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SYNOPSIS OF BIOLOGICAL DATA ON CALIFORNIA BLUEFIN TUNA
Thunnus saliens Jordan and Evermann 1926

Exposé synoptique sur la biologie du thon rouge
Thunnus saliens Jordan et Evermann 1926

Sinopsis sobre la biología del atún rojo
Thunnus saliens Jordan y Evermann 1926

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1 IDENTITY

1.1 Taxonomy

1.1.1 Definition

Phylum VERTEBRATA
Subphylum Craniata
Superclass Gnathostomata
Series Pisces
Class Teleostomi
Subclass Actinopterygii
Order Thunniformes
Family Thunnidae
Subfamily Thunnini
Genus Thunnus South 1845
Species Thunnus saliens
Jordan and Evermann 1926

1.1.2 Description

- Genus Thunnus South 1845

"Teeth small and sharp pointed, a single row in each jaw; body thick, rounded, and spindle-shaped, covered generally with very small scales, but about the chest are some much larger and rougher, forming a kind of corselet, which divides posteriorly into numerous points; on each side of the tail a horizontal, longitudinal, sharp, cartilaginous keel in addition to the two little crests seen in the mackerels (sic); first dorsal fin continued almost to the commencement of the second; false fins or finlets between the latter and the caudal fin; no free spine in front of the anal fin; branchiostegous rays seven" (South 1845).

- Thunnus saliens Jordan and Evermann 1926

"Body robust; depth 3-1/2 in length to base of caudal; pectoral 5; dorsal lobes falcate, 6 in body length; caudal strong, its breadth from tip to tip greater than head; mouth small, the maxillary barely reaching pupil. Finlets 8/8, the first adnate to base of fin. Color, dark blue, without silver streaks in the adult; finlets above bluish; no yellow on fins or finlets" (Jordan and Evermann 1926).

"No dark striping on body---vent round---lower posterior angle of preoperculum rounded---ventral surface of liver striated with blood vessels---" (Godsil 1945).

"The bluefin may generally be distinguished from the remaining tunas by its relatively short pectoral fin. Whereas the pectoral of the yellowfin reaches beyond the insertion of the second dorsal fin and that of the albacore and the big-eyed tuna reaches beyond the insertion of the anal fin, the pectoral of the bluefin extends normally only to the insertion of the eleventh or twelfth spine of the first dorsal fin. The margins of the gill-covers are rounded, particularly that of the preoperculum, but in the yellowfin they are quite angular on the posterior ventral corner. Also the vent is round in the bluefin, whereas in the other tunas, excepting the albacore, it is elongated or pear-shaped" (Godsil and Byers 1944).

"Dorsal finlets usually 8, and finlets usually 7; pectoral fin short, usually extending only to 11th or 12th dorsal spine, shorter than head; vent round; entire ventral surface of liver striated radially with blood vessels. (Generally distinguished from the other tunas by the relatively short pectoral fin; vent oval in the yellowfin and bigeye). Weight: to about 250 lbs; it is a much smaller fish than the Atlantic bluefin which is reputed to reach 1800 lbs. Commercial sizes usually 10 to 40 lbs; sporadic runs of fish over 100 lbs occur. Color: Deep blue above; silvery on the sides and belly; the belly with irregular white spots. Lacks the golden yellow band along the sides and tbe black edging of the finlets found on the yellowfin tuna when caught" (Roedel 1953).

The following authors support the specific distinction between the California and Atlantic bluefin tuna. In this paper the species is considered saliens.

In comparing specimens of California and Atlantic bluefin tuna, Godsil and Holmberg (1950) say:

"1. In the Atlantic form the air bladder is normal (five out of six specimens) and covers almost the entire length of the body cavity, whereas in the large California specimens the air bladder is extremely irregular, and in the

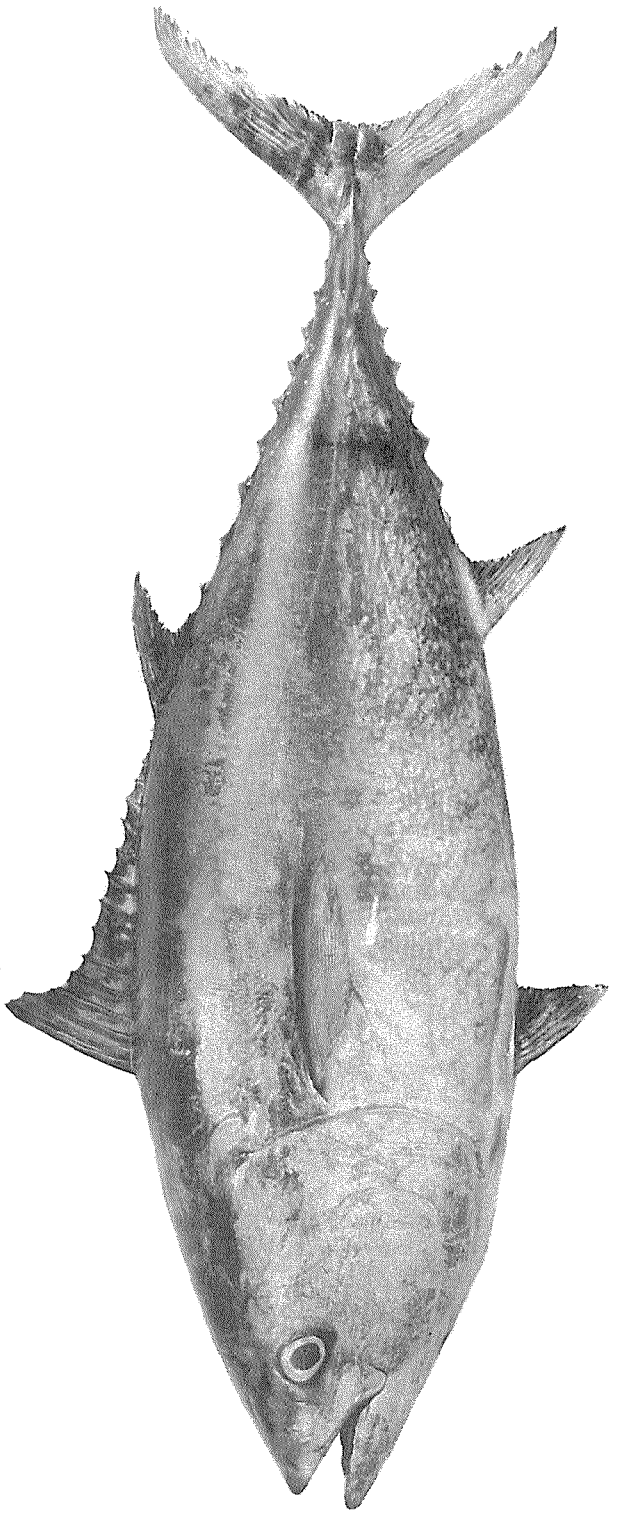

Fig. 1 Thunnus saliens Jordan and Evermann (Photograph by California State Fisheries Laboratory)

majority of cases where a functional air bladder is present, it is pear-shaped, covering only the anterior half of the abdominal cavity. To this extent it resembles both T. maccoyii and Kishinouye's description of T. orientalis, of which the author states, 'In immature tunnies the air bladder is short, very narrow, and almost collapsed'. This general description would fit the California variety also. In view of the instability of this organ throughout the order, one would hesitate to base a separation upon it alone.

"2. In the Atlantic bluefin, there is no arterial trunk connecting the No. II and No. III branches of the coeliac mesenteric artery, whereas in the California form this, or a connecting network, is present.

"3. The pelvic girdle differs in the two forms. However, this bone from five of the Atlantic specimens was inadvertently lost, and the conclusion is based upon the examination of only one assembly. It must therefore be accepted with reservations.

"4. The gill-raker count differs in the two varieties. The total count in the Atlantic form was 39 to 41, compared with 32 to 39 in the California bluefin. The difference was mainly in the number of rakers on the lower limb of the arch. In the Atlantic bluefin this number was 25 to 28, whereas in the California bluefin there were 21 to 25 rakers.

"5. The last and most conspicuous difference occurs in the shape of the roof of the body cavity. In large fish the difference is striking and consistent. Unfortunately no small Atlantic specimens were available for comparison."

"Godsil and Holmberg (1950) showed that the American Pacific bluefin tuna differs specifically from the western Atlantic bluefin. They diverge in the number of gill rakers, in the length of the head and pre-anal distance and other measurements, and in some internal characters. In general, the degree of divergence between them is evidently of species magnitude, and they should be treated as distinct species, notwithstanding their treatment hitherto as belonging to the same species by most authors.

"Although Jordan and Evermann's paper (1926) on the species of tunas is unsatisfactory in that it is based largely on photographs and very little or none of the critical data are included, nevertheless their name saliens is the only one that has been proposed for the bluefin tuna from the American Pacific coast. According to the International Rules this name is valid" (Ginsburg 1953).

"(California) bluefin tuna, Thunnus saliens Jordan and Evermann. Formerly regarded as identical with the Atlantic T. thynnus, recent studies (Godsil and Holmberg 1950) showed differences between Atlantic and Pacific specimens which, in the opinion of Dr. C. L. Hubbs and Mr. W. I. Follett, warrant recognition of the California bluefin as a distinct form, provisionally as a distinct species" (Roedel 1953). For an illustration of the species, see Fig. 1.

1.2 Nomenclature

1.2.1 Valid scientific names

Thunnus saliens Jordan and Evermann 1926

1.2.2 Synonyms

Thunnus thynnus

Fraser-Brunner (1950) mistakenly listed Thunnus saliens Jordan and Evermann 1926 as a synonym of Thunnus (Neothunnus) albacora (Lowe 1839), a yellowfin tuna collected in the Gulf of Aden. Although the first description of the California bluefin tuna by Jordan and Evermann in 1926 was quite poor it is clear that they had a bluefin tuna as their type. (Type: 595, Mus. Calif. Acad. Sci., a photograph of a specimen weighing 157-1/2 lbs taken by W. A. Van Brunt off Catalina, California.).

1.2.3 Standard common names, vernacular names (See Table I).

1.3 General variability

1.3.1 Subspecific fragmentation (Races, varieties, hybrids)

Table I
Common and vernacular names

Country	Standard Common Name	Vernacular Name(s)
California (English)	California bluefin tuna	Bluefin, tuna, tunny, great tunny, horse mackerel, leaping tuna
(Japanese)		Maguro
(Italian)		Tonno
(Portugese)		Atûm
(Spanish)		Atûn
(Yugoslavian)		Trup
Canada	Bluefin tuna	Tuna, horse mackerel, thon
Chile	Atûn cimarrón	Atûn grande de Juan Fernandez, Atûn de aleta azul
Hawaiian Islands	Bluefin tuna	Great albacore, short-finned tuna, leaping tuna, tuna, great tuna, horse mackerel, ahi
Mexico	Atûn de aletas azules	Atûn

- Meristic counts
  (See Table II)

- Varieties

There is no record of varieties among the California bluefin tuna. However, Godsil and Byers (1944) state: "Because the fish from the two adjacent regions investigated (Baja California and California, Guadalupe Island, Mexico and southern California) are similar in all characters examined, it is apparent that they are of the same species Thunnus thynnus (Thunnus saliens). Hence the bluefin fishery of California is supported by a single species. This does not preclude the possibility that another extraneous species may occasionally enter our commercial catch. Fishermen and canners are at times puzzled by catches of tuna which in the opinion of the industry constitute a different species than T. thynnus (Thunnus saliens). The fishermen sometimes referred to these fish as a cross between bluefin and yellowfin. We have examined several of these fish and pronounced them members of the genus Thunnus. The striations on the liver clearly separate them from the yellowfin. One specimen examined (but not described herein) differed significantly from all others".

1.3.2 Genetic data (chromosome number, protein specificity)

Electrophoresis of the soluble eye lens proteins from four specimens of California bluefin tuna revealed a characteristic curve with two components. This is presumed to reflect the presence of at least two protein moieties in the structure of the lens.

Electrophoresis of the hemoglobin from eight specimens of California bluefin tuna demonstrated the presence of four general curves, although two of the curves were somewhat similar. The interpretation is that these curves indicate the presence of three or four kinds of hemoglobin within the species, and that this is an example of intraspecific genetic variation. (Smith, unpublished)

Table II
Meristic counts of Thunnus saliens

Organs	Baja California		California	
Dorsal fin First	13-14	13 (3), 14 (8)	12-14	12 (1), 13 (1), 14 (9)
Dorsal fin Second	15	15 (11)	15	15 (11)
Dorsal finlets	8-9	8 (10), 9 (1)	8-9	8 (10), 9 (1)
Dorsal fin Second plus Dorsal finlets	23-24	23 (10), 24 (1)	23-24	23 (10), 24 (1)
Anal fin	14-15	14 (0), 15 (11)	14-15	14 (3), 15 (7)
Anal finlets	7-8	7 (11), 8 (0)	7-8	7 (8), 8 (3)
Anal fin plus Anal finlets	21-23	21 (0), 22 (11), 23 (0)	21-23	21 (1), 22 (8), 23 (1)
Gill rakers Upper limb	10-14	10 (0), 11 (1), 12 (7), 13 (2), 14 (1)	10-14	10 (1), 11 (0), 12 (6), 13 (4), 14 (0)
Gill rakers Lower limb	21-25	21 (1), 22 (2) 23 (6), 24 (1) 25 (1)	21-25	21 (1), 22 (1), 23 (4), 24 (5), 25 (0)
Gill rakers Upper and lower limbs combined	32-39	32 (1), 33 (0) 34 (1), 35 (6), 36 (2), 37 (0), 38 (0), 39 (1)	32-37	32 (1), 33 (1), 34 (0), 35 (3), 36 (3), 37 (3)

Godsil and Byers, 1944. The numbers in parentheses refer to frequency.

2 DISTRIBUTION

2.1 Delimitation of the total area of distribution and ecological characterization of this area

The bluefin tuna of the eastern Pacific Ocean is a member of the coastal fauna of Chile, Baja California and the United States. It inhabits subtropical and temperate water and is rarely captured in tropical water; this creates a discontinuous distribution on the west coast of North and South America. Records of capture delimit the range in the northeastern Pacific Ocean from Cape Flattery, Washington (Blunt 1958), the Shelikof Straits near Wide Bay, Kodiak, Alaska (Radovich 1961), to Mexico (Berdegue 1956) and across the eastern Pacific Ocean to the Hawaiian Islands (June 1952); however, the bluefin tuna is found in commercial numbers only from Point Conception, southern California, to Cape San Lucas, Baja California. In recent years the highest commercial production was from a more restricted area between the Channel Islands to the north, and Guadalupe Island and Point San Eugenio, to the south.

In the southeastern Pacific Ocean the bluefin tuna is accepted as a member of the fauna of Chile (Mann 1954), south to Juan Fernandez Islands (Rosa 1950) and has been recorded from the Galapagos Islands (Hildebrand 1946). (Considered a misidentification). (Alverson, personal communication) Beyond knowing of their presence in the southeastern Pacific Ocean nothing further is recorded.

The coastal waters of southern California and northern Baja California are the northeastern Pacific habitat of the bluefin tuna in summer. The land to the east is lower and upper Sonoran life zones and the agriculture is subtropical. The water has been termed subtropical or, more recently, warm-temperate (Garth 1955). It has also been described as anti-tropical. This is the water of the southern California eddy and the southern California counter-current, an enriched water zone bounded on the east by the arid California coast and on the west by the cold south-flowing California current. The north boundary is the peninsula of Point Conception and the cold water beyond and the south boundary is the warm water of the tropics about Cape San Lucas (Point Entrada) (Garth 1955). Below this water mass, the continental borderland (Shepard and Emery 1941) shallower than 2,000 m tapers from ten miles offshore at Cape San Lucas to 140 miles offshore at the Patton Escarpment or continental edge off southern California.

In summer, bluefin tuna occupy surface waters in commercial numbers. There are records of catches made every month of the year. However, bluefin tuna generally appear in the commercial catch from May to September. Nothing is known of their winter habitat. For distribution habitat see Figs. 2 and 3.

2.2 Differential distribution

2.2.1 Areas occupied by eggs, larvae and other junior stages: annual variations in these patterns, and seasonal variations for stages persisting over two or more seasons. Areas occupied by adult stages; seasonal and annual variations of these

California bluefin tuna eggs, larvae or juvenile stages have never been collected. If they exist in Baja California and southern California surface water the opportunity to collect them is excellent. The California Cooperative Oceanic Fisheries Investigations has regularly occupied oceanographic and biological stations throughout the habitat each month of the year between 1949 and 1960. The fish captured in the 125,000 square mile area covered by the fishing fleet are adults or subadults. Fish with mature ovaries have not been captured.

2.3 Behavioristic and ecological determinants of the general limits of distribution and of the variations of these limits and of differential distribution

In southern California, bluefin tuna are found in the epipelagic zone, the first 100 m of water over the continental borderland; about islands, over banks, and near the continental shore they enter the neritic zone. These are zones of light penetration and warm water with saturated or high oxygen values. At the surface oxygen values of 5.9 to 7.0 ppm, and at 100 m phosphate-phosphorus values of 2.0->2.5 microgram atoms per liter and zooplankton volumes of 200 to 799 cc/1,000 m^3, are common through-

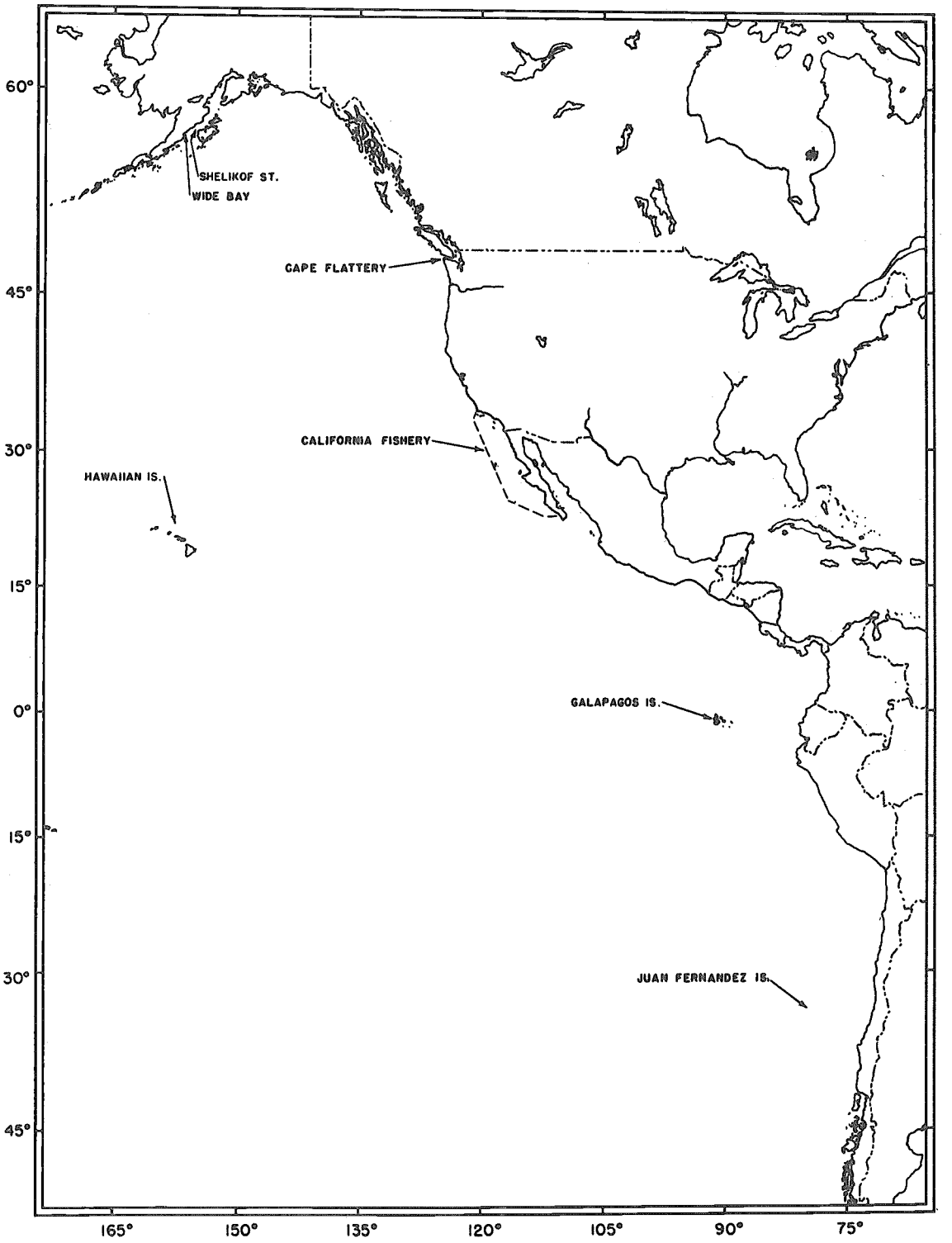

Fig. 2 Distribution of Thunnus saliens (Prepared by R. A. Iselin)

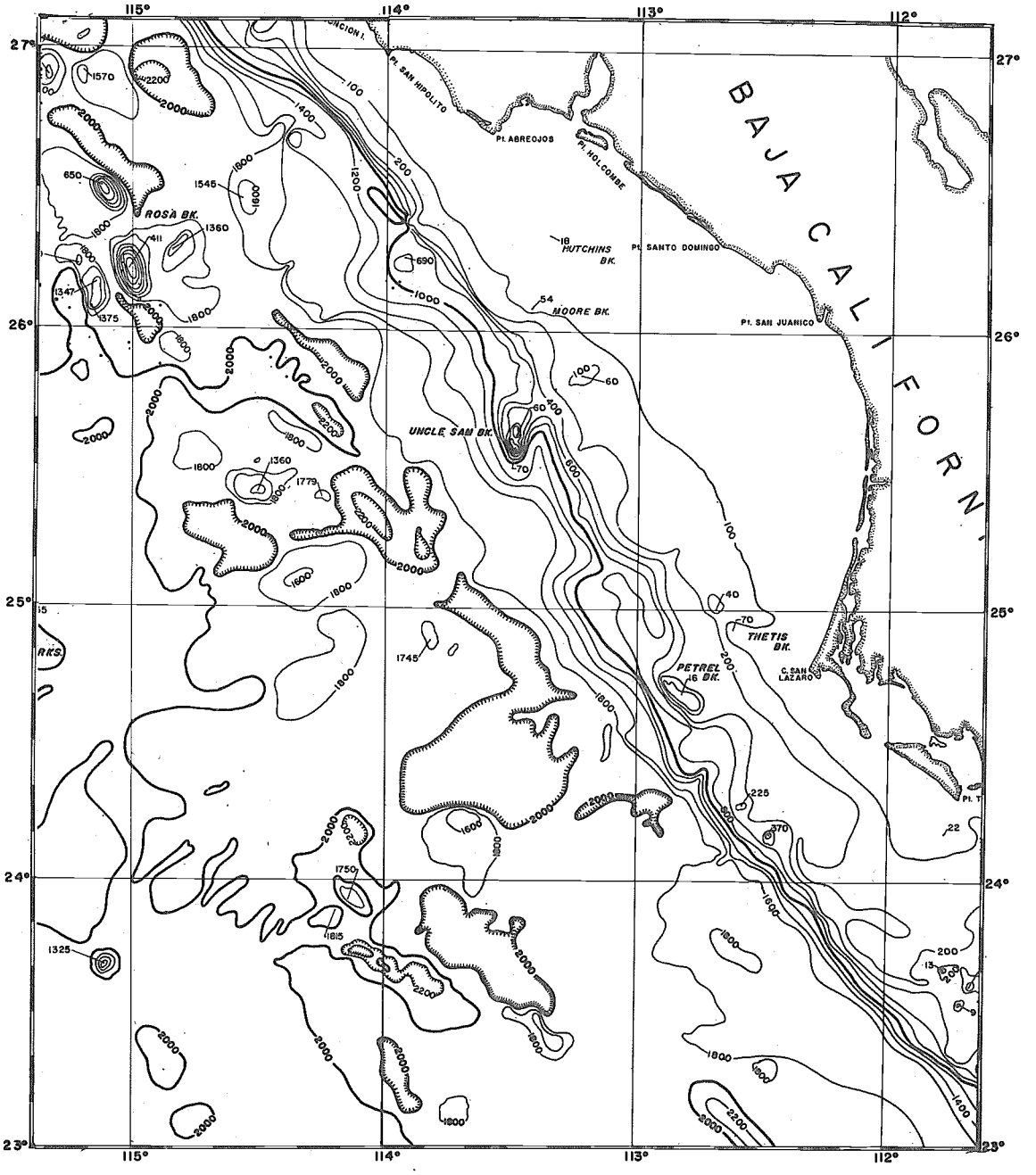

Fig. 3 Topography of the Uncle Sam Bank area, typical bluefin tuna habitat. (Chart prepared by the United States Bureau of Commercial Fisheries)

out the habitat in summer. At the spring maxima zooplankton values may reach 1,600 cc/ 1,000 m^3 in much of the bluefin tuna habitat. (Reid et al 1958).

At the surface, temperatures vary from 17°C in the northern extension of the range, to 23°C at the southern limit. Bluefin tuna preferential temperatures probably lie within these values. During summer the thermocline forms at 50 to 75 m west of the Channel Islands. East of the islands, the thermocline is established 10 to 20 m from the surface. The thermocline in Baja California inshore water (less than 10 miles from the shore) is near the surface but becomes deeper at stations further west. Southern California channel water is warmer then water further to the west. In Baja California, water temperatures are low near shore and increase at offshore stations. In both areas, volumes in the water column, containing dissolved oxygen values of 4 ppm, greatly increase to the west. Oxygen values are below 4 ppm at 50 m at inshore stations off Baja California. Water temperatures drop from 18° - 19°C to 13° - 14°C in depths of 30 to 50 m at many Baja California inshore stations.

At Point Conception inshore stations, surface temperatures drop 3° or 4°C below station values immediately south of the point. North of Point Conception, water temperatures continue to drop to about 11°C at shore stations. Progressing to the west, all northern stations have increasing water temperatures. The volume of the water column containing dissolved oxygen above 4 ppm is low at near shore stations. Offshore the oxygen values increase toward the west. (Reid et al 1958).

The mean surface water temperature where bluefin tuna were caught was different for three locations - 17.8°C at Guadalupe Island, 19.5°C off Baja California, and 21.1°C off the coast of southern California. There were modes at 17.8°C, 20.0°C, 21.1°C and 22.2°C, with the range from 13.9°C to 24.5°C. (Blunt unpublished)

3 BIONOMICS AND LIFE HISTORY

3.1 Reproduction

3.1.1 Sexuality (hermaphroditism, heterosexuality, intersexuality)

Thunnus saliens is heterosexual. No externally observable characters are known to distinguish males and females.

3.1.3 Mating (monogamous, polygamous, promiscuous)

Mating of the California bluefin tuna is presumed to be promiscuous.

3.1.4 Fertilization (internal, external)

External.

3.1.6 Spawning

"Spawning is believed to take place between December and May" (Whitehead 1931).

3.3 Adult History

3.3.2 Hardiness

The California bluefin tuna is hardy under normal or natural conditions, but it is vulnerable to handling and dies rapidly when confined, as in a closing purse seine.

3.3.3 Competitors

Pacific albacore Thunnus germo are competitors with bluefin tuna particularly in the waters of southern California. The two fish appear about the same time of the year. Bluefin tuna are found about islands and over banks; however, albacore generally seek more open water and competition is not constant. Competition with skipjack Katsuwonus pelamis and yellowfin tuna Neothunnus macropterus may take place occasionally when these species enter the southern range of bluefin tuna. In general, bluefin tuna occupy a habitat exclusively their own without strong competitors from any source. (See section 4.6).

3.3.4 Predators

"A number of hooked bluefin are lost to sharks, but aside from these and man no natural enemies are known at the present time" (Fitch 1958).

3.3.5 Parasites and diseases

The following parasites have been recovered from California bluefin tuna:

A. Worms
- Helminthes
  - Trematodes
    - Didymocystis guernei
      - Several fusiform adults in cysts up to 15 mm long under the serosa of the stomach; and, reproductive bodies from minute to 4 mm to diameter on the gill filaments, arches and rakers.
    - Hirudinella fusca
      - Stomach
    - Tricotyla thynni
      - Gills
  - Nematodes
    - Contracaecum (Thynnascaris) legendrei
      - Stomach

B. Crustaceans
- Copepods
  - Lepeophtheirus edwardsi
    - Branchial chamber and gills
  - Brachiella thynni
    - Skin at base of pectoral fin

(Smith, unpublished)

3.3.6 Greatest size

"The largest sport-caught fish on record is a 251 pounder taken off Santa Catalina Island in 1908. The largest authentic record is a commercially-caught fish six feet, two and one-quarter inches long (188.6 cm) to the fork of its tail that weighed 297 lb. This giant was caught at Guadalupe Island, Baja California, and delivered to San Pedro fresh fish markets on February 26, 1958. Most of the bluefin caught off our shores range in weight from 10 to 45 lb" (Fitch 1958). (See Table III).

Table III

Length of largest bluefin tuna recorded from routine market samples (1951-1960)

Year	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960
Fork length (cm)	120	102	126	133	130	148	163	106	157	170
Percent of sample	.820	.088	.094	.056	.028	.018	.019	.015	.038	.029

3.4 Nutrition and growth

3.4.2 Food (type, volume)

"Of 168 bluefin taken off California last year (1957), 70 per cent had been feeding on anchovies. Thus bluefin could be influenced by how plentiful the local bait fishes especially anchovies, may be.

Bluefin sometimes feed close inshore near the surf. Tuna captured in shallow water had eaten starfish, kelp, sanddabs, surf perches and white croakers, perhaps another factor in their migratory behavior" (Blunt 1958). (See Table IV).

3.5 Behavior

3.5.1 Migration and local movements

There is a local movement of bluefin tuna from Baja California waters to the southern California area in spring and summer. The year-around catches made some seasons about Guadalupe Island indicate a southern origin for the fishery (Blunt 1958). "The California bluefin tuna, Thunnus saliens, is a migratory species; which travels coastward into the rich feeding grounds near Guadalupe Island, Baja California and southern California each spring and summer and offshore again into the open ocean during the autumn. Unlike Pacific albacore, Thunnus germo, that usually stay offshore during their migrations, bluefin tuna seasonally concentrate around islands and near continental land masses" (Clemens 1961b). Some seasons bluefin tuna may first be observed about the Channel Islands but the heaviest catches are most frequently made in Baja California waters with the exception of the warm water years (see section 5.3.5). Observations of bluefin tuna to the north of Point Conception have been recorded in the late summer and in the autumn (Godsil 1949). When the fishing season draws to a close the last catches are often made in Baja California waters. The preliminary tagging that has been conducted does not conclusively support the belief in a spring movement north. Most authorities, Walford (1937), Blunt (1958), Clemens (1961a), do agree that bluefin tuna do migrate and probably most extensively, the records of widespread Pacific coast distribution and the confined commercial fishery with its seasonal appearance supports the migration theory.

3.5.2 Schooling

California bluefin tuna are a close schooling fish, found in unmixed schools, but occasionally individuals will appear with albacore. Purse seine sets yielding over 200,000 lb have been known. Some schools may extend over a quarter of a mile in area with an unknown depth. In August 1958, 8,000,000 lb were removed from a school group off San Benito Island. Thirty-six vessels participated in this catch with a revenue of over one million dollars to the fishermen (Anonymous 1958).

Table IV

California bluefin tuna stomach analysis

Food Item	Number of items	Number of stomachs in which these items appeared
Northern anchovies, Engraulis mordax	682	112
Jacksmelt, Atherinopsis californiensis	35	15
Squid, -----	32	16
Pacific mackerel, Pneumatophorus diego	3	3
Pacific sanddab, Citharichthys sordidus	6	5
White croaker, Genyonemus lineatus	3	2
Round herring, Etrumeus acuminatus	12	7
Jack mackerel, Trachurus symmetricus	5	5
Pompano, Palometa simillima	3	3
White seaperch, Phanerodon furcatus	3	3
Queenfish, Seriphus politus	2	2
Pacific saury, Cololabis saira	1	1
California flyingfish, Cypselurus californicus	1	1
Slim midshipman, Porichthys myriaster	1	1
Pacific sardine, Sardinops caerulea	1	1
Sea weed pieces	18	8
Empty		256
Starfish	Trace	
(Blunt, unpublished)		

4 POPULATION (STOCK)

4.1 Structure

4.1.1 Sex ratio

In all likelihood the sex ratio of the California commercial catch of bluefin tuna is 1:1. However, in a sample of 75 fish (770 to 892 mm in fork length) from the 1960 season, the ratio was 35 females to 40 males.

4.1.3 Size composition

Between 1951 and 1960, three to four modes can be distinguished in the California commercial catch. The 620 to 660 mm mode can be found in each year. The 750 to 880, the 900 to 1100, and the 1200 to 1400 mm modes are prominent but not as readily distinguishable.

"In the early 1900's bluefin in the landings ranged from 20 to 250 lb, although most of the catch consisted of fish weighing 100 lb and less. By 1949 the bulk of the catch consisted of individuals ranging from 10 to 40 lb. Larger fish (100 lb or more) were not uncommon, but they appeared primarily in the sporadic winter catches from Guadalupe Island. During the eight-year period 1950 throught 1957, bluefin larger than 50 lb were almost a rarity. In 1958 fairly large fish once again appeared in the catches, when fish ranging 40 lb and heavier were taken at Guadalupe Island along with a dozen or more in the 200 lb class. In 1959, quantities of 80-pounders appeared in the fishery and in 1960 large numbers of fish in the 100 lb class were caught. Small (15 lb) fish journey into the southern California fishing grounds regularly each season, while 25-pounders and heavier arrive occasionally. All sizes have been found to the south, although the appearance of large fish is erratic. As a rule, small bluefin are distributed throughout the grounds while large ones abound in the southern part.

"During the nine years 1950 to 1958, small fish were first to appear in the season's catches. The reverse was true during the 1960 season, when 80 to 100 lb bluefin appeared first. These large tuna apparently traveled northward for a considerable distance, because fair numbers were taken in September as far north as Cape Mendocino, California - one weighed 210 lb" (Clemens 1961a).

"Measures of the size composition of the catch show that since about 1951 the fishery has depended primarily upon fish weighing under 30 to 40 lb; probably representing at least four size or age classes. During 1959, and 1960, however, larger fish weighing 50 to 100 lb or more once again entered the fishery in fair numbers.

"An unsteady market demand, large fluctuations in availability, prolonged disappearance of large mature adults, seasonal nature of the fishery, and many other factors historically have resulted in a relatively low annual yield" (Clemens 1961b). For methods of measuring and weighing, see Fig. 4.

4.6 Relation of population to community and ecosystem, biological production etc.

In the southern range, the waters of Baja California, the California bluefin tuna is one of several schooling pelagic fish of large size competing for the abundant forage fishes of the region. In the southern California fishery, bluefin tuna compete to some extent with albacore. In both areas there are a number of smaller species along shore such as yellowtail, barracuda and mackerel which feed on the principal forage species such as sardines and anchovies; however, the large, highspeed and voracious bluefin schools probably dominate any feeding area they enter. Offshore the saury schools, in the main, not subject to heavy predation, seasonally support the albacore and may offer a transition feeding for entering bluefin tuna schools.

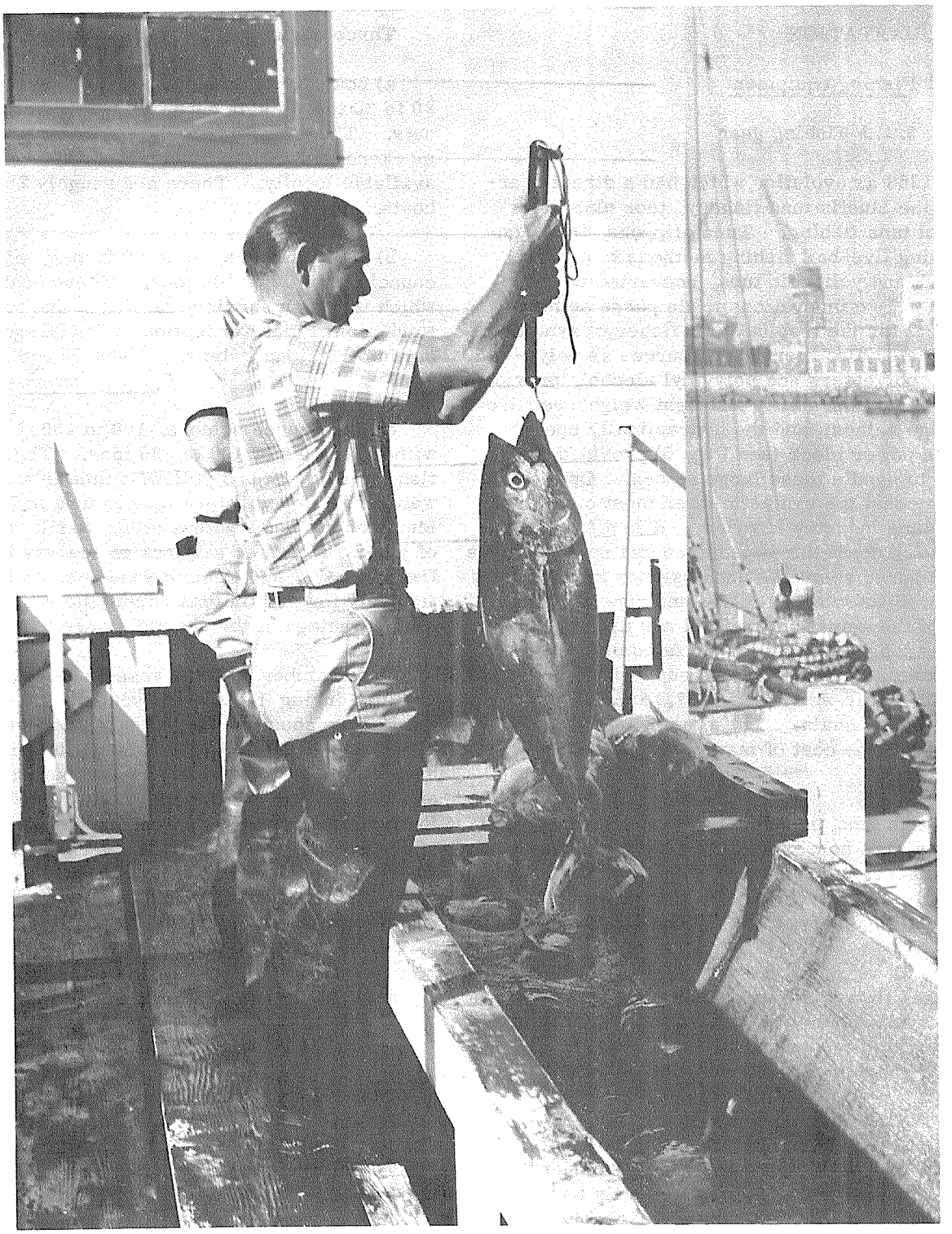

Fig. 4 Measuring and weighing California bluefin tuna at a cannery. (photograph by R. A. Iselin)

5 EXPLOITATION

5.1 Fishing equipment

5.1.1 Fishing gear

In 1958 a revolution, which had a direct bearing on the bluefin tuna fishery, took place in tropical tuna fishing. Tuna clippers, traditionally using live-bait fishing methods to capture skipjack and yellowfin tuna, converted to purse seines. Two innovations made purse seining practical for the tropical tuna fishery; synthetic seine materials, from such sources as polyamides, polyesters and polyvinyl alcohol, provided the strength, durability and light weight required for large seines; and the hydraulically operated Puretic power block (see Fig. 5) provided the means to handle these large seines. On the east Pacific coast the synthetic fiber most often used by the tuna industry is nylon. It is difficult to generalize about the dimensions and specifications of tuna purse seines as each skipper incorporates his own ideas into the design and construction. Some of the seines in the fleet are almost 500 fathoms long and most are 40 fathoms deep. Seven to nine thousand floats support the seine and the lead line is weighted with 7/16 or 5/8 in galvanized steel chain. These seines may weigh 15 tons and the cost of materials may exceed $60,000.

Bluefin tuna, never successfully taken by bait methods, are now exploited by the large tropical tuna seiners. The fleet of smaller vessels which regularly fish bluefin tuna also have converted to the synthetic fiber seines and the Puretic power block.

In addition, the bluefin tuna seiners are assisted by land-based spotting aircraft. These aircraft work on a share basis for several boats, sighting schools and directing the boats by radio.

5.1.2 Fishing boats

Southern California based boats conduct the bluefin tuna fishery off Baja California and southern California. It is not an exclusive fishery; bluefin tuna frequently are caught by boats principally engaged in other fisheries which turn to bluefin tuna when they make an appearance.

Three classes of boats take bluefin tuna.

a) boats 40 to 60 ft long, with capacities of 20 to 30 tons, using purse seines or lampara nets. These boats fish chiefly for sardine and mackerel but turn to bluefin tuna when they are available locally. There are roughly 25 such boats.

b) purse seiners, 60 to 90 ft long, with capacities of 50 to 100 tons. These boats, which may fish sardine, mackerel and tuna, work from Point Conception to San Diego and out into Mexican waters. About 50 are in operation.

c) tuna purse seiners, 100 to 150 ft long, with capacities of 100 to 380 tons. These boats fish for skipjack and yellowfin tuna in tropical waters. They will take bluefin tuna in both Mexican and local waters either to fill out a load of yellowfin tuna or skipjack on the way to port from Mexico and Central America, or they will fish only for bluefin tuna during the season to take advantage of the short distance to port.

"The number of large vessels has decreased steadily during the past ten years. At present the fleet is about 50 percent of what it was in 1950 in spite of the fact that large tuna clippers have converted to purse seine gear during 1958 and 1959. The number of 'local' vessels landing bluefin fluctuates markedly from year to year depending on general market conditions. Occasionally some of the lampara boats will catch bluefin, but the landings are very small and infrequent " (Clemens 1961b). Figs. 6, 7 and 8 show illustrations of tuna seiners.

5.2 Fishing areas

5.2.1 General geographic distribution

There are two important fishing areas for California bluefin tuna, the waters off southern California and the waters of Baja California. These constitute the entire fishery. Catches made outside this range have had no commercial importance in the past.

In the waters of Baja California the following are important fishing areas :

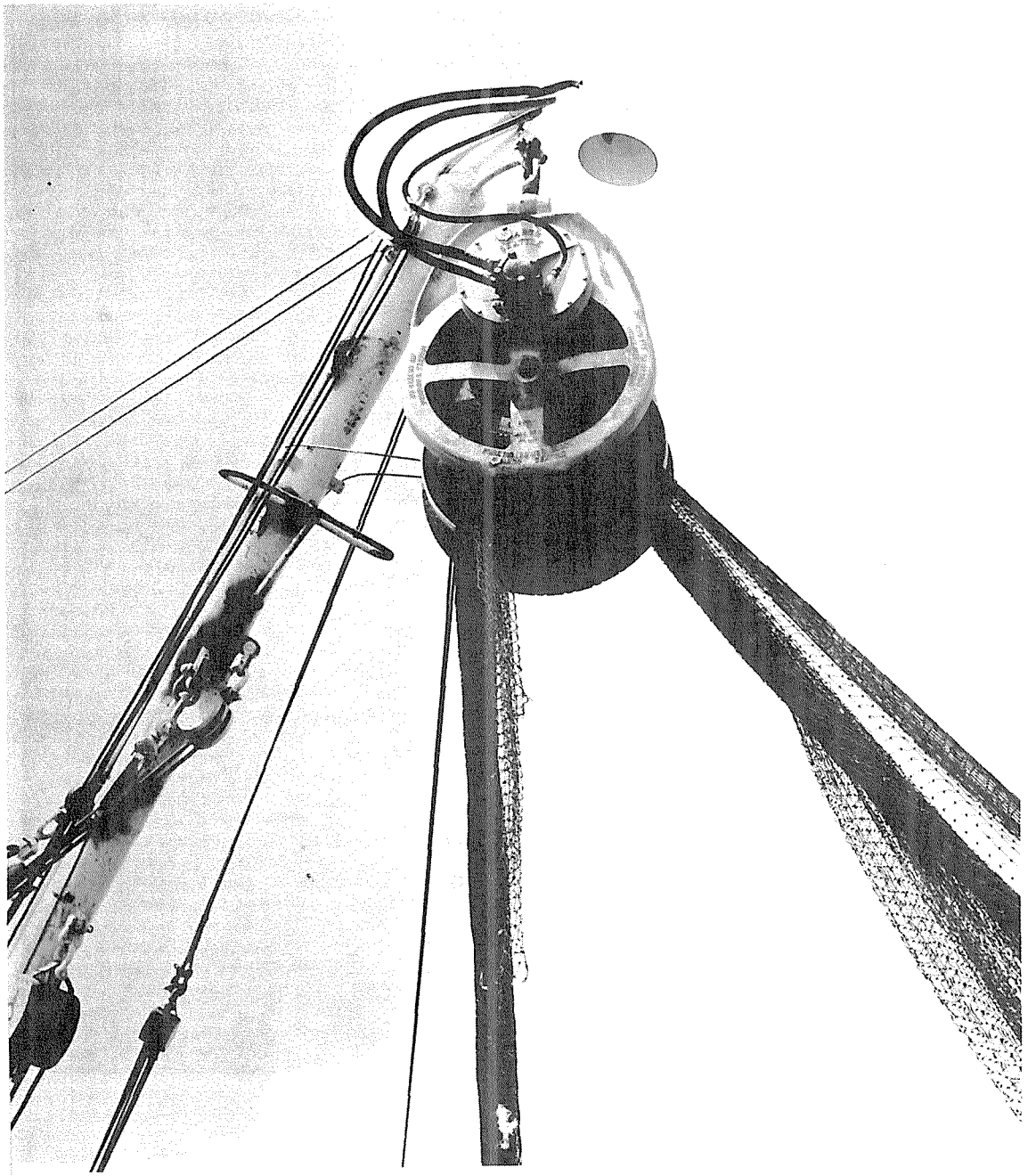

Fig. 5 The puretic power block. (Photograph by R.A. Iselin)

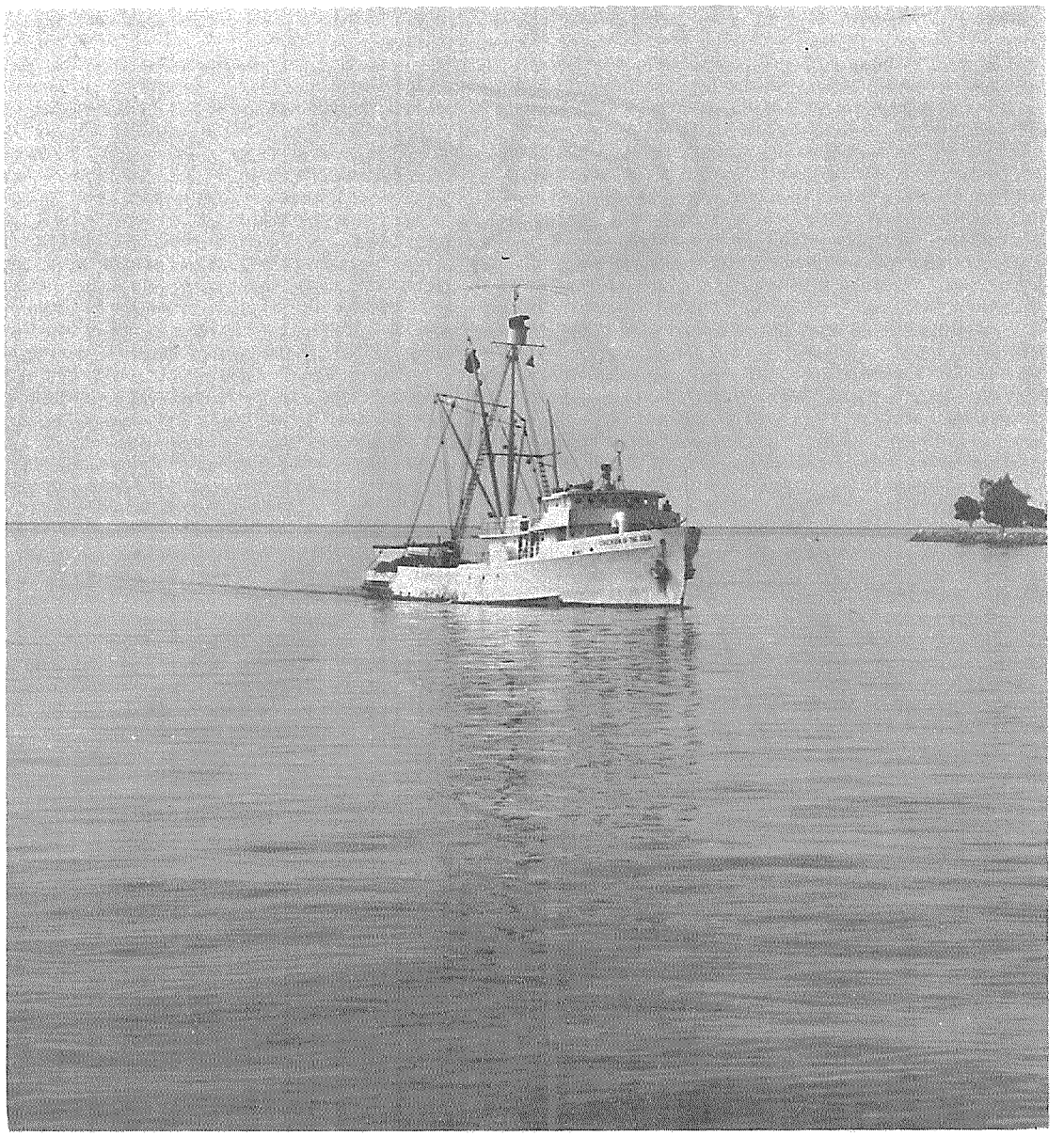

Fig. 6 Tuna seiner entering Los Angeles Harbor after being on the Pacific tuna grounds. (Photograph by R. A. Iselin)

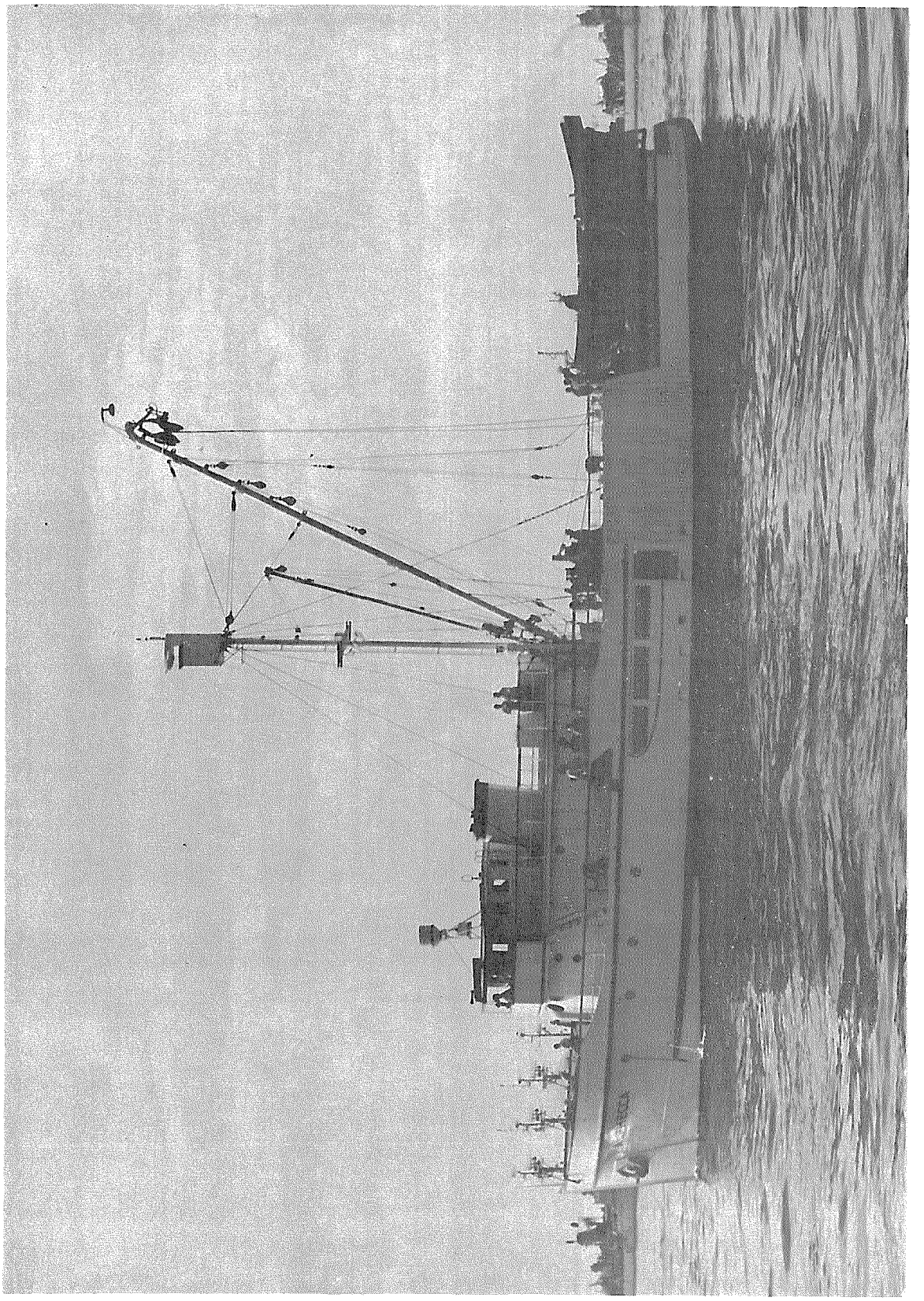

Fig. 7 Tropical tuna seiner, a vessel which seasonally engages in the bluefin tuna fishery.
(Photograph by J.J. Seapin)

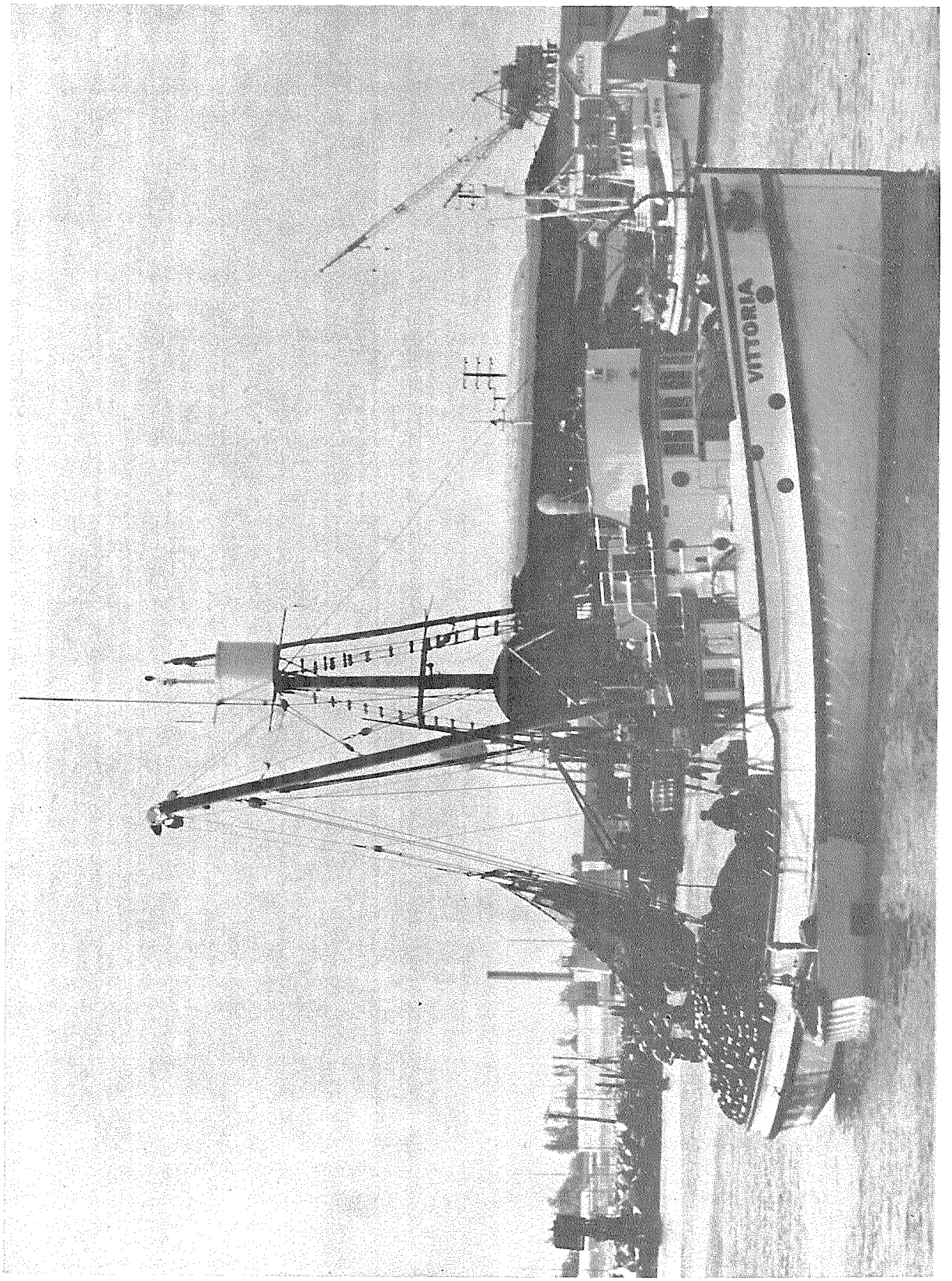

Fig. 8 Local purse-seiner of medium class. (Photograph by R. A. Iselin)

a) Los Coronados Islands
32° 20' N lat., 117° 17' W long.

b) Guadalupe Island
29° 11' N lat., 118° 17' W long.

c) San Benito Island
28° 19' N lat., 115° 35' W long.

d) Ranger Bank
28° 35' N lat., 115° 30' W long.

e) Cerros Island
28° 15' N lat., 115° 16' W long.

f) Natividad Island
27° 50' N lat., 115° 08' W long.

g) Abreojos Point
26° 42' N lat., 113° 34' W long.

h) Uncle Sam Bank
25° 37' N lat., 113° 23' W long.

i) Alijos Rocks
24° 57' N lat., 115° 45' W long.

j) San Geronimo Island
29° 45' N lat., 115° 52' W long.

k) Thetis Bank
24° 53' N lat., 112° 36' W long.

l) Cape San Lazaro
24° 48' N lat., 112° 19' W long.

m) Morgan Bank
23° 27' N lat., 111° 13' W long.

n) Rosa Bank
26° 10' N lat., 115° 00' W long.

o) Sebastian Viscaino Bay
28° 13' N lat., 114° 45' W long.

p) Santa Margarita Island
24° 25' N lat., 111° 43' W long.

q) 13 Fathom Bank
25° 44' N lat., 113° 09' W long.

r) Cape Colnett
30° 57' N lat., 116° 19' W long.

s) 60 Mile Bank
32° 08' N lat., 118° 18' W long.

t) 23 Fathom Spot
25° 21' N lat., 112° 51' W long.

In the waters of southern California the following are important fishing areas:

a) Cortes Bank
32° 30' N lat., 119° 09' W long.

b) San Clemente Island
32° 50' N lat., 118° 30' W long.

c) The Channel Islands
34° 00' N lat., 120° 00' W long.

d) Tanner Bank
32° 41' N lat., 119° 04' W long.

e) Osborn Bank
33° 11' N lat., 119° 03' W long.

5.2.2 Geographical ranges (latitudes, distances from coast, etc.)

The major fishery extends from 34°30' N in the north to 23° 10' N in the south. The farthest west longitude is 120° 30' W. The fishery seldom extends beyond 150 miles offshore and is confined in all areas to waters about banks and islands or along the coast. For principal fishing areas in California waters, see Fig. 9.

5.2.3 Depth ranges

The California bluefin tuna is caught in surface waters. Nets fishing as deep as 40 fathoms presumably catch fish near that depth.

5.3 Fishing seasons

5.3.1 General pattern of fishing season

This is a summer fishery beginning about May and lasting until September. As mentioned above, catches have been made every month of the year but these have been small, sporadic and distributed over a number of seasons.

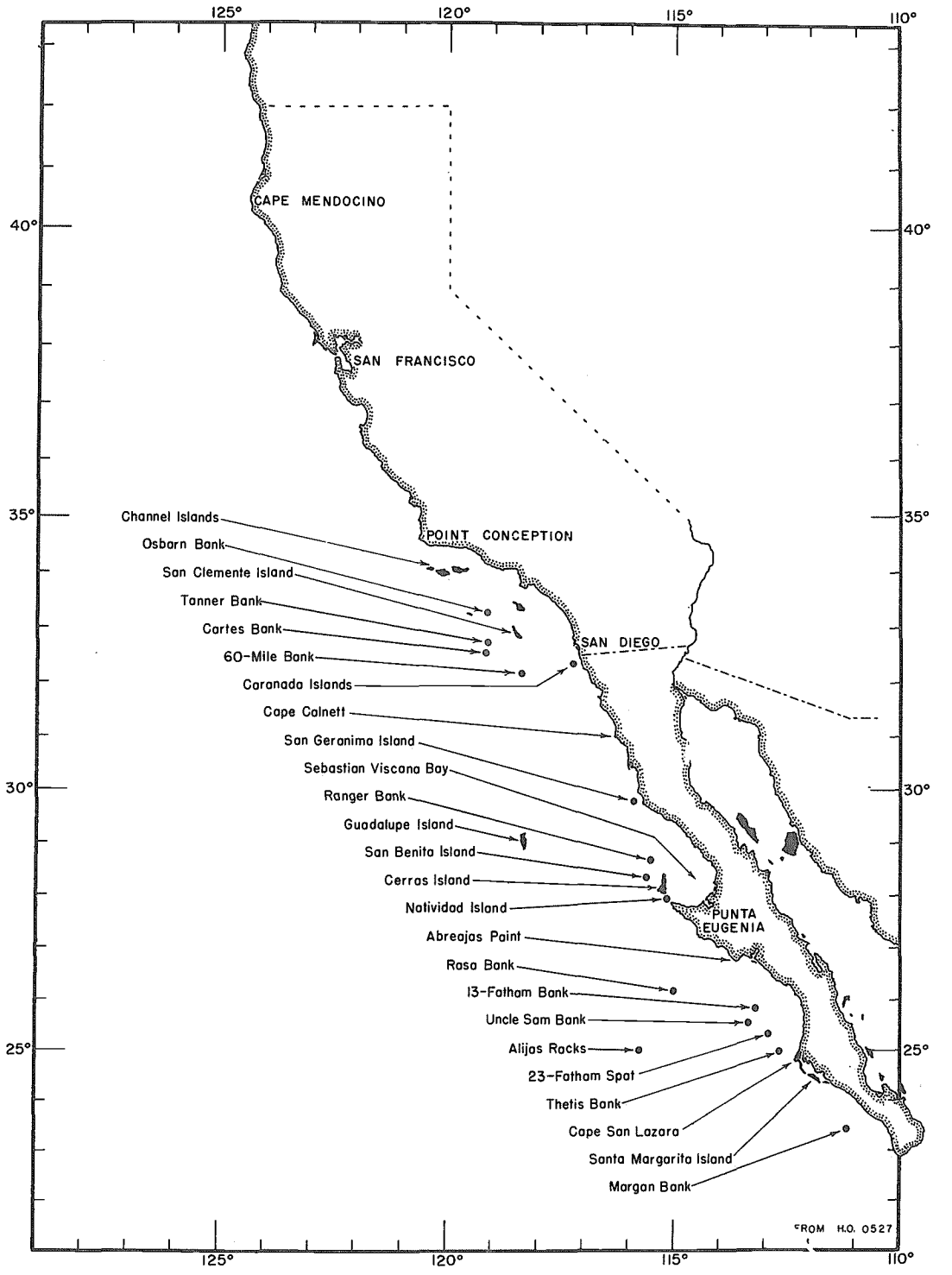

Fig. 9 Principal fishing areas of the California bluefin tuna.
(Prepared by R. A. Iselin)

5.3.2 Duration of fishing season

The fishing season lasts about five months.

5.3.3 Dates of beginning, peak and end of season

There are no California laws governing the fishing season. The appearance of fish each spring and their departure each autumn determines the season. The catch is small in May, increases until July and August and then declines in the autumn.

5.3.4 Variation in time or duration of fishing season

The beginning of the fishing season has varied between April and July and the close has varied between September and November or December.

5.3.5 Factors affecting fishing season

Climatic and oceanographic factors are probably most influential in determining the beginning, duration and end of the commercial fishery. Sea surface temperatures, position of currents, appearance of upwelling -- all make major contributions to changing the character of the summer habitat. This in turn must influence the development of the fishery to a major degree.

"Water conditions determine if best fishing is to be found by day or night. If bluefin are in 'dirty' water they cannot readily see the net and are not frightened into sounding when encircled; thus good fishing occurs during daylight hours. If they are in clear water, however, they can see the net during the daytime and so night fishing, especially during the dark of the moon, is more successful" (Clemens 1961b).

A correlation can be observed between the warmwater years phenomenon (Radovich 1961) and the catch of bluefin tuna. The southern California catch during the warmwater years of 1957, 1958 and 1959 was compared with the Baja California catch during the same years. This in turn was compared with the previous three years of 1954, 1955 and 1956 (Table V). The southern California area, traditionally a second place contributor to the total California landing became a prominent catch origin during the warmwater years. There appears to be a correlation with sea surface temperatures but it could also be a result of many unmeasured properties attendant on the warmwater phenomenon. (See Hester 1961).

Table V

The southern California and Baja California bluefin tuna catch compared with warmwater years and three years previous

Year	Southern California Catch	Baja California Catch
	lb	lb
1954	5,647,572	15,377,248
1955	2,477,735	11,131,442
1956	2,612,046	10,013,922
Warmwater Years		
1957	10,462,534	9,851,982
1958	15,609,801	15,109,431
1959	13,126,174	2,169,236

5.4 Fishing operations and results

5.4.1 Effort and intensity

The average catch per day's fishing for the two high production months of July and August have been computed for the years 1952 through 1958. This is based on vessels catching bluefin tuna exclusively (Table VI). The catch per trip for the years 1949 through 1960 is also given (Table VII).

5.4.2 Selectivity

The fishery is highly selective. Species other than bluefin tuna are not usually caught in a purse seine set for bluefin tuna. Occasionally dolphin and a few albacore and skipjack find their way into a seine that is being set on bluefin.

5.4.3 Catches

The California commercial bluefin tuna catches for the years 1918 through 1960 are given in Table VIII. Monthly landings by origin and landing port are found in Tables IX through XIX.

The sport catches for 1936 through 1960 are found in Table XX.

Table VI

Average catch per day's fishing 1952 - 1958
(July and August)

Year	Catch per day
	lb
1952	7, 860
1953	5, 560
1954	9, 300
1955	11, 420
1956	5, 900
1957	12, 200
1958	23, 200

Table VII

Average catch per trip 1949 - 1960

Year	Number of trip	Catch per trip
		lb
1949	290	15, 017
1950	36	78, 821
1951	172	22, 333
1952	215	21, 245
1953	436	22, 528
1954	709	30, 524
1955	422	33, 004
1956	273	46, 778
1957	484	42, 645
1958	610	50, 352
1959	390	40, 282

Table VIII
California bluefin tuna landings, shipments and value

Year	Origin of Landings: California	Origin of Landings: South of the International Boundary	Total Landings lb	Shipments lb	Total Landings and Shipments lb	Value of Landings and Shipments U.S.$
1918			6,000,000			
1919			14,990,860			
1920			10,530,272			
1921			1,971,813			
1922			2,811,283			
1923			3,218,090			
1924			3,241,110			
1925			3,803,677			
1926			6,526,533			
1927			4,898,465			
1928			13,700,870			
1929			7,526,857			
1930			21,921,282			
1931			3,534,030			
1932			1,071,206			
1933			560,492			
1934			18,357,828			
1935			25,173,083			
1936			18,924,883			
1937			12,693,922	430	12,694,352	
1938			17,728,031			
1939			11,835,715			
1940			19,970,268			
1941			9,519,012			
1942			12,844,564			
1943			10,178,768			
1944			20,343,550			
1945			20,594,309			
1946			22,031,791			
1947			20,837,634			
1948	1,693,760	4,835,047	6,528,807	168,180	6,696,987	1,124,538
1949	2,266,155	2,123,235	4,389,390	...	4,389,390	712,702
1950	9,339	2,729,624	2,738,963	107,878	2,846,841	438,500
1951	837,185	3,025,209	3,862,394	2,112	3,864,506	604,352
1952	907,215	3,669,470	4,576,685	...	4,576,685	733,224
1953	3,903,642	5,868,973	9,772,615	62,447	9,835,062	1,560,385
1954	5,647,572	15,377,248	21,024,820	638,286	21,663,106	3,655,684
1955	2,477,735	11,131,442	13,609,177	343,346	13,952,523	1,985,392
1956	2,612,046	10,013,922	12,625,968	162,875	12,788,843	1,669,979
1957	10,462,564	9,851,982	20,314,546	323,024	20,637,570	2,449,432
1958	15,609,801	15,109,431	30,719,232	529,428	31,248,660	4,097,140
1959	13,126,174	2,169,236	15,295,410	522,128	15,817,538	1,952,934
1960	4,339,031	7,613,480	11,952,511	1,227,771	13,180,282	1,633,062

Table IX
Monthly landings of bluefin tuna (lb) into San Diego area
Origin: California Waters

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
1947						9, 621	58, 602	53, 369					121, 592
1948							1, 242	186	61				1, 489
1949							6, 359	21, 037	280				27, 676
1950								552	697				1, 249
1951							22, 739		6, 235		82	12, 805	41, 861
1952						23, 425	73, 980	9, 498	13, 760	10, 383			131, 046
1953						57	153, 466	128, 116					281, 639
1954					97, 791	146, 041	311, 503	191, 845	12, 491			46	759, 717
1955					46, 751	322, 183	172, 700	18, 972					560, 606
1956							21, 611	4, 886	23, 653				50, 150
1957						12, 719	34, 506	116, 359	87, 456	39	67		251, 146
1958				6, 598	46, 809		120, 286	826, 832					1, 000, 525
1959				62, 649	61, 898	223, 281	532, 046	16, 670				170	896, 714
1960													

Table X
Monthly landings of bluefin tuna (lb) into San Diego area
Origin: Waters South of State Border

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
1947							164, 973	26, 091	153				191, 217
1948							73, 148	1, 502	1, 820	16, 370	640		93, 480
1949								212	7, 299	58, 541			66, 052
1950	57, 093	54, 472		10, 370			89	2, 381	5, 581				129, 986
1951							5, 685	53, 366	233, 882	56, 177			349, 110
1952					11, 007	5, 794	72, 374	132, 304			3, 167		224, 646
1953							461, 920	542, 953	94, 824	83, 635		9, 348	1, 192, 680
1954					30, 897	50, 151	3, 166	658, 952	42, 423				785, 589
1955						120, 349	10, 589	186, 568		64	45, 360		362, 930
1956					104		40, 927	669, 486	13, 843	150, 559	645		875, 564
1957	116					402, 299	48, 187	927, 850	93, 102				1, 471, 554
1958							1, 186, 204	664, 612	583, 569	3, 207			2, 437, 592
1959			23, 067			77, 428							100, 495
1960													

Table XI
Monthly shipments of bluefin tuna (lb) into San Diego area

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
1947													
1948													
1949													
1950													
1951							2, 112						2, 112
1952													
1953													
1954						152, 118	220, 640	72, 607		5, 660			451, 025
1955													
1956													
1957							321, 824						321, 824
1958							327, 864	78, 438	46, 133				452, 435
1959													
1960													

Table XII
Monthly landings of bluefin tuna (lb) into Los Angeles area
Origin: California Waters

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
1947						60, 649	931, 130	6, 907, 766	6, 394, 397	332, 843			14, 626, 785
1948							59, 383	1, 396, 778	227, 439				1, 683, 600
1949						151	812, 440	1, 090, 585	335, 231	72			2, 238, 479
1950						2, 119	2, 472	3, 467			32.		8, 090
1951							360, 000	375, 616	8, 963	24, 583	25, 750		794, 912
1952					57	20, 818	289, 138	442, 296	23, 730	130			776, 169
1953							854, 383	1, 682, 268	453, 435	498, 198	10, 359	10, 717	3, 509, 360
1954				1, 000	296, 772	750, 667	562, 878	1, 697, 498	1, 232, 428	27, 617	43	211, 000	4, 779, 903
1955	193, 869				33, 096	854, 514	275, 309	431, 881	91, 167		22, 200	15, 093	1, 917, 129
1956					20		65, 805	1, 333, 097	718, 754	11, 391	432, 829		2, 561, 896
1957					36	147, 159	3, 126, 326	5, 509, 859	882, 698	335, 485			10, 001, 563
1958				880, 406	1, 697, 214	320, 353	2, 563, 463	6, 024, 364	2, 997, 988	125, 462			14, 609, 250
1959				4, 020, 066	83, 753	104, 449	3, 507, 059	3, 556, 868	855, 035				12, 127, 230
1960													

Table XIII
Monthly landings of bluefin tuna (lb) into Los Angeles area
Origin: Waters South of State Border

Yr	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
47		957, 503	1, 576, 809	480, 192	259, 997	119, 950	1, 399, 739	983, 963	60, 394	52, 248			5, 890, 795
48	265, 657	638, 450	302, 070		26, 750	52, 371	1, 752, 711	1, 563, 965	139, 593				4, 741, 567
49	109, 985	943, 081	204, 031		7, 350	210, 479	56, 090	132, 172	104, 833	2, 500		56, 164	1, 826, 685
50	734, 150	592, 433	37, 832				64, 009	513, 791	447, 145		210, 278		2, 599, 638
51	251, 308	69, 125		700			400, 807	827, 531	1, 058, 399			1, 134	2, 609, 004
52	150					184, 803	439, 704	2, 679, 533	140, 634				3, 444, 824
53			18, 800				708, 405	2, 143, 603	1, 395, 424	331, 090	1, 000	77, 971	4, 676, 293
54	560, 505	317, 190	29, 820	238, 611	54, 831	394, 638	5, 717, 255	4, 554, 165	2, 054, 318	234, 339	45, 970	390, 017	14, 591, 659
55	47, 820	54, 517	137, 617		39, 630	74, 968	592, 137	6, 609, 648	511, 931	49, 514	794, 154	1, 235, 998	10, 147, 934
56					313, 706	2, 478, 487	452, 361	3, 212, 879	1, 888, 001	497, 866	275, 039	150	9, 118, 489
57		290, 047	5, 552			952, 513	3, 769, 617	3, 073, 099	289, 600				8, 380, 428
58		435, 458	494, 080	6, 583	9, 825	302, 325	8, 150, 346	2, 839, 535	427, 017	6, 670			12, 671, 839
59	28, 696	205, 395	33, 014	2, 966	119, 411	2, 875	646, 039	735, 652	274, 815		1, 253	625	2, 068, 741
60													

Table XIV
Monthly shipments of bluefin tuna (lb) into Los Angeles area

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
1947													
1948									45, 156	91, 791			136, 947
1949													
1950													
1951													
1952													
1953									60, 371	2, 076			62, 447
1954												187, 261	187, 261
1955	162, 384			180, 962									343, 346
1956			162, 875										162, 875
1957							1, 200						1, 200
1958							76, 993						76, 993
1959					42, 964		279, 852	124, 838				21, 584	469, 238
1960													

Table XV
Monthly landings of bluefin tuna (lb) into Santa Barbara area
Origin: California Waters

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
1947						47		806	6, 392				7, 245
1948								9	8, 662				8, 671
1949													
1950													
1951								412					412
1952													
1953							54, 335	58, 308					112, 643
1954					6, 528	56, 765	24, 297	2, 222	18, 140				107, 952
1955													
1956													
1957							73, 019	75, 055	61, 696				209, 770
1958										26			26
1959							102, 230						102, 230
1960													

Table XVI
Monthly landings of bluefin tuna (lb) into Monterey area
Origin: Waters South of State Border

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
1947													
1948													
1949		7, 793											7, 793
1950													
1951									67, 095				67, 095
1952													
1953													
1954													
1955										183, 619			183, 619
1956					19, 869								19, 869
1957													
1958													
1959													
1960													

Table XVII
Monthly landings of bluefin tuna (lb) into the Eureka area
Origin: California Waters

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
1947													
1948													
1949													
1950													
1951													
1952													
1953													
1954													
1955													
1956													
1957										85			85
1958													
1959													
1960													

Table XVIII
Monthly landings of bluefin tuna (lb) into San Francisco area
Origin: Waters South of State Border

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
1947													
1948													
1949		222, 705											222, 705
1950													
1951													
1952													
1953													
1954													
1955									244, 491	192, 468			436, 959
1956													
1957													
1958													
1959													
1960													

Table XIX
Monthly shipments of bluefin tuna (lb) into San Francisco area

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
1947													
1948		31, 233											31, 233
1949													
1950	60, 340				47, 538								107, 878
1951													
1952													
1953													
1954													
1955													
1956													
1957													
1958	Atlantic Bluefin Tuna										9, 090		9, 090
1959	Atlantic Bluefin Tuna										32, 610		32, 610
1959								2, 200				50, 690	52, 890
1960													

Table XX
California bluefin tuna party boat sport catch
1936 - 1961

Year	Number of fish landed
1936	2, 920
1937	4, 020
1938	11, 927
1939	9, 909
1940	6, 878
1941)	
1942)	War
1943)	years,
1944)	no
1945)	data
1946)	
1947	2, 194
1948	104
1949	1, 941
1950	27
1951	7, 142
1952	145
1953	4, 276
1954	966
1955	8, 179
1956	34, 187
1957	6, 428
1958	884
1959	1, 330
1960	97
1961	

(Young, unpublished)

5.4.4 Past and present factors of effect on operations and results

In the early days, California bluefin tuna were subjected to a limited fishery by Santa Catalina Island based sportsmen who sometimes resorted to exotic fishing methods. California bluefin tuna are difficult to catch with hook and line and these sportsmen often used kites to carry their lines far behind the trolling boats. The bluefin was a trophy caught with difficulty and considerable effort although it entered southern California waters in abundance. During this time the bluefin was virtually unexploited by commercial interests but in 1914 the West Coast industry first considered the use of seines, although the first significant catch was not made until 1918. In 1919 the purse seine was used and the postwar demand for fish was responsible for the sharp increase in production; in 1921 a postwar depression lowered the demand and the catch dropped abruptly, but recovered in 1923 when economic conditions improved.

Between 1924 and 1929, a pattern developed in which the fishing season began at the Mexican border and worked north to the Channel Islands as the season progressed. In 1930 this pattern was broken as the first catches were made south of the Mexican border.

In 1931 a minimum size limit of 9 lb was set. In 1933 this was lowered to 7-1/2 lb.

California boats fishing in Mexican territorial waters must purchase licenses and satisfy various fees applied to boat tonnage and nets. The sum of these fees and licenses often exceeds $1,500 for each fishing trip regardless of catch.

This may have a limiting influence on the fishery south of the International Boundary. It must certainly limit marginal operations to fishing home waters.

Since the bluefin tuna fishery is not a distinct fishery exploited exclusively by a single fleet, it is difficult to locate correlating factors which will explain the fluctuation in the catch; we do know that price, demand and equipment are influential.

5.5 Fisheries Management and Regulations

Management and regulation of the California bluefin tuna fishery is principally a responsibility of the California State Department of Fish and Game. Regulation is minimal and management is expressed in research exclusively.

There are no California regulations or laws which affect the bluefin tuna fishery to an appreciable degree. The California Fish and Game Code minimum size limit (Article 9, Section 8375) which prevents the sale, purchase or processing of bluefin tuna below 7-1/2 lb weight is not an operation factor; bluefin tuna this small are seldon caught. In 1931 a minimum size was set at 9 lb and a maximum size was set at 150 lb. In 1933 the minimum size was lowered to 7-1/2 lb. The 150 lb maximum was suspended from 1945 until 1955. Two years later, in 1957, the 150 lb maximum size limit was deleted. The sportfishing bag limit of 10 bluefin tuna (Title 14, Article 5, Section 78.1) has no effect on the population.

The two southern California areas currently closed to round haul nets, Santa Monica Bay and the lee side of Santa Catalina Island, probably do not reduce the take of bluefin tuna and a weekend closure within three miles of the coast of Orange County is without effect on the fishery.

There are no Federal laws or regulations which apply directly to the bluefin tuna fishery. Bluefin tuna are admitted duty-free iced or frozen. The 35 percent ad valorem duty for tuna canned in oil and the 12.5 percent duty (25 percent duty over quota) canned in brine tuna has no individual effect on the California bluefin tuna fishery but protects the domestic tuna industry as a whole.

In the California State organization reduced staffs and appropriations restrict tuna research to California bluefin tuna and Pacific albacore. It is anticipated that a moderately increased program will be conducted on the California bluefin tuna and the Pacific albacore in the near future. In the past, California bluefin tuna research has been modest. The identification of the California bluefin tuna summer habitat certainly requires increased refinement and the preliminary delimitation of the winter habitat is

yet to come. The adjunct investigation of migration behavior and routes is one of the first areas of research to be approached.

"California bluefin research first started in 1931 with a catch analysis by S.S. Whitehead. He concluded that during the period studied (1924-1930) the stocks of bluefin appeared adequate to support the fishery. He felt that no protection was necessary at that time, but a continuation of boat catch analysis should be made.

The next major contribution was in the field of anatomy and systematics. Godsil and Byers published a complete anatomical description, and compared the California bluefin with the Japanese bluefin. The Japanese bluefin was found to be remarkably similar. Two characters appeared to differ which they though would be substantiated by direct comparisons at a later date.

Godsil and Holmberg compared California bluefin with New England and Australian southern bluefin, and published the results in 1950. The Australian bluefin was found to be distinct from the remaining members of the genus. The California and the Atlantic forms differed in a number of characters and could be individually distinguished.

In 1952, Department personnel commenced collecting length frequency data and by 1954 a routine program had developed. The program was further expanded in 1955 when bluefin logbook data were saved and fishermen were interviewed whenever possible. Further expansion of research has been curtailed because of budgetary limitations" (Clemens 1961b).

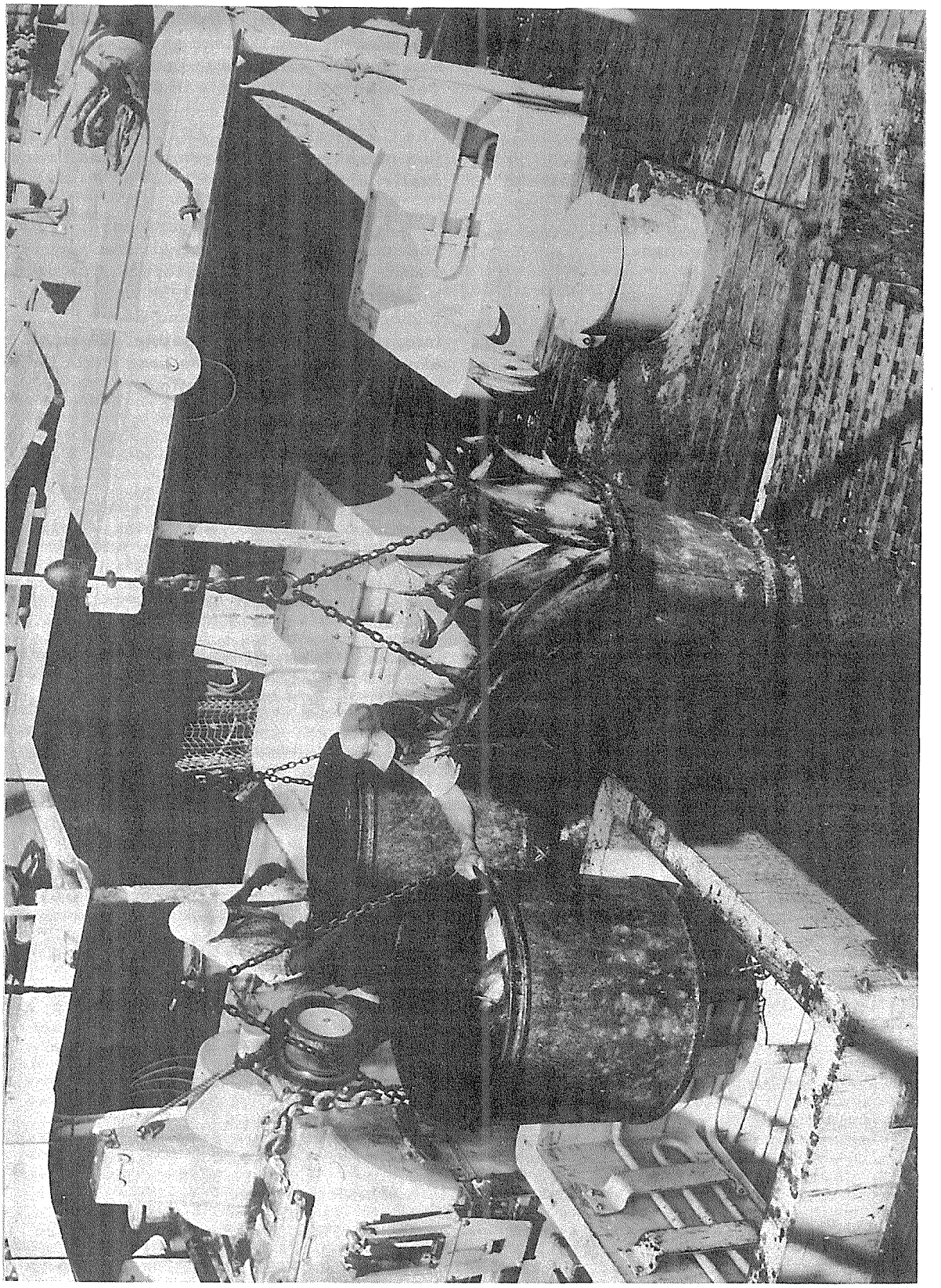

Fig. 10 Unloading California bluefin tuna at Terminal Island. (Photographed by R.A. Iselin)

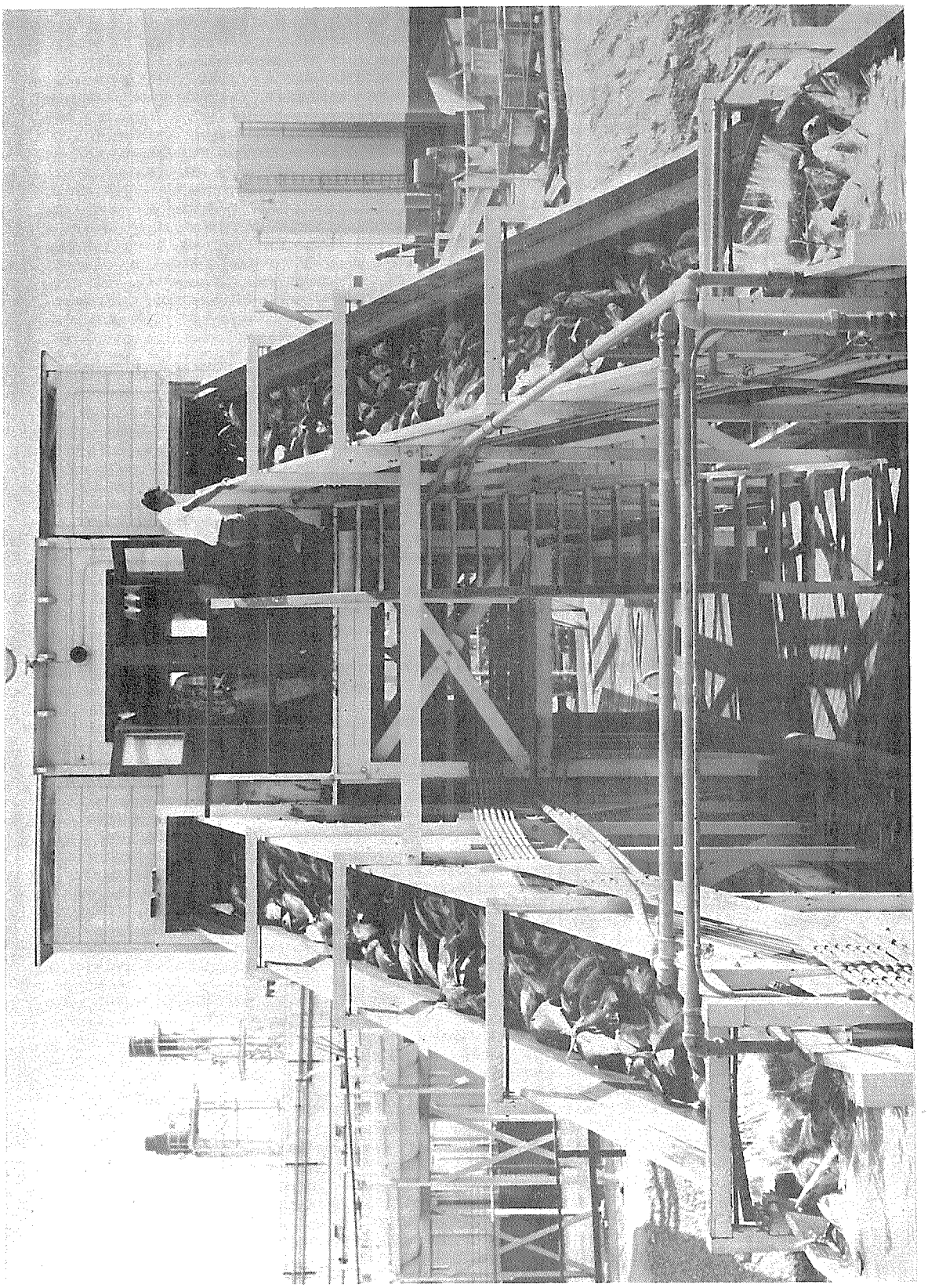

Fig. 11 California bluefin tuna entering a cannery weight tower at Terminal Island, California. (Photograph by R. A. Iselin)