development of the world tuna fisheries; and the role of fisheries science in the study of oceanography. Considers known influences of oceanographic features and variables on tunas and on the fisheries.

KEY WORDS: tuna, distribution, catch, food, depth, habitat, stock, spawning, oceanography, currents, temperature, fronts, discontinuity, transparency, season, enrichment, upwelling, thermocline, water mass, water type.

Yamanaka, I., and H. Yamanaka. 1970. On the variation of the current pattern in the equatorial western Pacific Ocean and its relationship with the yellowfin tuna stock. Proc. 2nd CSK Symposium, Tokyo, 1970:527-533.

Oceanographic data from training cruises in the 1960's were used to delineate major current boundaries, meanders and eddies, and seasonal variations which were compared with fluctuations in boundaries of the currents and major climatic events. Yellowfin year classes were compared to the interannual variations.

KEY WORDS: tuna, yellowfin, environment, sea surface temperature, depth, currents, boundaries, season, catch.

Yoshida, H.O., and T. Otsu. 1962. Synopsis of biological data on albacore _Thunnus germo_ (Lacèpède), 1800 (Pacific and Indian Oceans). _In_ H. Rosa, Jr. (editor), Proceedings of the world scientific meeting on the biology of tunas and related species, La Jolla, California, U.S.A., 2-14 July, 1962, p. 274-318. FAO Fish. Rep. 6.

Synopsis includes geographic distribution of fish and temperatures of water inhabited. Fishing areas and depth ranges were related by season.

KEY WORDS: tuna, albacore, distribution, temperature, depth, season, currents, catch.

KEYWORD INDEX

(Note: Tuna species are entered under their common names, see page 1)

	Johnson, J. H. 1962
	Johnson, J. H. 1963
	Kawai, H. 1959
	Kawasaki, T. 1957
	Kawasaki, T. 1957
	Kawasaki, T. 1957
	Kawasaki, T., and Y. Aizawa 1956
	Kikawa, S., T. Shiohama, Y. Morita, and S. Kume 1977
	Laevastu, T., and H. Rosa, Jr. 1963
	Laurs, R. M., and R. J. Lynn 1975
	Laurs, R. M., and R. J. Lynn 1977
	Laurs, R. M., H. S. H. Yuen, and J. H. Johnson 1977
	Manar, T. A. (editor) 1966
	Matsumoto, W. M., and R. A. Skillman MS
	McGary, J. W., J. J. Graham, and T. Otsu 1960
	McKenzie, M. K. [1964?]
	Murphy, G. I., and R. S. Shomura 1972
	Nakagome, J. 1969
	Nakagome, J., H. Tsuchiya, S. Suzuki, S. Tanaka, T. Sakakibara, and H. Honda 1965
	Nakamura, H., and H. Yamanaka 1959
	Owen, R. W., Jr. 1968
	Pearcy, W. G. 1973
	Radovich, J. 1961
	Roberts, P. E. 1974
	Rosa, H., Jr., and T. Laevastu 1961
	Saito, S. 1973
	Saito, S., K. Ishii, and K. Yoneta 1970
	Saito, S., and S. Sasaki 1974
	Sandoval, T. E. 1971
	Sato, T., S. Mishima, K. Shimazaki, and S. Yamamoto 1964
	Schaefer, M. B. 1961
	Sharp, G. D. 1978
	Squire, J. L., Jr. MS
	Suda, A. 1956
	Suda, A. 1962
	Suda, A., and M. B. Schaefer 1965
	Suda, A., and T. Shiohama 1962
	Suda, A., and T. Shiohama 1964
	Suzuki, Z., Y. Warashina, and M. Kishida 1977
	Symposium on Tuna Resources and Oceanography June 1963
	Tomczak, G. H. 1977
	Uda, M. 1961
	Uda, M. 1974
	Ueyanagi, S. 1969
	Ueyanagi, S. 1974
	VanCampen, W. G. 1952
	Yamanaka, H. 1956
	Yamanaka, H., and N. Anraku 1961
	Yamanaka, H., J. Morita, and N. Anraku 1969
	Yoshida, H. O., and T. Otsu 1962
Area	Brown, R. P., and K. Sherman 1961
	Calkins, T. P. 1961
Atmosphere/Atmospheric Pressure/Pressure	Berlage, H. P. 1966
	Berlage, H. P., and H. J. DeBoer 1959
	Berlage, H. P., and H. J. DeBoer 1960
	Bjerknes, J. 1961
	Caviedes, C. N. 1973
	Favorite, F., and W. J. Ingraham, Jr. 1976
	Inter-American Tropical Tuna Commission 1974
	Miller, F. R., and R. M. Laurs 1975

	Namias, J. 1973 Quinn, W. H. 1974 Quinn, W. H., D. O. Zopf, K. S. Short, and R. T. W. Yang 1978 Troup, A. J. 1965 Uda, M. 1952 Walsh, J. J. 1978 Wyrtki, K., E. Stroup, W. Patzert, R. Williams, and W. Quinn 1976
Auxis	Klawe, W. L. 1963 Klawe, W. L., J. J. Pella, and W. S. Leet 1970
Behavior	Clemens, H. B., and W. L. Craig 1965 Dizon, A. E. 1977 Dizon, A. E., R. W. Brill, and H. S. H. Yuen 1978 Dizon, A. E., T. C. Byles, and E. D. Stevens 1976 Dizon, A. E., W. H. Neill, and J. J. Magnuson 1977 Dizon, A. E., E. D. Stevens, W. H. Neill, and J. J. Magnuson 1974 Neill, W. H., R. K. C. Chang, and A. Dizon 1976 Neill, W. H., E. D. Stevens, F. G. Carey, K. D. Lawson, N. Mrosovsky, and W. Frair 1974
Bigeye Tuna	Alverson, F. G., and C. L. Peterson 1963 Anonymous 1962 Blackburn, M. 1965 Enami, S., and T. Toyotaka 1954 Fox, W. W. 1971 Grandperrin, R. 1976 Hanamoto, E. 1974 Hanamoto, E. 1975 Hanamoto, E. 1976 Howard, G. V. 1963 Kamimura, T., and M. Honma 1963 Kikawa, S. 1957 Kume, S. 1963 Kume, S. 1969 Laevastu, T., and H. Rosa, Jr. 1963 LeGuen, J. C., F. Poinsard, and J. P. Troadec 1965 Manar, T. A. (editor) 1966 Matsumoto, W. M., and R. A. Skillman MS Meehan, J. M. 1965 Murphy, G. I., and R. S. Shomura 1972 Nakagome, J. 1958 Nakagome, J. 1958 Nakagome, J. 1958 Nakagome, J. 1958 Nakagome, J. 1960 Nakagome, J. 1960 Nakagome, J. 1965 Nakamura, H. 1952 Nakamura, H., and H. Yamanaka 1959 Rosa, H., Jr., and T. Laevastu 1961 Sandoval, T. E. 1971 Schaefer, M. B. 1961 Sharp, G. D. 1978 Suda, A., S. Kume, and T. Shiohama 1969 Suda, A., and M. B. Schaefer 1965 Suzuki, Z., Y. Warashina, and M. Kishida 1977 Symposium on Tuna Resources and Oceanography June 1963 Uda, M. 1961 Uda, M. 1974 Ueyanagi, S. 1969 Yamanaka, H. 1969 Yamanaka, H., and N. Anraku 1961

	Yamanaka, H., J. Morita, and N. Anraku 1969
Billfishes	deBuen, F. 1955
	deBuen, F. 1957
	Fox, W. W. 1971
	LeGuen, J. C., J. R. Donguy, and C. Henin 1977
Black Skipjack Tuna	Klawe, W. L. 1963
Bluefin Tuna (Northern Pacific)	Anonymous 1962
	Blackburn, M. 1965
	Fox, W. W. 1971
	Hester, F. J. 1961
	Howard, G. V. 1963
	Kikawa, S. 1957
	Laevastu, T., and H. Rosa, Jr. 1963
	Manar, T. A. (editor) 1966
	Nakamura, H., and H. Yamanaka 1959
	Neill, W. H., E. D. Stevens, F. G. Carey, K. D. Lawson, N. Mrosovsky, and W. Frair 1974
	Okachi, I. 1963
	Okiyama, M. 1974
	Richards, W. J. 1969
	Rosa, H., Jr., and T. Laevastu 1961
	Saito, S., and S. Sasaki 1974
	Sharp, G. D. 1978
	Symposium on Tuna Resources and Oceanography June 1963
	Uda, M. 1952
	Uda, M. 1961
	Uda, M. 1961
	Uda, M. 1974
	Ueyanagi, S. 1969
	Ueyanagi, S. 1974
	Yabe, H., S. Ueyanagi, and H. Watanabe 1966
Bottom Features	Blackburn, M. 1969
Boundaries	Kikawa, S. 1957
	Sasaki, T. 1952
	Seckel, G. R. 1964
	Uda, M. 1952
	Yamanaka, H. 1956
	Yamanaka, I., and H. Yamanaka 1970
Bullet Tuna	Klawe, W. L. 1963
	Klawe, W. L., J. J. Pella, and W. S. Leet 1970
Catch	Alverson, D. L. 1961
	Alverson, F. G. 1959
	Anonymous 1962
	Calkins, T. P. 1961
	Clemens, H. B., and W. L. Craig 1965
	Davidoff, E. B. 1969
	Forsbergh, E. D. 1969
	Green, R. 1967
	Hanamoto, E. 1974
	Hanamoto, E. 1975
	Hanamoto, E. 1976
	Hester, F. J. 1961
	Inoue, M. 1960
	Inoue, M. 1961
	Inter-American Tropical Tuna Commission 1976
	Inter-American Tropical Tuna Commisison 1977

	Johnson, J. H. 1961
	Johnson, J. H. 1962
	Johnson, J. H. 1963
	Johnson, J. H., and G. R. Seckel 1976
	Kamimura, T., and M. Honma 1963
	Kanagawa Prefectural Fisheries Experimental Station 1952-1956
	Kanagawa Prefectural Fisheries Experimental Station 1961
	Kawasaki, T. 1957
	Kawasaki, T. 1957
	Kawasaki, T. 1965
	Kawasaki, T. 1967
	Kume, S. 1969
	LeGuen, J. C., F. Poinsard, and J. P. Troadec 1965
	Manar, T. A. (editor) 1966
	Miller, F. R. MS
	Miyake, M. P. 1968
	Morita, T. 1959
	Morita, T. 1960
	Nakagome, J. 1958
	Nakagome, J. 1960
	Nakagome, J. 1960
	Nakamura, H. 1952
	Nakamura, H., and H. Yamanaka 1959
	Okachi, I. 1963
	Pearcy, W. G. 1973
	Saito, S., and S. Sasaki 1974
	Sandoval, T. E. 1971
	Sato, T., S. Mishima, K. Shimazaki, and S. Yamamoto 1964
	Seckel, G. R. 1963
	Seckel, G. R. 1964
	Shimada, B. M. 1958
	Shingu, C. 1970
	Squire, J. L., Jr. MS
	Suda, A., and M. B. Schaefer 1965
	Suda, A., and T. Shiohama 1962
	Suzuki, Z., Y. Warashina, and M. Kishida 1977
	Symposium on Tuna Resources and Oceanography June 1963
	Tomczak, G. H. 1977
	Uda, M. 1961
	Uda, M. 1974
	Williams, F. 1970
	Williams, K. F. 1977
	Yamanaka, H. 1956
	Yamanaka, H., J. Morita, and N. Anraku 1969
	Yamanaka, I. 1978
	Yamanaka, I., and H. Yamanaka 1970
	Yoshida, H. O., and T. Otsu 1962
Chlorinity (Salinity)	Nakagome, J. 1958
Circulation	Blackburn, M. 1963
Climate	Cushing, D. H., and R. R. Dickson 1976
	Johnson, J. H. 1963
	McGowan, J. A. 1974
Climatology	Forsbergh, E. D. 1969
	Seckel, G. R. 1963
Color/Transparency	Blackburn, M. 1965
	Blackburn, M. 1969
	Laevastu, T., and H. Rosa, Jr. 1963
	McKenzie, M. K. [1964?]

Owen, R. W., Jr. 1968
Roberts, P. E. 1974
Squire, J. L., Jr. MS
Yamanaka, H. 1962
Yamanaka, I. 1978

Concentration

Hanamoto, E. 1975

Convergence/Divergence (Discontinuity)

Alverson, D. L. 1961
Blackburn, M. 1965
Creswell, G. R. 1976
Cromwell, T. 1958
Garvine, R. W. 1974
Inoue, M. 1960
Inter-American Tropical Tuna Commission 1973
Jerlov, N. G. 1953
Jerlov, N. G. 1956
Johnson, J. H., and G. R. Seckel 1976
Kawasaki, T. 1957
Kume, S. 1963
Laurs, R. M., and R. J. Lynn 1975
LeGuen, J. C., J. R. Donguy, and C. Henin 1977
Matsumoto, W. M., and R. A. Skillman MS
McKenzie, M. K. [1964?]
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	Yamanaka, I. 1978
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Broadhead, G. C., and I. Barrett 1964
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Schaefer, M. B., G. C. Broadhead, and C. J. Orange 1962
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Sette, O. E. 1956
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Shimada, B. M. 1958
Stretta, J. M. 1977
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Uda, M. 1974
Ueyanagi, S. 1969
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Yamanaka, H. 1969
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