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AN ANNOTATED BIBLIOGRAPHY OF THE ECOLOGY OF CO-OCCURRING TUNAS (*Katsuwonus pelamis*, *Thunnus albacares*) AND DOLPHINS (*Stenella attenuata*, *Stenella longirostris* and *Delphinus delphis*) IN THE EASTERN TROPICAL PACIFIC

Sandra D. Hawes

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U.S. DEPARTMENT OF COMMERCE
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AN ANNOTATED BIBLIOGRAPHY OF THE ECOLOGY OF CO-OCCURRING TUNAS (KATSUWONUS PELAMIS, THUNNUS ALBACARES) AND DOLPHINS (STENELLA ATTENUATA, STENELLA LONGIROSTRIS AND DELPHINUS DELPHIS) IN THE EASTERN TROPICAL PACIFIC

by

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INTRODUCTION

This bibliography was compiled to provide a source of information on the ecology of the co-occurring tunas and dolphins in the Eastern Tropical Pacific (ETP). While some of the articles give information concerning distribution and ecology of tunas and dolphins in other geographic areas, the primary focus is upon the tunas and dolphins that occur together in the ETP.

The bibliography has been divided into subject headings with articles arranged alphabetically by author. Although some references may fall under more than one subject heading, the compiler has placed each reference within the most relevant category. Subject categories include: 1) the tuna-dolphin bond, 2) feeding habits of tuna, 3) feeding habits of dolphins, 4) factors affecting the distribution of tuna, 5) factors affecting the distribution of dolphins, 6) biology of tuna and dolphin prey, 7) productivity of the ETP, and 8) physical oceanography of the ETP.

Annotations of the cited papers were extracted by the compiler from the text and/or an abstract of the article. The compiler assumes responsibility for the inclusions, omissions, and comments made in the bibliography.

TUNA-DOLPHIN BOND

ALLEN, R. L. 1981. Dolphins and the purse seine fishery for yellowfin tuna. Inter-Am. Trop. Tuna Comm., Internal Rep. No. 16, 23 pp. 1a

A description of the tuna fishery and its impact on dolphin populations, including general characteristics of tuna schools associated with dolphins or floating objects. Management of the tuna-dolphin complex is also discussed.

HAMMOND, P. S. (ed.) 1981. Report on the workshop on tuna-dolphin interactions. Inter-Am. Trop. Tuna Comm., Spec. Rep. No. 4, 259 pp. 1b

Edited version of the discussions of the workshop presented as a single contribution prepared by IATTC staff. The report discusses dolphin distribution and stocks, dolphin life history, dolphin abundance, tuna-dolphin interactions, and management of the tuna-dolphin complex.

PERRIN, W. F. 1968. The porpoise and the tuna. Sea Frontiers 14(3):166-174. 1c

Description of procedure for catching dolphin-associated tuna with purse seiners. Several hypotheses explaining the tuna-dolphin bond are discussed: (1) feeding relationships between tuna and dolphin (2) protection of tuna from shark attacks, and (3) spatial orientation of tuna.

PERRIN, W. F. 1969. Using porpoise to catch tuna. World Fishing 18(6):42-45. 1d

Description of purse seine fishing for tuna (Thunnus albacares and Katsuwonus pelamis) associated with dolphins (Stenella longirostris and S. graffmani = S. attenuata) in the eastern Pacific. A food-based relationship is suggested as the cause of the tuna-dolphin association.

STUNTZ, W. E. 1981. The tuna-dolphin bond, a discussion of current hypotheses. Southwest Fisheries Center Admin. Report No. LJ-81-19, 9 pp. 1e

Six hypotheses are presented as possible explanations for the tuna-dolphin bond: (1) contagious distribution, (2) innate schooling behavior, (3) predator avoidance, (4) cover seeking, (5) orientation to a site, (6) food finding.

FEEDING HABITS OF TUNA

ALVERSON, F. G. 1961. Daylight surface occurrence of myctophid fishes off the coast of Central America. Pac. Sci. 15(3):483. 2a

On three separate occasions schools of the myctophid Benthosema pterota were observed on the surface during daylight hours by tuna clippers. On two of the three occasions the schools of the myctophid were being fed upon by skipjack tuna, yellowfin tuna, or sea birds.

ALVERSON, F. G. 1963. The food of yellowfin and skipjack tunas in the eastern tropical Pacific Ocean. Inter-Amer. Trop. Tuna Comm., Bull. 7(5):293-396. 2b

Stomach contents of yellowfin and skipjack tuna were analyzed in terms of volume and frequency of occurrence of forage species. Importance of food items by volume for yellowfin was fish (47%), crustacea (45%) and cephalopods (8%). Food items in terms of frequency of occurrence were crustacea (76%), fish (54%) and cephalopods (33%). A similar analysis of skipjack stomach contents

revealed importance of food by volume to be crustaceans (59%), fish (37%) and cephalopods (3%). Analysis by frequency of occurrence revealed crustaceans (76%), fish (36%), and cephalopods (13%).

BLACKBURN, M. 1968. Micronekton of the eastern tropical Pacific Ocean: family composition, distribution, abundance, and relations to tuna. U. S. Fish. and Wildl. Serv., Fish. Bull., U. S. 67:71-115. 2c

The taxonomic composition and distribution of micronekton (fishes, crustaceans, and cephalopods, 1 to 10 cm) were studied from catches of night net hauls in the upper 90 m in the eastern tropical Pacific Ocean. Agreement on fish family composition was poor between the net catches and the stomach contents of yellowfin tuna (Thunnus albacares) and skipjack tuna (Katsuwonus pelamis) from the same areas; agreement between catches and stomach samples was fair for crustaceans.

BLUNT, C. E. 1960. Observations on the food habits of longline-caught bigeye and yellowfin tuna from the tropical eastern Pacific 1955-1956. Calif. Dep. Fish Game, Fish Bull. 46(1):69-80. 2d

Most yellowfin tuna analyzed for food habits were captured off Costa Rica, while the bigeye tuna were captured near the equator. Stomach contents were analyzed in terms of total volume and percent frequency of occurrence. The food items most important to both tuna species were fish, squid, and portunid crabs. Importance of the three prey items varied between species and between frequency of occurrence versus total volume.

COLE, J. S. 1980. Synopsis of biological data on the yellowfin tuna, Thunnus albacares (Bonnaterre, 1788), in the Pacific Ocean. p. 71-150. In: W. H. Bayliff (ed.). Synopses of biological data on eight species of scombrids. Inter-Am. Trop. Tuna Comm., Spec. Rep. No. 2. 2e

A review of information on the identity, distribution, bionomics, life history, population, exploitation, protection and management, and culturing of yellowfin tuna.

FORSBERGH, E. D. 1980. Synopsis of biological data on the skipjack tuna, Katsuwonus pelamis (Linnaeus, 1758), in the Pacific Ocean. p. 295-360. In: W. H. Bayliff (ed.). Synopses of biological data on eight species of scombrids. Inter-Am. Trop. Tuna Comm., Spec. Rep. No. 2. 2f

A review of information on the identity, distribution, bionomics, life history, population, exploitation, protection and management, and culturing of skipjack tuna.

HIDA, T. S. 1973. Food of tunas and dolphins (Pisces: Scombridae and Coryphaenidae) with emphasis on the distribution and biology of their prey *Stolephorus buccaneeri* (Engraulidae). *Fish. Bull., U. S.* 71(1):135-143. 2g

Examination of stomach contents of tunas and dolphins caught by live-bait pole-and-line fishing and trolling in the equatorial Pacific and around the islands of Samoa. Fishes (e.g., *Stolephorus buccaneeri*), crustaceans, and molluscs were found to be important food items. Distribution, size, fecundity, and stomach contents of *S. buccaneeri* were also analyzed.

JUHL, R. 1955. Notes on the feeding habits of subsurface yellowfin and bigeye tunas of the eastern tropical Pacific Ocean. *Calif. Dep. Fish Game, Fish Bull.* 41(1):99-101. 2h

Results of studies of the stomach contents of 10 yellowfin tuna and 5 bigeye tuna caught by longline fishing. Nine of the fifteen stomachs contained fish and squid, and eight stomachs contained crabs. By volume, 57.8 percent of the total contents of the entire sample was fish; 27.2 percent, squid; and 15.0 percent, crabs.

INTER-AMERICAN TROPICAL TUNA COMMISSION. 1978. Yellowfin feeding habits study. *Inter-Am. Trop. Tuna Comm., Bi-Monthly Rep.*, July-August, 10-15. 2i

Diversity analysis of stomach samples of yellowfin tuna in the eastern Pacific. Samples taken during 1970 and 1971 show an overview of the diversity and importance of fish, cephalopods, and crustaceans ingested in the offshore areas.

INTER-AMERICAN TROPICAL TUNA COMMISSION. 1979. Feeding habits of yellowfin. *Inter-Am. Trop. Tuna Comm., Annu. Rep.* 1978: 34-37. 2j

Fish known to be common prey of yellowfin tuna were collected. Their caloric value was measured in order to estimate the amount of energy available to a tuna on a daily basis.

INTER-AMERICAN TROPICAL TUNA COMMISSION. 1980. Feeding habits of yellowfin. *Inter-Am. Trop. Tuna Comm., Annu. Rep.*, 1979: 43-46. 2k

A continuation of work by the IATTC on identifying food organisms found in stomach samples of yellowfin tuna caught in offshore areas. Families of prey new since IATTC Annual Report 1978 are reported (i.e., Acanthundae and Molidae). A small study was also conducted to investigate the possibility of using information from stomach samples to estimate metabolic rates of tunas at normal activity levels in nature.

KING, J. E., and I. I. IKEHARA. 1956. Comparative study of food of bigeye and yellowfin tuna in the central Pacific. *U. S. Fish and Wildl. Serv., Fish. Bull.* 57:61-85. 21

Stomach contents of longline-caught bigeye and yellowfin tuna were analyzed 1) to determine whether feeding differences occur that are associated with the horizontal and vertical distribution of these fish, and 2) to obtain information on food preferences of each fish which may be useful to the commercial fishery.

MAGNUSON, J. J. 1969. Digestion and food consumption by skipjack tuna (*Katsuwonus pelamis*). *Trans. North Am. Fish. Soc.* 98(3):379-392. 2m

Feeding experiments on skipjack held in captivity. Food consumption by skipjack was examined in relation to the quantity of food material in their stomach in three experiments: (1) fish fed at different intervals after a meal (2) fish fed at 15-minute intervals throughout the day (3) fish fed over time and their response to food as their stomachs filled. The results are discussed in relation to the effects of satiation of the food drive on pole-and-line fishing, and the relation between feeding motivation and quantity of food in the stomach.

MAGNUSON, J. J., and J. G. HEITZ. 1971. Gill-raker apparatus and food selectivity among mackerels, tunas, and dolphins. *Fish. Bull., U. S.* 69(2):361-370. 2n

Gill-raker morphology and fork length were measured for 411 fish, representing 8 species of scombrids and 2 species of coryphaenids. Mean gill-raker gaps were compared with the percentage of crustaceans in stomachs of central Pacific fishes based on literature records. Presence of euphausiids in stomachs of *Katsuwonus pelamis* and their absence in *Thunnus albacares* may have resulted from the small size of euphausiids and the smaller gill-raker gaps of *K. pelamis* relative to *T. albacares*.

REINTJES, J. W., and J. E. KING. 1953. Food of yellowfin tuna in the central Pacific. *U. S. Fish and Wildl. Serv., Fish. Bull.* 54:91-110. 2o

Collections of surface-caught tuna (trolling or live bait) and longline-caught tuna obtained during the Pacific Oceanic Fishery Investigation cruise. Stomach contents of both groups were analyzed in relation to several variables, i.e., stomach volume, diversity of prey organisms and morning versus afternoon catch.

SCHAEFER, M. B., G. C. BROADHEAD, and C. J. ORANGE. 1963. 2p
Synopsis on the biology of yellowfin tuna Thunnus (Neothunnus) albacares (Bonnaterre) (Pacific Ocean). Proceedings of the World Scientific Meeting on the Biology of Tuna and Related Species, FAO Fish. Rep. 6(3):539-561.

Detailed information on taxonomy, distribution, biometrics and life history, population dynamics, and exploitation of yellowfin tuna. Includes information on feeding of yellowfin larvae and adults.

SHARP, G. D., and R. C. FRANCIS. 1976. An energetics model for 2q
the exploited yellowfin tuna, Thunnus albacares, population in the eastern Pacific Ocean. Fish. Bull., U. S. 74(1):36-50.

Development of an energy-budget model used 1) to assess the energy flow through the exploited yellowfin tuna population, and 2) to compare the estimated utilization of energy by yellowfin tuna with the estimated primary productivity in the Inter-American Tropical Tuna Commission's Yellowfin Regulatory Area (CYRA). Food appears to be the most probable source of population limitation in young tunas (<40cm), but not for the late juvenile or adult populations.

WALDRON, K. D. 1963. Synopsis of biological data on skipjack 2r
Katsuwonus pelamis (Linnaeus 1758) (Pacific Ocean). Proceedings of the World Scientific Meeting on the Biology of Tuna and Related Species, FAO Fish. Rep. 6(2):695-748.

Detailed information on taxonomy, distribution, bionomics and life history, population dynamics, and exploitation of the skipjack tuna. Includes information on feeding of skipjack tuna larvae and adults.

WALDRON, K. D., and J. E. KING. 1963. Food of skipjack in the 2s
central Pacific. Proceedings of the World Scientific Meeting on the Biology of Tuna and Related Species, FAO Fish. Rep. 6(3):1431-1457.

Examination of stomach contents of 707 skipjack tuna showed that by volume the food consisted of 74.6 percent fish, 19.9 percent molluscs, 3.7 percent crustaceans, and 3.7 percent unidentifiable remains. Larval and juvenile tuna, mostly skipjack, constituted a high percentage of the food of skipjack tuna.

YUEN, H.S.H. 1959. Variability of skipjack response to live bait. U. S. Fish and Wildl. Serv., Fish. Bull. 60:147-160. 2t

High variability in skipjack response to live bait was demonstrated during commercial fishing of 92 skipjack schools. Stomach contents were examined in relation to % volume of fish, molluscs and crustaceans. Factors causing the variation in biting response were also analyzed.

FEEDING HABITS OF DOLPHINS

FITCH, J. E., and R. L. BROWNELL, JR. 1968. Fish otoliths in cetacean stomachs and their importance in interpreting feeding habits. J. Fish. Res. Bd. Can. 25(12):2561-2574. 3a

Contents analysis of stomachs representing 7 species of cetaceans (including Stenella longirostris) in the eastern tropical Pacific yielded otoliths of many fish species. A family-by-family discussion of the habits of the fish represented by the otoliths is used to indicate feeding habits of the cetaceans.

LEATHERWOOD, S., and D. K. LJUNGBLAD. 1979. Nighttime swimming and diving behavior of a radiotagged spotted dolphin, Stenella attenuata. Cetology 34:1-6. 3b

A radiotagged Stenella attenuata was followed for 11 hours and its dive length, swimming speed, and diving patterns were noted. The major diving patterns were of 3 types: "running," "travelling or exploratory diving," and "feeding."

NORRIS, K. S., and T. P. DOHL. 1980. Behavior of the Hawaiian spinner dolphin. Stenella longirostris. Fish. Bull., U. S. 77(4):821-849. 3c

Analyses of school movements, structure, and rest areas were made using a variety of techniques including land, boat, and underwater observations. Daily cycle of dolphins consisted of nighttime feeding, morning approach to shore, morning-midday rest, and travel to feeding grounds near dusk. Feeding was upon scattering layer fishes, squid, and shrimp.

PERRIN, W. F., R. R. WARNER, C. H. FISCUS, and D. B. HOLTS. 1973. Stomach contents of porpoise, Stenella spp. and yellowfin tuna, Thunnus albacares in mixed species aggregations. Fish. Bull., U. S. 71(4):1077-1092. 3d

Analysis of stomach contents indicated that an ommastrephid squid (probably Dosidicus gigas) was the most important food item co-occurring in the tuna and dolphin's diet. In general, the results suggest that the tuna and spotted dolphins fed together largely on epipelagic prey, whereas the spinner dolphin fed deeper and at different times of the day. It was also found that only the tuna ate crustaceans.

SHOMURA, R. S., and T. S. HIDA. 1965. Stomach contents of a dolphin caught in Hawaiian waters. J. Mammal. 46(3):500-501. 3e

Stomach contents of a spotted dolphin, *Stenella attenuata*, caught 3 miles offshore in waters 180 fathoms deep were analyzed. Squids were the most abundant food item, comprising 86% of the total stomach volume. Myctophids were the most abundant of the fishes present, 6% of the total stomach volume.

FACTORS AFFECTING THE DISTRIBUTION OF TUNA

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(3):653-662. 4a

Experiments with captive skipjack tuna indicate that their habitat has more restricted boundaries within the warm surface layers of tropical and subtropical ocean than was thought previously. The boundaries seem to be defined by both temperature and dissolved oxygen levels.

BLACKBURN M. 1965. Oceanography and the ecology of tunas. Oceanogr. Mar. Biol., Annu. Rev. 3:299-322. 4b

Includes information on limits of spatial distribution, oceanic properties as determinants of distribution, and major temporal changes in distribution and abundance.

BLACKBURN, M. 1969. Conditions related to upwelling which determine distribution of tropical tunas off western Baja California. U. S. Fish and Wildl. Serv., Fish. Bull. 68(1):147-176. 4c

The hypothesis that tunas generally do not aggregate in waters cooler than 20°C, but do aggregate in warmer waters provided that suitable food is abundant, was supported in general by the results of oceanographic cruises made off Baja California.

BLACKBURN, M. 1976. Review of existing information on fishes in the Deep Ocean Mining Environmental Study (DOMES) area of the tropical Pacific. Univ. of Calif. Inst. Mar. Resour., Ref. No. 76.1. 4d

A review of information about commercial fisheries (including skipjack tuna and yellowfin tuna), and large epipelagic fish in non-commercial fishing.

BLACKBURN, M., AND ASSOCIATES. 1962. Tuna oceanography in the eastern tropical Pacific. *U. S. Fish and Wildl. Serv., Spec. Sci. Rep.-Fish.* (400), 48 pp. 4e

A presentation of field observations made on cruises in the eastern tropical Pacific. Physical, chemical, and biological measurements obtained on cruises were analyzed statistically in relation to the changes in the distribution and abundance of the yellowfin tuna (*Thunnus albacares*) and skipjack tuna (*Katsuwonus pelamis*).

BLACKBURN, M., and F. WILLIAMS. 1975. Distribution and ecology of skipjack tuna, *Katsuwonus pelamis*, in an offshore area of the eastern tropical Pacific Ocean. *Fish. Bull., U. S.* 73(2):382-411. 4f

A latitudinal sampling of skipjack individuals and environmental parameters in meridional areas considered critical to their migrations. Data on relative abundance of skipjack, and environmental variables (i.e., temperature, mixed layer depth, currents, zooplankton, and forage items) in relation to skipjack distribution were collected.

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.* 8:419-469. 4g

Presentation of the apparent abundance and distribution of yellowfin and skipjack tuna in relation to sea surface temperature and thermocline topography.

BROCK, V. E. 1959. The tuna resources in relation to oceanographic features. *U. S. Fish and Wildl. Serv., Circ.* 65:1-11. 4h

Description of the food relationships, oceanographic features, distribution, and spawning areas of oceanwide tuna. Some information on distribution and fisheries of yellowfin, skipjack, albacore, bigeye, and bluefin tunas is also included.

DIZON, A. E., R. W. BRILL, H.S.H. YUEN. 1978. Correlations between environment, physiology, and activity, and the effects on thermoregulation in skipjack tuna. p. 233-259 In: Gary D. Sharp and Andrew D. Dizon (eds.). The physiological ecology of tunas. Academic Press, New York. 4i

Coverage of three broad topics: 1) "real world" estimations of tuna performance based on data from free-swimming fish carrying depth-sensitive ultrasonic transmitters; 2) experiments relating behavioral responses to alterations of the environment; 3) interrelation of environment, behavior and physiology.

GREEN, R. E. 1967. Relationship of the thermocline to the success of purse seining for tuna. Trans. Am. Fish. Soc. 96(2):126-130. 4j

Bathythermograph casts made with fishing sets on tuna in the eastern tropical Pacific Ocean were examined for a relationship between fishing success and characteristics of the thermocline. Success was highest in thin mixed layers over thermoclines of sharp temperature gradients.

HIDA, T. S. 1970. Surface tuna schools located and fished in equatorial eastern Pacific. Commer. Fish. Rev. 32(4):34-37. 4k

Information was collected during a cruise between Hawaii and 700 miles southwest of Clipperton Island. Skipjack tuna schools, mixed tuna schools, and large bird flocks were encountered where few tuna schools had previously been reported.

KITCHELL, J. F., W. H. NEILL, A. E. DIZON, and J. J. MAGNUSON. 1978. Bioenergetic spectra of skipjack and yellowfin tunas. Pp. 357-368. In: Gary D. Sharp and Andrew D. Dizon (eds.). The physiological ecology of tunas. Academic Press, New York. 4l

An attempt to combine principles of bioenergetics with data from experimental and field studies to construct energy budgets for skipjack and yellowfin tunas, and thereby define their scope for growth. The goal of this work was to make a more coherent characterization of the growth process in tunas and identification of those physiological, behavioral, and/or ecological processes that have the greatest potential for improved understanding of tuna biology.

KLAWE, W. L. 1980. Classification of tunas, mackerels billfishes, and related species, and their geographical distribution. p. 5-16 In: W. H. Bayliff (ed.). Synopsis of biological data on eight species of scombrids. Inter-Am. Trop. Tuna Comm., Spec. Rep. No. 2. 4m

A presentation of the worldwide distribution of the species in the family scombridae.

LAEVASTU, T., and H. ROSA, Jr. 1962. Distribution and relative abundance of tunas in relation to their environment. Experience Paper No. 47, FAO Fish. Rep. 6(3):1835-1851. 4n

A presentation of the distribution and fishing areas of world-wide tuna in relation to temperature, depth, currents, transparency of water, food, submarine topography, and meteorological factors.

MAGNUSON, J. J., L. B. CROWDER, and P. A. MEDVICK. 1979. Temperature as an ecological resource. Am. Zool. 19:331-343. 4o

An analysis of temperature as an ecological resource rather than as a factor influencing the behavior and physiology of an animal. This paper reviews the response of fish to temperature in terms of ecological concepts related to the niche theory and competition as cited in the literature.

MURPHY, G. I., and I. I. IKEHARA. 1955. A summary of sightings of fish schools and bird flocks and of trolling in the central Pacific. U.S. Fish and Wildl. Serv., Spec. Sci. Rep.-Fish. No. 154, 19 pp. 4p

Evaluation of sightings of surface tuna schools and bird flocks observed on Pacific Oceanic Fishery Investigations (POFI) from 1950-1953. The observations are arranged to furnish comparisons between the vicinity of land and the open ocean, and to estimate variations in abundance associated with different times of the year.

MURPHY, G. I., and R. S. SHOMURA. 1972. Pre-exploitation abundance of tunas in the equatorial central Pacific. Fish. Bull., U. S. 70(3):875-913. 4q

An examination of the abundance of deep-swimming yellowfin tuna, and the distribution and abundance of surface tunas (skipjack and small yellowfin), in relation to various environmental factors. The data are based upon surveys by the Bureau of Commercial Fisheries from 1950-1953. Water circulation in the equatorial region is also described.

ROTHSCHILD, B. J. 1965. Hypotheses on the origin of exploited skipjack tuna (Katsuwonus pelamis) in the eastern and central Pacific Ocean. U. S. Fish and Wildl. Serv., Spec. Sci. Rep.-Fish., No. 512, 20 pp. 4r

Hypotheses formulated to account for the origin and movement of exploited groups of skipjack tuna in the eastern and central Pacific Ocean. The hypotheses take into account the available evidence on larval distributions, gonad indices, size distributions, tag recoveries, catch predictions, and immunogenetic studies. The evidence suggests that most skipjack taken by the eastern Pacific skipjack fisheries originate in the central Pacific.

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

A study of the equatorial current system, with attendant upwelling and increased numbers of zooplankton, in relation to concentrations of fish. Included in the study are yellowfin and skipjack tunas.

SHARP, G. D. 1978. Behavioral and physiological properties of tuna and their effect on vulnerability to fishing gear. pp. 397-449. In: Gary D. Sharp and Andrew D. Dizon (eds.). The physiological ecology of tunas. Academic Press, New York. 4t

An investigation of the changes in size (yield) of successful sets as a function of time of day, depth of the mixed layer, the depth of the 23°C isotherm and the 15°C isotherm, over a 6 month term in the specific case of yellowfin tuna.

SUND, P. N. 1981. Tunas, oceanography and meteorology of the Pacific, an annotated bibliography, 1950-78. NOAA Tech. Rep., SSRF No. 744, 123 pp. 4u

An annotation of papers on Pacific tunas, including environmental variables affecting tuna distributions and/or ecology, published between 1950 and 1978. Cross referenced key words are included.

SUND, P. N., M. BLACKBURN, and F. WILLIAMS. 1981. Tunas and their environment in the Pacific Ocean: a review. Oceanogr. Mar. Biol., Ann. Rev. 19:443-512. 4v

A thorough review of knowledge on tuna distribution in relation to bathymetry, seasonal variation, larval stage,

and a wide range of environmental factors. There is also a discussion on physiology and behavior in relation to the environment.

WALDRON, K. D. 1964. Fish schools and bird flocks in the central Pacific Ocean, 1950-1961. U.S. Fish and Wildl. Serv., Spec. Sci. Rep.-Fish. No. 464. 20 pp. 4w

A summary of the results of visual observations of bird flocks and fish schools made by biologists and fishermen aboard vessels of the Bureau of Commercial Fisheries Biological Laboratory in Honolulu from 1950 to 1961.

WILLIAMS, F. 1970. Sea surface temperature and the distribution and apparent abundance of skipjack (Katsuwonus pelamis) in the eastern Pacific Ocean, 1951-1968. Inter-Am. Trop. Tuna Comm., Bull. 15(2):231-281. 4x

Isograms of sea surface temperature (°C) have been produced for 1949-1968 for the areas of the eastern Pacific Ocean where the majority of the skipjack catch is taken. Skipjack occurrence and apparent abundance for 1951-1968 were then superimposed on the surface temperature isograms. Results show that skipjack occur at surface temperatures >17°C but with the majority between 20°-30°C. There were no apparent relationships between annual thermal conditions in the coastal zone and skipjack abundance.

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(3):741-762. 4y

A presentation of three models describing the migration of young skipjack from their central Pacific spawning origin to the eastern Pacific Ocean based on factors influencing skipjack distribution (i.e., temperature, surface currents, and the supply and distribution of food).

FACTORS AFFECTING THE DISTRIBUTION OF DOLPHINS

AU, D.W.K., W. L. PERRYMAN, and W. F. PERRIN. 1979. Dolphin distribution and the relationship to environmental features in the eastern tropical Pacific. Southwest Fisheries Center, Admin. Rep. No. LJ-79-43. 59 pp. 5a

This paper discusses the oceanography of the eastern tropical Pacific, historical range of pelagic dolphins, seasonal changes in dolphin distribution, relationship of dolphin sightings to water structure, and seabird-dolphin associations.

BERZIN, A. A. 1978. Whale distribution in tropical eastern Pacific waters. *Rep. Int. Whaling Comm.* 28:173-177. 5b

Observations on the distribution of sperm, fin, blue, sei and Bryde's whales in relation to environmental factors in the eastern tropical Pacific. The distribution of each species is separately discussed. The distribution of dolphins in the eastern tropical Pacific is also briefly mentioned.

BERZIN, A. A., A. F. VOLKOV, and I. F. MOROZ. 1976. Soviet-American expedition for the study of cetaceans in the east Pacific (in Russian). *Biologiya Morya* 4:74-75. 5c

The sighting and marking of whales and dolphins in the eastern tropical Pacific. Though concentrations of delphinids were usually sighted somewhat apart from concentrations of baleen whales, they both were sighted in greatest abundance around the northern tropical and equatorial divergence areas which are characterized by relatively stable high indices of plankton.

DAVIES, J. L. 1963. The antitropical factor in cetacean speciation. *Evolution* 17:107-116. 5d

An attempt to review the nature of anti-tropical distributions among the Cetacea, and to suggest something of their evolutionary significance.

GASKIN, D. E. 1968. Distribution of Delphinidae (Cetacea) in relation to sea surface temperature off eastern and southern New Zealand. *N. Z. J. Mar. Freshwater. Res.* 2(3):527-534. 5e

The occurrence of delphinid species as related to warm and cold surface temperatures affected by areas of ocean convergence (i.e., subtropical and Antarctic Convergence regions).

LIPPS, J. H., and E. MITCHELL. 1976. Trophic model for the adaptive radiations and extinctions of pelagic marine mammals. *Paleobiology* 2:147-155. 5f

A model proposing that the radiations and declines of pelagic marine mammals over geologic time were responses to the availability of trophic resources in oceanic environments. These trophic resources are closely related to upwelling processes in the oceans. It is suggested that increased upwelling intensity permitted initial invasions and radiations and that decreased upwelling intensity caused cetacean extinctions in the oligocene.

VOLKOV, A. F., and I. MOROZ. 1977. Oceanological conditions of the distribution of Cetacea in the eastern tropical part of the Pacific Ocean. Rep. Int. Whaling Comm. 27:186-188. 5g

An analysis of the relationship between the distribution of baleen and sperm whales and the hydrological and hydrobiological conditions of the eastern tropical Pacific. In general, there appears to be a correlation between presence of whales and areas of divergence, high productivity, and distribution of the whale's food (i.e., epipelagic squid).

BIOLOGY OF TUNA AND DOLPHIN PREY

AHLSTROM, E. H. 1971. Kinds and abundance of fish larvae in the eastern tropical Pacific, based on collections made on EASTROPAC I. Fish. Bull., U. S. 69(1):3-77. 6a

Based on collections taken by oblique plankton hauls, the dominant fish groups were found to be myctophids (47%), gonostomatids (23%), sternoptychids (6%), bathylagids (5%), and scombrids (2%).

AHLSTROM, E. H. 1972. Kinds and abundance of fish larvae in the eastern tropical Pacific on the second multivessel EASTROPAC survey, and observations on the annual cycle of larval abundance. Fish. Bull., U. S. 70(4):1153-1242. 6b

A description of data regarding composition and relative abundance of fish larvae collected during the EASTROPAC II survey cruise. This cruise, conducted 6 months after EASTROPAC I, dealt with the composition of fish larvae during the non-spawning season.

AHLSTROM, E. H., and R. C. COUNTS. 1958. Development and distribution of *Vinciguerria lucetia* and related species in the eastern Pacific. U. S. Fish. and Wildl. Serv., Fish. Bull. 58:363-416. 6c

Detailed information on the development, and general information on the distribution and abundance of *V. lucetia*. The information was collected from frequent CalCOFI cruises off California and Baja California, and less frequent cruises in the eastern north Pacific and eastern tropical Pacific. There is also information on other species occurring in the eastern Pacific, along with information on the vertical distribution of eggs and larvae of *V. lucetia*.

BEEBE, W., and M. VAN DER PYL. 1944. Eastern Pacific expeditions of the New York Zoological Society XXXIII, Pacific Myctophidae (fishes). _Zoologica_, N. Y. 29:59-95. 6d

A description of the distribution, morphology and biology of 24 species of myctophids collected on 3 cruises off Mexico, Central America, and the Galapagos Islands.

CLARKE, M. R. 1966. A review of the systematics and ecology of oceanic squids. _Adv. Mar. Biol._ 4:93-300. 6e

A taxonomic treatment of the distribution, depth, and life history of oceanic squids.

CLARKE, T. A. 1973. Some aspects of the ecology of lanternfishes (Myctophidae) in the Pacific Ocean near Hawaii. _Fish. Bull., U. S._ 71(2):401-434. 6f

Forty-seven species of myctophids were collected over a period of one year during the day and night by a mid-water trawl covering the upper 1000 m. The goals of sampling were to determine the vertical migration patterns of the species present, and to examine changes in abundance, size composition, and reproductive state as related to depth and season.

CLARKE, T. A. 1974. Some aspects of the ecology of stomiatoid fishes in the Pacific Ocean near Hawaii. _Fish. Bull., U. S._ 72(2):337-351. 6g

Forty-seven species representing eight families of stomiatoid fishes were collected in the upper 1000m near Hawaii. For many species sufficient numbers were collected to present reliable estimates of depth ranges, migrations, and seasonal changes in size composition.

CLARKE, T. A. 1978. Diel feeding patterns of 16 species of mesopelagic fishes from Hawaiian waters. _Fish. Bull., U. S._ 76(3):495-513. 6h

Nine species of myctophids and one of melamphaids, all vertical migrators, appeared to feed solely or principally at night in the upper layers. Four species of stomiatoid fishes appeared to feed during the day regardless of the extent of their migration or the absence thereof. One myctophid and one gonostomatid showed no diel feeding pattern.

COLLARD, S. B. 1970. Forage of some eastern Pacific midwater fishes. Copeia 1970:348-354. 6i

An analysis of the stomach contents of 1087 specimens representing 42 species of midwater fishes collected along the eastern Pacific Ocean (Antarctic to British Columbia). Results indicate that these fishes had diverse diets and were nonpreferential in their selection of prey. Various crustaceans (principally copepods and euphausiids) comprised the forage of 95% of all specimens with identifiable stomach contents.

DEWITT, F. A. and G. M. CAILLIET. 1972. Feeding habits of two bristle mouth fishes, *Cyclothone acclinidens* and *C. signata* (Gonostomatidae). Copeia 1972:868-871. 6j

Determination and comparison of feeding habits of two congeneric bristle mouth fishes occurring above 600m off Santa Barbara, California, with respect to their differences in vertical migration and feeding apparatus structure.

HARTMANN, A. R., and T. A. CLARKE. 1975. The distribution of myctophid fishes across the central equatorial Pacific. Fish. Bull., U. S. 73(3):633-641. 6k

Distribution and abundance of myctophid fishes collected by shallow (50-75m) night-trawl tows across a latitudinal transect of the Pacific equatorial water mass. The observed change in distribution of different species within the equatorial water mass was regarded as a response to the increased primary production and food supply resulting from upwelling near the equator and northward transport of enriched surface waters.

HOLTON, A. A. 1969. Feeding behavior of a vertically migrating lanternfish. Pac. Sci. 23:325-331. 6l

Selective fishing of the deep scattering layer in the southern portion of the Gulf of California helped to define the diurnal vertical migration and feeding behavior of the myctophid *Lampanyctus mexicanus*. The feeding behavior was thought to be affected by food available at the surface and by the lower oxygen content of the water at the deepest range of the vertical migration of the fish.

HOPKINS, T. L., and R. C. BAIRD. 1977. Aspects of the feeding ecology of oceanic midwater fishes. p. 325-360. In: N. R. Andersen and B. J. Zahuranec (eds.) Oceanic sound scattering prediction, Mar. Sci. 5. Plenum Press, N.Y. 6m

A review of the feeding ecology of oceanic midwater fishes (e.g., Myctophidae, Gonostomatidae, Sternopthyidae) with a discussion of their vertical distribution and migration, diet composition, feeding chronology, daily food ration, selective feeding, resource partitioning, and bioenergetics.

KING, J. E., and R.T.B. IVERSEN. 1962. Midwater trawling for forage organisms in the central Pacific, 1951-1956. U. S. Fish and Wildl. Serv., Fish. Bull. 62:271-321. 6n

Midwater trawls in the central Pacific were used to measure distribution and abundance of potential tuna food, to estimate the standing crop of forage organisms and to study tuna feeding behavior. There is also a discussion of the sampling of juvenile tuna by trawls and an evaluation of catching abilities of different midwater trawls.

LONGHURST, A. R. 1967. The pelagic phase of Pleuroncodes planipes Stimpson (Crustacea, Galatheidae) in the California Current. Calif. Coop. Oceanic Fish. Invest. Rep. 11:142-154. 6o

A discussion of the distribution of the pelagic stage in P. planipes collected with a 1 m zooplankton net at a 140 meter depth in offshore and oceanic areas of the California Current system.

LONGHURST, A. R. 1968. Distribution of the larvae of Pleuroncodes planipes in the California Current. Limnol. Oceanogr. 13(1):143-155 6p

Zoea and megalops larvae were collected in plankton samples from the California Current in 1957 and 1958. Their distribution in the samples showed 1) breeding occurred during winter, 2) the greatest larval concentrations were over the continental shelf, 3) breeding extended far to the north of the usual range in the warm period around 1959, and 4) evidence of late zoea and megalops being carried offshore in accordance with known geostrophic flow patterns.

NESIS, K. N. 1970. The biology of the giant squid of Peru and Chile, Dosidicus gigas. Oceanology 10(1):108-118. Translated from Russian for the American Geographical Union. 6q

A description of the sex ratio, sexual maturity, mating, fecundity, larvae, young, distribution of the population by size and age, nutrition, migrations, and parasites of Dosidicus in the eastern tropical Pacific from August-November 1978.

NESIS, K. N. 1972. Oceanic cephalopods of the Peru Current: horizontal and vertical distribution. Oceanology 12(3):506-519. Translated from Russian for the American Geophysical Union. 6r

Forty-one cephalopod species were identified in collections made in the eastern equatorial and southeast Pacific Ocean using different types of trawls at different depths. These species were analyzed for their horizontal and vertical distribution.

PARIN, N. V. 1960. Distribution of flyingfishes (family Exocoetidae) in the western and central parts of the Pacific Ocean. U. S. Bureau Comm. Fish., Translation No. 52., 15 pp. 6s

General distribution patterns in relation to different variables within the western and central Pacific, i.e., ocean temperature differences causing a bipolar distribution of flyingfishes, neritic versus oceanic groups of species, and presence of favorable conditions for spawning.

ROPER, C. E., and R. E. YOUNG. 1975. Vertical distribution of pelagic cephalopods. Smithson. Contrib. Zool. 209. 48 pp. 6t

A review of the information on vertical distribution of pelagic cephalopods collected on three sampling programs in three different oceanic regions of the world: Hawaii, California, and Bermuda.

UCHIDA, R. N. 1981. Synopsis of biological data on frigate tuna, Auxis thazard, and bullet tuna, A. rochei. U. S. Nat'l Mar. Fish. Serv., Tech. Rep. Circ., No. 436, 63 pp. 6u

A synopsis containing information on the identity, distribution, bionomics, life history, population, and exploitation of frigate and bullet tunas. Over 200 published and unpublished reports, up to and including those published in 1978, are covered.

VOSS, G. L. 1971. Cephalopods collected by the R/V John Elliot Pillsbury in the Gulf of Panama in 1967. Bull. Mar. Sci. 21(1):1-34. 6v

Collection locations and general descriptions of 26 species of cephalopods collected on a cruise in the Gulf of Panama.

VOSS, G. L. 1973. Cephalopod Resources of the World. FAO Fish. Circ. No. 149. 75 pp. 6w

A report covering the biological aspects, fishing methods, mariculture, and reviews of cephalopods in different regions of the oceans, including the central east Pacific and southeast Pacific.

WISNER, R. L. 1974. The taxonomy and distribution of lanternfishes (family Myctophidae) of the eastern Pacific Ocean. Navy Ocean Research and Development Activity, No. 3, 229 pp. 6x

Keys to and illustrations of adult and subadult stages of 150 species of myctophids occurring in the eastern Pacific.

PRODUCTIVITY OF THE EASTERN TROPICAL PACIFIC

BEERS, J. R., and G. L. STEWART. 1971. Microplankters in the plankton communities of the upper waters of the eastern tropical Pacific. Deep-Sea Res. 18(9):861-883. 7a

The numerical abundance, biomass, and taxonomic composition of the micro-zooplankton, and the levels of chlorphyll, phaeophytin, and total seston were determined for six depth intervals. These depth intervals were within the upper 200 m at 12 locations from approximately 10^oN to 12^oS latitude on 105^oW longitude. Average micro-zooplankton volume over the euphotic zone showed a threefold range: from 15 mm^3/m^3 at the southerly extreme of sampling to 47 mm^3/m^3 near the equator.

BLACKBURN, M. 1966. Biological oceanography of the eastern tropical Pacific: summary of existing information. U. S. Fish Wildl. Serv., Spec. Sci. Rep.-Fish. No. 540:1-18. 7b

A review of investigations on the biological oceanography of the eastern tropical Pacific. On most of the 29 biological-oceanographic expeditions made since 1952, similar properties were measured by similar methods. Properties available for comparable measurements are: standing crops of surface and overall chlorophyll a, standing crop of small zooplankton in the upper 300m, standing crop of micronekton in the upper 100m, and surface primary productivity.

BLACKBURN, M. 1973. Regressions between biological oceanographic measurements in the eastern tropical Pacific and their significance to ecological efficiency. Limnol. Oceanogr. 18:552-563. 7c

Simple regressions of various standing stocks (chlorophyll *a*, zooplankton, and micronekton) on each other and on primary productivity were compared by covariance analysis for different seasons, latitudes, and longitudes in the eastern tropical Pacific.

BLACKBURN, M., R. M. LAURS, R. W. OWEN, and B. ZEITSCHEL. 1970. Seasonal and areal changes in standing stocks of phytoplankton, zooplankton, and micronekton in the eastern tropical Pacific, *Mar. Biol.* 7:14-31. 7d

Five standing stocks were measured at similar latitudes and longitudes on seasonally repetitive cruises in three areas, west, east, and south in the eastern tropical Pacific. The stocks were chlorophyll *a*, night and day zooplankton, night crustacean micronekton, and fish-plus-cephalopod micronekton. Each stock was analyzed with respect to season, latitude, and longitude.

BRANDHORST, W. 1958. Thermocline topography, zooplankton standing crop, and mechanisms of fertilization in the eastern tropical Pacific. *Jour. Cons. Intern. Explor. Mer.* 24(1):16-31. 7e

A comparison between thermocline topography during the autumn (based on bathythermograph observations) and zooplankton distribution reveals an inverse relationship between depth of the thermocline and size of the zooplankton standing crop. This is also related in some regions to the abundance of tuna. Additional fertilizing mechanisms in areas of high standing crop show a dynamic topography, and the surface distribution of temperature, salinity, and phosphates.

EL-SAYED, S. Z., and S. TAGUCHI. 1979. Phytoplankton standing crop and primary productivity in the tropical Pacific. p. 241-286 *In*: J. L. Bischoff and D. Z. Piper (eds.). *Marine geology and oceanography of the Pacific Manganese Nodule Province*. Plenum Press, N. Y. 7f

A study of the short-term, vertical, spacial, and temporal variabilities of chlorophyll *a*, phaeopigments, and primary production in the tropical Pacific DOMES area (5^o-20^oN and 128^o-155^oW).

FRYXELL, G. A., S. TAGUCHI, and S. Z. EL-SAYED. 1979. Vertical distribution of diverse phytoplankton communities in the central Pacific. p. 203-240 *In*: J. L. Bischoff and D. Z. Piper (eds.) *Marine geology and oceanography of the Pacific Manganese Nodule Province*. Plenum Press, N. Y. 7g

Phytoplankton samples were taken from discrete depths on three transects in the central Pacific. An average of over 20,500 cells/liter was found for all depths counted, with about equal numbers of diatoms, dinoflagellates, and coccolithophorids together accounting for half of that number. Cell numbers versus depth showed a subsurface maximum, and decreasing numbers at greater depths. The Shannon Weaver diversity index (H'), summed over all depths for each station, appeared to approach an asymptote in most cases.

GASKIN, D. E. 1979. Change in particle size in diatom populations as a possible factor in pelagic marine ecosystem resilience. Tuatara 24(1):23-39. 7h

The drawing together of a number of ideas and findings from several independent lines of research that have a possible bearing on the resilience of pelagic marine ecosystems which characteristically have large component fluctuations. Due to their large population fluctuations, the diatoms' reproductive strategy (change in particle size) is discussed. As an adaptation to a short season of nutrient availability in the pelagic environment, diatoms appear to undergo a maximization of numbers as nutrients are depleted.

GRAHAM, H. W. 1941. Plankton production in relation to character of water in the open Pacific. J. Mar. Res. 4(3):189-197. 7i

Vertical tow-net samples were made at 0, 50, and 100 meter depths on a cruise from latitudes 34°N to 11°S. Waters richer in phosphate and plankton occurred in regions where there were indications that some form of vertical circulation was transporting phosphate from the reservoirs below to the upper layers. These regions were in the California Current and its outflow, the North Equatorial Current, the northern edge of the Equatorial Counter Current, and the northern part of the South Equatorial Current.

HOLMES, R. W., M. B. SCHAEFER, and B. M. SHIMADA. 1957. Primary production, chlorophyll, and zooplankton volumes in the tropical eastern Pacific Ocean. Inter-Am. Trop. Tuna Comm., Bull. 2(4):129-169. 7j

Values of surface chlorophyll a, surface primary production in situ, and zooplankton volumes were observed in relation to oceanographic features. Correlation of surface primary production and zooplankton volumes with surface chlorophyll was also analyzed.

KING, J. E., and J. DEMOND. 1953. Zooplankton abundance in the central Pacific. *U. S. Fish and Wildl. Serv., Fish. Bull.* 54(82):111-144. 7k

Zooplankton collections were analyzed for composition and abundance with respect to location and seasonal variation. Abundance was found to be correlated with such chemical and physical factors as inorganic phosphate, water temperature, dissolved oxygen, and thermocline depth, which were in turn influenced by the upwelling resulting from the equatorial divergence.

KING, J. E., and T. S. HIDA. 1957. Zooplankton abundance in the central Pacific. 2. *U. S. Fish and Wildl. Serv., Fish. Bull.* 57:365-395. 7l

Measurements were made of the abundance of the zooplankton standing crop which might be used as an index of the relative productivity of different areas of the sea. The highest concentration of zooplankton was found at the equator, which is a region of divergence and upwelling under the influence of the trade winds. Although the greatest abundance of yellowfin tuna occurred just to the north in the convergence zone, there was a high degree of covariation in yellowfin and zooplankton with respect to the current system.

LONGHURST, A. R. 1976. Interactions between zooplankton and phytoplankton profiles in the eastern tropical Pacific Ocean. *Deep-Sea Res.* 23:729-754. 7m

Data from zooplankton profiles taken during the EASTROPAC cruises of 1967 to 1968 enabled a first-order description of zooplankton distribution in the upper 1000m of the water column in relation to density, light, oxygen, and phytoplankton. An hypothesis is proposed that the form of phytoplankton profiles, in periods or regions of stable production, may be primarily determined by depth-differential herbivore grazing pressure, rather than by differential cell-sinking rates as is suggested in classical production models.

TONT, S. A. 1976. Deep scattering layers: Patterns in the Pacific. *Calif. Coop. Oceanic Fish. Rep.* 18:112-117. 7n

A discussion of the characteristics of the deep scattering layer in the major biotic regions of the Pacific Ocean based on acoustical records from 26 cruises (1958-1972). Daytime depth of the deep scattering layers was found to be correlated with light levels, although at some locations a sharp temperature gradient seems to inhibit a particular layer from migrating to the surface. The oxygen minimum layer seems to have no effect on the behavior of the layers.

PHYSICAL OCEANOGRAPHY OF THE EASTERN TROPICAL PACIFIC

CROMWELL, T. 1958. Thermocline topography, horizontal currents and "ridging" in the eastern tropical Pacific. Inter-Am. Trop. Tuna Comm., Bull. 3(3):133-164. 8a

An analysis of thermocline depth, horizontal currents, and vertical motion (i.e., ridging, water transferred up from thermocline, and vertical stirring and mixing at the ocean surface) of the eastern tropical Pacific. The Costa Rica dome area is given special emphasis.

FRANCESCHINI, G. A. 1979. The solar radiation environment in the eastern tropical north Pacific Ocean. p. 1-42. In: J. L. Bischoff and D. Z. Piper (eds.) Marine geology and oceanography of the Pacific Nodule Province. Plenum Press, N. Y. 8b

Net photon irradiance above the surface and downward photon irradiance to a depth of 150m were measured for the wave band of photosynthetically active radiation (400-700nm). Results showed an average net irradiation of 39 (E/m^2-day) in summer and 45 (E/m^2-day) in winter due to reduced cloudiness (16% greater irradiation in winter). During the same interval, biological primary productivity increased by 20%. Submarine measurements show the water to be a clear open-ocean type.

HALPERN, D. 1979. Observations of the upper currents at DOMES sites A, B, and C in the tropical central North Pacific Ocean during 1975 and 1976. p. 43-82. In: J. L. Bischoff and D. Z. Piper (eds.) Marine geology and oceanography of the Pacific Manganese Nodule Province. Plenum Press, N. Y. 8c

Current measurements were made from 20m to 300m depths at 3 different sites during various months of the year. During the time that the measurements were made, Sites A and B were located within the eastward flowing North Equatorial Countercurrent and Site C was within the westward flowing North Equatorial Current.

MILLER, F. R., and R. M. LAURS. 1974. The El Niño of 1972-73 in the eastern tropical Pacific Ocean. Inter-Am. Trop. Tuna Comm., Bull. 16:403-447. 8d

Hypotheses on the origin of the El Niño phenomenon. Ocean temperature and atmospheric influences on the 1972 El Niño, and similarities in ocean temperature during recent well-developed

El Niños are discussed.

OHMAN, M. D., E. OZTURGUT, and R. J. OZRETICH. 1979. A seasonal and spatial summary of oceanographic data from the northeastern tropical Pacific (DOMES Region). Summer 1975 and winter 1976. Univ. of Wash. Dept. Oceanogr., Spec. Rep. No. 91, Ref: M79-53. 117 pp. 8e

A presentation of data on the upper water column including data on dissolved chemical constituents, biochemical parameters, phytoplankton pigments and primary production rates, and suspended particulate concentrations.

SVERDRUP, H. U., M. W. JOHNSON, and R. H. FLEMING. 1942. p. 698-712. In: The oceans. Their physics, chemistry and general biology. Prentice, N. J. 8f

Descriptions and sources of water masses and currents in the south Pacific and Equatorial Pacific Oceans.

WOOSTER, W. S., and T. CROMWELL. 1958. An oceanographic description of the eastern tropical Pacific. Univ. Calif., Scripps Inst. Oceanogr., Bull. 7(3):169-282. 8g

The results of a cooperative oceanographic survey analyzing the vertical distribution of temperature, salinity, oxygen, phosphate, and silicate in the eastern tropical Pacific. Profiles of these parameters were plotted in terms of variation in geographic location and time.

WYRTKI, K. 1965. Surface currents of the eastern tropical Pacific Ocean. Inter-Am. Trop. Tuna Comm., Bull. 9(5):271-303. 8h

A general description and seasonal variation of the circulation patterns of the surface currents in the Eastern Tropical Pacific (i.e., California Current, Equatorial Countercurrent, Peru Current).

INDEX OF AUTHORS CITED

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12 Stock assessment activities within the National Marine Fisheries Service.
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13 Planning double-tagging experiments.
J. A. WETHERALL and M. Y. Y. YONG
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14 Histological gonad analyses of late summer—early winter collections of bigeye tuna, *Thunnus obesus*, and yellowfin tuna, *Thunnus albacares*, from the Northwest Atlantic and the Gulf of Mexico.
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15 Status reports on world tuna and billfish stocks.
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