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A Study of The Yellowtail Seriola Dorsalis (Gill)

By
JOHN L. BAXTER
AND A STAFF OF ASSOCIATES
1960

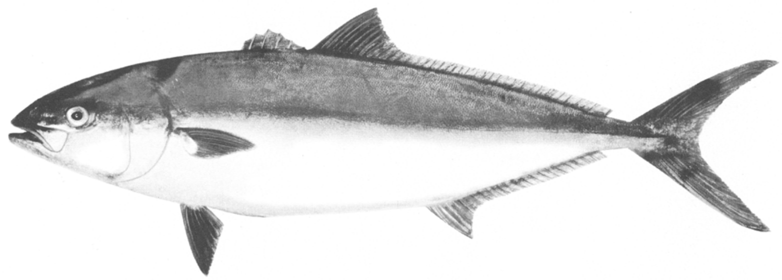

FIGURE 1. Yellowtail—*Seriola dorsalis* (Gill 1864)

FIGURE 1. Yellowtail—Seriola dorsalis (Gill 1864)

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FOREWORD

This work was performed as Dingell-Johnson Project California F-1-R, "Yellowtail Study," supported by Federal Aid to Fish Restoration funds. As with any work of such magnitude, its success resulted from the aid, advice and participation of many people. Between the time of inception and completion there was a complete turnover of personnel.

Robert D. Collyer helped organize the project and initiated, directed and participated in all of the studies. After Mr. Collyer left State service, the task of directing the final stages of the work and publication of this bulletin was assigned to John L. Baxter.

William L. Craig was an initial project member. Although promotion brought his assignment to other duties, he willingly finished his segments of the investigation. His counsel and advice on many phases were invaluable.

Harry M. Mekjian was associated with the yellowtail study for three years. Before leaving State service to enter private industry, his efforts resulted in the successful age determination of yellowtail. His redescription of the species also has a most worthwhile place in this publication.

Clyde V. Paul and Emil J. Smith, Jr. joined the staff of the project in its final stages. Their ability to analyze the data at hand, describe the results and draw conclusions with little prior knowledge of project activities was largely responsible for the successful completion of this report. Mr. Paul also prepared the section on sportcatch in relation to ocean temperatures which appears in the paper entitled "The Sport and Commercial Fisheries."

Ed V. Dwyer was a charter member of the Yellowtail Project. Before transferring to the Department's Inland Fisheries Branch in 1954, he participated in much of the early field work and many of the methods he instigated were used throughout the study.

The project was also fortunate in having very competent seasonal aid help. Jo Ann Spangler and Alan G. Lewis performed much of the tedious and time-consuming laboratory work. Mr. Lewis also participated in the field work.

Credit for drafting and lettering the illustrations belongs to Richard J. Nitsos and William J. Donnelly.

John E. Fitch, Phil M. Roedel and Dr. Frances N. Clark supervised the project and gave much valuable counsel and advice.

At one time or another almost every staff member of the California State Fisheries Laboratory participated in project activities.

The captains and crews of the Department's research vessels assisted immeasurably in the work at sea.

Numerous individuals and organizations contributed both time and financial support to many phases of the investigation. Notable were Charles Crawford; Ben and George Fukuzaki, and the crew of the vessel *Stella Maris;* Bill and Jack Horner, and the crew of the vessel *American Venture;* Ralph Larrabie; Claude M. Kreider; Marineland of the Pacific, particularly Kenneth F. Norris, Frank Brocato and Frank Calandrino; the Ocean Fish Protective Association; the Sefton Foundation; the many party fishing boat and landing operators, particularly the H & M Sportfishers, and the Point Loma Sportfishing Association.

To all of the above and the many others who helped in so many ways, go sincere appreciation and profound thanks.

JOHN L. BAXTER
March, 1960

1. INTRODUCTION

The yellowtail enjoys an unique position among California marine fishes. As a sportfish it is highly favored and one of the most sought-after. The beginner and veteran angler both hold it in high regard for its fighting ability. As a commercial species, yellowtail definitely take a back seat, being relegated to at least a second-rate position in desirability.

It is the largest member of the jack family, Carangidae, found in California waters. Their geographical distribution at one time or another has covered the area from southern Washington, (Hubbs, 1948) to Mazatlan, Mexico. In the Gulf of California it ranges only as far north as the vicinity of Los Angeles Bay, Baja California. The present economic range is from Los Angeles County, California to Cape San Lucas, Baja California.

Decreased catches in the area fished by California anglers during the years immediately following World War II caused considerable apprehension and led directly to the establishment of this investigation in January, 1952. The principal objectives of the study were to determine: the geographic origin of the yellowtail appearing each year in the areas fished by California-based anglers; the effects of fishing on the population; and, life history information on which to base wise management practices.

The material for life history studies was obtained throughout the year from three principal sources—fish sampled at the canneries, specimens saved in conjunction with tagging operations and catches made by anglers on party fishing vessels.

Cannery sampling began in 1952 and provided the bulk of the material. Fifty yellowtail from each boatload were weighed, measured, sexed and aged. Ovary and stomach samples were taken from one (usually the first) fish in every 100 mm. size group, preserved in 10 percent formalin and labeled as to date, locality and method of capture. After cannery demand for yellowtail became practically nil following 1954, other sources had to be found.

Special samples collected during tagging cruises were important sources of material, particularly after cannery sampling was no longer possible. There were always some casualties—fish swallowed the hook, their gills were damaged, they were out of water too long or otherwise expired. These were always saved.

Anglers and commercial fishermen were encouraged to return tagged yellowtail with the tags in place and the fish not beheaded or cleaned. This source provided a number of excellent specimens.

A September, 1955 tagging cruise aboard the commercial purse seiner *Stella Maris* provided much needed samples. During this cruise, the

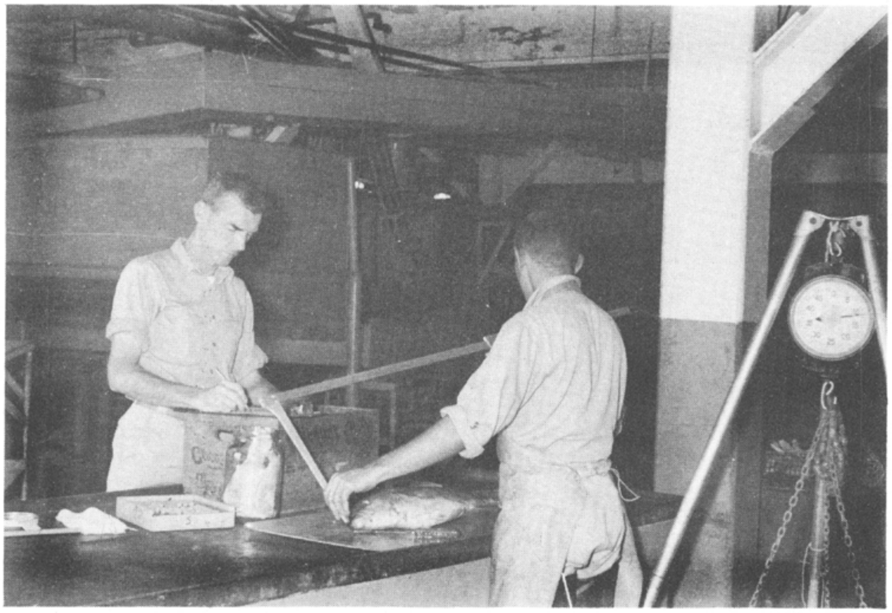

FIGURE 2. Measuring commercially caught yellowtail at the cannery. The gallon jar contains samples of stomachs and ovaries for food and maturity studies. The box beside it contains vials of scale samples for age and growth studies. *Photo by Robert D. Collyer.*

FIGURE 2. Measuring commercially caught yellowtail at the cannery. The gallon jar contains samples of stomachs and ovaries for food and maturity studies. The box beside it contains vials of scale samples for age and growth studies. Photo by Robert D. Collyer.

first 25 fish from each of three sets were saved for study and the remainder tagged and released.

The other source of material was fish caught by anglers aboard party fishing vessels. The necessary data and materials were collected during the vessels' return trip to port from the fishing grounds. *John L. Baxter.*

2. A REDESCRIPTION OF THE YELLOWTAIL

The yellowtail has been redescribed by a number of investigators since Theodore Gill wrote his original description in 1864. These are of questionable value because they seldom were adequate or complete and usually were either based on a minimum of specimens or were a rehash of someone else's work.

In the present study, eight meristic counts and 29 body measurements were made on each of 210 specimens, 357 to 970 mm. standard length, captured throughout most of the geographic range of the species (Table 1). No significant differences were found among specimens from different localities so all were combined for a composite description (Table 2).

2.1. Methods of Making Counts and Measurements

With the following exceptions measurements and counts were in accordance with those recommended by Hubbs and Lagler (1947). All measurements are straight line distances taken with calipers or dividers.

Fork length is the distance from the snout to the tips of the middle rays at the fork of the tail.

Snout to second dorsal fin was measured from the snout to the anterior insertion of the second dorsal (anteriormost element).

Snout to anal fin was measured from the tip of the snout to the anterior insertion of the third spine; the first two spines are usually embedded and separate from the remainder of the fin.

Snout to pectoral fin was measured from the tip of the snout to the upper insertion of the pectoral fin.

Snout to ventral fin was measured from the tip of the snout to the anterior insertion of the ventral fin with the fin extended.

Pectoral to first dorsal fin was measured from the upper insertion of the pectoral fin to the anterior insertion of the first dorsal.

Ventral to first dorsal fin was measured from the insertion of the extended ventral fin to the anterior insertion of the first dorsal.

Perpendicular to the anal fin was measured perpendicular from the insertion of the anal fin to the dorsal surface of the body where it meets the dorsal fin.

Caudal peduncle width is the width just anterior to the emergence of the caudal rays.

Dorsal peduncle length is the distance from the posterior insertion of the second dorsal to the posterior margin of the urostyle at the lateral line.

Length of first dorsal was measured along the base, from the insertion of the anterior spine to the last visible spine.

Length of the first gill raker below the angle on the first gill arch was measured from the base of the raker to its tip.

Spines. In the first dorsal fin, only visible spines were counted, no probing was done (Table 3). In the case of the anal fin spines, the two free spines were probed for, if necessary.

Gill rakers. The gill arch was divided into three sections; the upper limb (epibranchial), middle (the joint between the epibranchial and the ceratobranchial) and the lower limb (ceratobranchial and hypobranchial). Only functional rakers were counted (Table 5).

Gill teeth (posterior rakers). The arch was divided into two sections; the epibranchial, and the ceratobranchial and hypobranchial.

TABLE 1

Locality of Capture and Number of Specimens Used in the Description of *Seriola dorsalis*

Locality of Capture	Number of Specimens
Pt. Conception, Calif., to Ensenada, B. C.	13
San Quintin Bay Area	5
Guadalupe Island Area	32
Cedros Island Area to Abreojos Pt.	14
Abreojos Pt. to Magdalena Bay	90
Magdalena Bay to Cape San Lucas	25
Gulf of California	31
Total	210

TABLE 1

Locality of Capture and Number of Specimens Used in the Description of Seriola dorsalis

TABLE 2

Measurements and Counts Made on 210 Yellowtail, 357-970 mm. Standard Length, Captured at Various Localities Throughout Their Range (Measurements Expressed as Thousandths of Standard Length)

	Pt. Conception-Ensenada		San Quintin Area		Guadalupe Island		Cedros Is.-Abreojos Pt.		Abreojos Pt.-Magdalena Bay		Cape San Lucas		Gulf of California		Total		
	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Number	Mean	Range
MEASUREMENTS																	
Total length	1216	1189-1253	1210	1188-1229	1215	1184-1247	1223	1198-1240	1227	1183-1260	1228	1215-1250	1229	1207-1251	199	1224	1183-1260
Fork length	1066	1045-1085	1058	1054-1062	1068	1039-1079	1065	1008-1078	1072	1046-1097	1072	1061-1080	1070	1063-1077	208	1070	1008-1097
Head length	260	253- 268	260	253- 266	268	244- 294	265	250- 273	269	250- 283	268	257- 282	271	262- 281	210	268	244- 294
Eye diameter	34	30- 37	36	33- 40	37	32- 40	37	34- 41	39	32- 53	38	34- 45	36	32- 40	208	37	30- 53
Snout length	101	94- 105	99	97- 101	103	93- 117	100	95- 107	101	90- 112	102	96- 110	105	100- 114	210	102	91- 117
Maxillary length	106	102- 113	105	101- 110	109	98- 120	108	104- 114	109	85- 126	109	104- 117	110	104- 135	209	109	85- 135
Suborbital	13	10- 14	11	10- 12	12	10- 16	12	10- 13	13	10- 16	13	11- 14	13	10- 17	207	13	10- 17
Interorbital	94	86- 107	91	88- 97	91	80- 97	93	89- 98	92	83- 108	91	85- 97	92	86- 97	207	92	80- 108
Pectoral length	132	124- 146	131	121- 138	133	121- 145	132	122- 142	137	116- 150	136	131- 145	138	126- 153	208	136	116- 153
Ventral length	127	117- 137	133	124- 138	131	116- 144	135	126- 143	138	115- 154	135	100- 150	133	119- 146	207	135	100- 154
Dorsal height	123	109- 134	120	101- 143	118	107- 131	115	103- 125	122	101- 144	122	110- 134	132	119- 150	207	123	101- 150
Anal height	96	80- 108	93	86- 103	93	81- 105	90	82- 105	93	77- 107	91	80- 102	97	84- 109	207	93	77- 109
Snout to dorsal 1	356	342- 368	347	338- 356	359	341- 391	360	351- 375	361	347- 386	360	344- 377	363	350- 376	210	360	338- 391
Snout to dorsal 2	480	458- 497	476	466- 483	480	459- 507	484	477- 494	485	465- 517	481	463- 504	484	472- 495	210	483	458- 517
Snout to anal	663	640- 680	656	642- 662	666	650- 690	658	644- 685	660	640- 692	659	636- 704	666	649- 681	209	662	636- 704

TABLE 2

Measurements and Counts Made on 210 Yellowtail, 357–970 mm. Standard Length, Captured at Various Localities Throughout Their Range (Measurements Expressed as Thousandths of Standard Length)

Snout to pectoral	267	253– 279	266	256– 270	276	253– 313	272	259– 283	275	260– 292	274	263– 293	278	269– 287	210	275	253– 313
Snout to ventral	294	283– 305	292	285– 298	304	285– 347	299	291– 326	304	272– 325	302	286– 318	301	290– 310	210	302	272– 347
Pectoral to dorsal 1	163	148– 174	156	149– 168	155	141– 176	160	152– 176	162	145– 176	156	147– 165	157	147– 170	208	159	141– 176
Ventral to dorsal 1	242	223– 261	237	230– 243	233	208– 259	244	228– 269	217	216– 273	240	220– 255	326	218– 253	210	242	208– 273
Perpendicular to anal	208	185– 224	193	185– 206	187	174– 219	198	186– 218	198	172– 238	195	179– 209	190	180– 207	209	195	172– 238
Caudal peduncle depth	37	32– 40	37	35– 40	37	33– 41	37	34– 40	37	34– 42	36	34– 38	36	33– 39	210	37	32– 42
Caudal peduncle width	47	39– 50	45	40– 48	41	36– 50	44	39– 49	45	37– 52	45	42– 52	46	41– 51	210	44	36– 54
Dorsal peduncle length	107	93– 112	113	109– 117	107	92– 125	108	99– 118	106	95– 121	104	95– 115	99	88– 109	210	105	88– 125
Anal peduncle length	107	98– 119	113	112– 115	108	98– 124	109	98– 118	107	93– 126	106	100– 115	101	92– 109	210	106	92– 126
Dorsal 1 base	100	89– 112	99	90– 107	100	76– 118	102	93– 114	105	88– 124	106	95– 116	102	80– 118	205	103	76– 124
Dorsal 2 base	448	416– 475	449	434– 460	442	419– 464	446	426– 462	445	423– 464	446	428– 468	449	431– 468	207	446	416– 475
Anal base	261	250– 276	256	243– 270	251	244– 263	253	247– 261	254	237– 271	255	234– 265	254	246– 267	209	254	234– 276
Length 1st Gill raker	36	33– 42	36	33– 38	36	29– 42	37	32– 41	38	29– 44	38	32– 43	38	31– 43	206	37	29– 44
COUNTS																	
Dorsal 1	V-VII		V-VII		IV-VII		V-VII		V-VII		III-VII		IV-VII		207	VI	III-VII
Dorsal 2	I, 33-37		I, 32-36		I, 31-37		I, 32-35		I, 31-37		I, 31-37		I, 31-37		207	35	I, 31-37
Anal	II-I, 20-21		II-I, 20-21		II-I, 19-23		II-I, 19-22		II I, 19-23		II-I, 19-22		II-I, 19-22		208	21	II-I, 19-23
Gill raker Upper Limb	5-9		4-8		5-9		5-9		5-9		7-8		6-9		207	8	4-9
Gill raker Middle	1		1		1		1		1		1		1		207	1	--
Gill raker Lower Limb	14-18		15-17		14-19		16-19		14-21		15-19		13-18		207	16	13 21
Gill teeth Upper Limb	3-4		4-5		3-5		3-5		2-5		2-5		2-4		208	3	2-5
Gill teeth Lower Limb	13-15		14-17		12-16		13-17		13-18		13-16		13-15		208	15	12-18
Lateral line scales	--		--		--		--		--		--		--		130	--	114-162
Vertebrae Precaudal	--		--		--		--		--		--		--		--	11	--
Vertebrae Caudal	--		--		--		--		--		--		--		3	14	--
NUMBER OF FISH	13		5		32		14		90		25		31				
STANDARD LENGTH, mm.	534-924		523-743		493-970		467-695		357-956		420-854		694-926				357-970

TABLE 2—Cont'd.

2.2. Description

Dorsal III to VII-I, 31 to 37; Anal II-I, 19 to 23.

Gill rakers 4 to 9 + 1 + 13 to 21; Gill teeth 2 to 5 + 12 to 18

The body is elongate, somewhat compressed, tapering to a rather sharp snout and slender caudal peduncle. The profile from snout to second dorsal is gently and evenly convex; the ventral outline is slightly curved and convex from the tip of the lower jaw to the caudal peduncle. The head is rather long, 24.4 to 29.4 percent of standard length and is naked of scales except on the cheeks. The length of the eye (fleshy orbit) is 3.0 to 5.3 percent of standard length. The mouth is fairly small and oblique. The maxillary, 8.5 to 13.5 percent, is longer than the snout (9.1 to 11.7 percent) and reaches slightly past the anterior margin of the fleshy orbit. The fleshy suborbital is narrow, 1.0 to 1.7 percent. The least bony interorbital is 8.0 to 10.8 percent of standard length. The body depth perpendicular to the anal is 17.2 to 23.8; oblique depth, from the ventral insertion to the first dorsal insertion is 20.8 to 27.3 percent; the caudal peduncle depth is 3.2 to 4.2 and has a width of 3.6 to 5.4 percent. The second dorsal and the anal fins are similar in form; the height of the longest ray of the second dorsal is 10.1 to 15.0 and the height of the longest ray of the anal is 7.7 to 10.9 percent of standard length. The pectorals and ventrals are usually equal in length; the pectorals 11.6 to 15.3 and the ventrals 10.0 to 15.4. The first dorsal fin contains 3 to 7 spines connected to each other by a membrane. The two anteriormost anal spines disappear under a fleshy covering with age.

The origin of the first dorsal is behind that of the pectoral. Length of the first dorsal base is 7.6 to 12.4 percent of standard length. The origin of the second dorsal is well back, being 45.8 to 51.7 percent of standard length; the base of this fin is fairly long, 41.6 to 47.5 percent. The anal fin is placed notably behind the second dorsal insertion, 63.6 to 70.4 percent of standard length; it is fairly short in base length, 23.4 to 27.6 percent.

The gill rakers on the anterior arch are long and fairly strong; the first raker below the angle is 2.9 to 4.4 percent of standard length; there are 4 to 9 on the upper limb (epibranchial); 1 at the angle between the upper and lower limb and 13 to 21 on the lower limb. The total raker count is 19 to 31.

The lateral line, gently arched over the pectoral fin, reaches the midline of the body beneath the anterior lobe of the second dorsal fin and runs straight from there posteriorly, forming a fleshy keel along the caudal peduncle. There are 114 to 162 pored scales in the lateral line to the emergence of the caudal keel. The caudal fin is widely forked and the two lobes are of nearly equal length. There are 25 vertebrae, of which 11 are precaudal and 14 caudal, including the urostyle (hypural).

When freshly caught, yellowtail are a bright metallic blue to green above, and have a brassy horizontal stripe along their sides from the eye to the tail. The lower sides and belly are silvery. The fins are a dusky greenish-yellow except the caudal which is a bright yellow.

The general shape and configuration of four juvenile yellowtail, 42 to 149 mm. standard length, was similar to the adult.

The coloring is markedly different between the juvenile and adult and also varies during the different stages of development.

Dorsal I Spines	Number of Fish
III	1
IV	2
V	22
VI	158
VII	26
Total	209

TABLE 3
Number of Spines in First Dorsal Fin

Rays in anal	Rays in Second Dorsal							Total
	31	32	33	34	35	36	37	
19	--	2	4	3	1	--	--	10
20	7	5	13	14	7	2	2	50
21	5	13	21	16	26	8	5	94
22	--	2	5	7	21	10	4	49
23	--	--	--	1	--	1	--	2
Total	12	22	43	41	55	21	11	205

TABLE 4
Frequency Distribution of Soft Rays in Second Dorsal and Anal Fins

Lower limb	Upper Limb									Total
	13	14	15	16	17	18	19	20	21	
4	--	--	--	--	1	--	--	--	--	1
5	--	--	2	3	4	1	--	--	--	10
6	1	2	1	5	2	3	--	--	--	14
7	--	--	14	12	6	5	2	--	--	39
8	1	8	15	39	27	25	8	1	1	125
9	--	--	--	3	6	5	4	--	--	18
Total	2	10	32	62	46	39	14	1	1	207

TABLE 5
Frequency Distribution of Rakers on First Gill Arch (Raker at Angle of Arch not Included)

The smallest specimen examined (42 mm. standard length) was a dusky greenish-yellow above and silvery white below. The caudal fin and anal base were lightly tinged with yellow while the membranes of the dorsal, anal and ventral fins were heavily pigmented. Ten dark vertical bands were rather evenly spaced along each side. At this size the bands were narrower than the spaces between.

A 70 mm. specimen was olive green above and deep yellow ventrally. The caudal fin was orange, and the margins of the dorsal fins were yellow while the bases were dusky. The 10 dark horizontal bands along the sides were wider than the spaces between the bands. *Harry M. Mekjian.*

3. THE SPORT AND COMMERCIAL FISHERIES

3.1. The Sportfishery

3.1.1. *Areas and Seasons*

Along the Pacific Coast the most productive yellowtail fishing areas are found between Point Dume and Huntington Beach, Dana Point and Oceanside, La Jolla and Point Loma, and off Ensenada, Mexico. offshore, Santa Catalina, San Clemente, and the Coronado Islands produce the best results (Figure 3). The Coronado Islands, which ironically are not located in California, but across the International Boundary in Mexico, consistently provide the best fishing.

For Those sportsmen who are physically and financially hearty, the fishing grounds include the west coast of Baja California, Mexico, its outlying islands and a large part of the Gulf of California.

At the southern extremity of the California sport fishery (including the Coronado Islands) yellowtail are generally caught from April through September with catches reaching their peak most often in May. The beginning of the fishery and peak months of the catch are slightly later to the north.

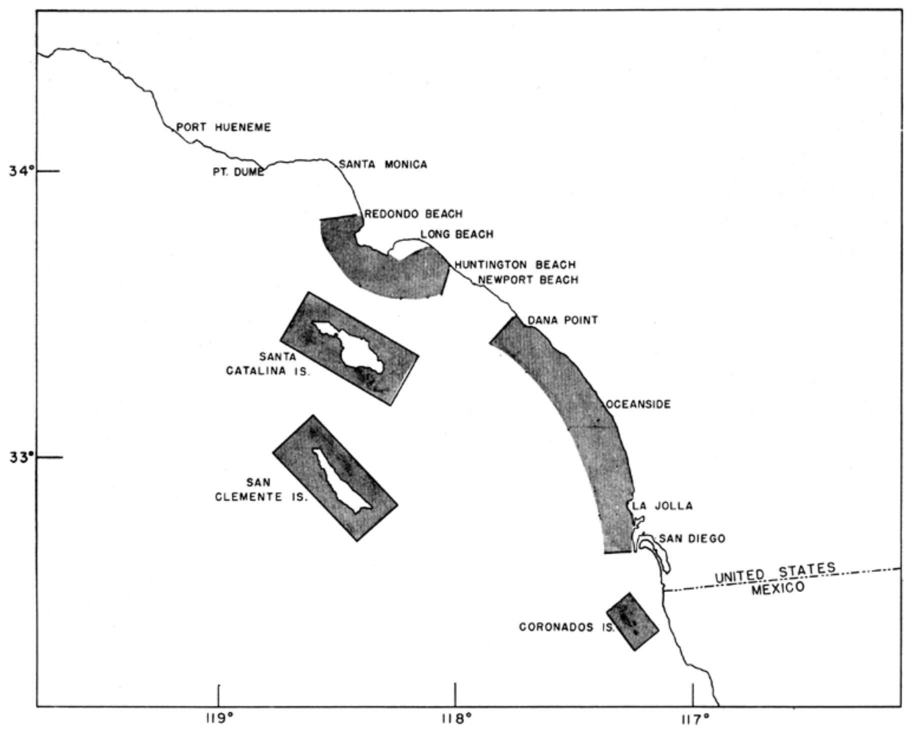

FIGURE 3. Most productive southern California yellowtail fishing areas as determined from party boat catch records.

FIGURE 3. Most productive southern California yellowtail fishing areas as determined from party boat catch records

3.1.2. Gear and Methods

Types of gear and modifications thereof, designed to capture yellowtail are nearly as varied as the number of sportfishermen who use them. Most fishing is with rod and reel using a barbed hook baited with an anchovy or sardine. Cast and trolled artificial lures are popular with some sportfishermen.

In the past 15 years the greatest changes in angling gear have been brought about by the re-introduction of the spinning reel and development of plastics and synthetic fibers.

Almost every type of vessel afloat can be seen at the favored "fishing holes" off southern California on any given day during the peak of the season. For example, at the Coronado Islands, some 10 miles offshore and nearly 20 miles from San Diego, small skiffs with a single outboard motor are a common sight. In contrast is the multitude of private yachts ranging in length up to 150 feet. Carefully inspected vessels with an experienced captain and crew make the familiar "party boat" a popular means of transportation.

3.1.3. *Sizes of Fish*

Yellowtail are known to reach 80 pounds in weight but in general the sizes caught by sportfishermen average between 12 and 18 pounds. On some days the schools are composed of small fish around 6 to 10 pounds, while on others, catches are predominated by "lunkers" ranging from 25 to 35 pounds.

3.1.4. *Use for Food*

Most of the sportfisherman's catch either is prepared for immediate consumption or is frozen for use at a later date. A smaller portion is preserved by means of smoking. A fairly recent innovation is the creation of small-scale canneries specifically for personalized preservation of the sportfisherman's catch.

FIGURE 4. Typical scene aboard a party fishing boat. Note the live bait tank in the left foreground. *Photo by Claude M. Kreider.*

FIGURE 4. Typical scene aboard a party fishing boat. Note the live bait tank in the left foreground. Photo by Claude M. Kreider.

3.1.5. *Landings*

A legislative addition to the Fish and Game Code in 1935 required the holder of a Party Boat Permit to maintain records and report the numbers, approximate weights and catch locality of all fish taken by passengers during each day of fishing, or each trip if more than one is made in a single day. As a result, records of the sportcatch are available since 1936, with the exception of the war period from 1941 through 1945 (Table 6).

Much of the justification for undertaking this study resulted from a cursory examination of the annual landings and the associated number of anglers. During the prewar period, 1936 to 1940, records indicated that excellent yellowtail catches were made throughout southern California. With the exception of 1939, an angler could reasonably expect to catch at least one yellowtail for each day of fishing. Approximately two days fishing would have been necessary in 1939, the worst prewar year on record. With resumption of the sportcatch record system in 1946, a substantial decline in landings and angler success

FIGURE 5. Sacking a freshly caught yellowtail aboard a party fishing vessel. Note the tails of other yellowtail. *Photo by Claude M. Kreider.*

FIGURE 5. Sacking a freshly caught yellowtail aboard a party fishing vessel. Note the tails of other yellowtail. Photo by Claude M. Kreider.

TABLE 6

Number of Yellowtail Landed by Sportfishermen in Southern California from 1936 through 1957, as Reported by Party Boat Operators

Year	Number of fish	Year	Number of fish
1936	97,453	1947	7,082
1937	62,847	1948	12,787
1938	44,974	1949	18,023
1939	26,730	1950	7,673
1940	96,756	1951	23,721
1941	--	1952	59,263
1942	--	1953	27,702
1943	--	1954	40,872
1944	--	1955	36,468
1945	--	1956	29,198
1946	3,051	1957	242,686

[1] No data collected during World War II (1941-1945).

TABLE 6

Number of Yellowtail Landed by Sportfishermen in Southern California from 1936 through 1957, as Reported by Party Boat Operators

was evident. At the time this study was initiated (January 1952), the best catch an angler could anticipate was one yellowtail for each two days of fishing, or equal to the poorest season of the prewar years.

Catch statistics for the Coronado Islands are presented separately from those of California (Table 7), simply because their distinct geographical position permitted making the most accurate and reliable estimates of angler effort and success. Data for 1936 through 1940 and 1946 are not exactly comparable to those for years since 1946, because of refinements in the method of collecting and processing the original records. As a result, their primary use has been to demonstrate the contrast in angler success between the pre- and postwar periods. Many insignificant and erroneously reported catches were eliminated by using only those from the specific areas outlined in Figure 3. Further, it was possible to consider only the months of April, May and June, the period of peak catches and when effort often is expended solely in this fishery.

The difference between the rough average of one and one-half fish per angler day during the pre- World War II period and the less than one-quarter of a fish per angler in the immediate postwar period appears quite alarming. Two possible causes are immediately apparent: either a reduction in the size of the population took place or there was a reduction in the number of fish available to the angler. There is also the possibility that a complex interrelationship exists between these two factors.

It is my opinion that reduction in the number of fish available best explains the decline in angler success. The erratic but steady rise in angler success, particularly notable at the Coronado Islands, makes it difficult to believe that a population, reduced to the low level evidenced by the 1946 landings, could possibly recover in 10 years, to such an extent as to produce nearly two fish per angler day in 1957.

Furthermore, examination of commercial catch records and the results of interviews with commercial fishermen indicate no evidence of a decrease in abundance at the population center off central Baja California. Thus, it seems logical to conclude that some environmental barrier or barriers (temperature, salinity, pollution, food, etc.) played

TABLE 7

Yellowtail Catch per Day of Angling for April, May and June, 1936-1957, Based Upon Party Boat Records [1]

	CALIFORNIA			CORONADO ISLANDS		
Year	Number of Fish	Number of Anglers	Catch per Angler Day	Number of Fish	Number of Anglers	Catch per Angler Day
1936	24,719	--	--	72,734	43,943	1.655
1937	11,929	--	--	50,918	45,934	1.109
1938	17,113	--	--	27,861	36,877	0.756
1939	6,771	--	--	19,959	36,548	0.546
1940	17,035	--	--	79,721	48,904	1.630
1947	573	83,219	0.007	4,151	13,573	0.306
1948	1,016	82,407	0.012	5,422	16,278	0.333
1949	4,050	107,511	0.038	9,206	20,974	0.439
1950	338	99,933	0.003	4,233	16,502	0.257
1951	1,805	92,859	0.019	12,836	23,859	0.538
1952	25,761	120,938	0.213	17,620	21,866	0.806
1953	10,763	90,065	0.120	12,319	21,815	0.565
1954	4,929	87,608	0.056	16,583	26,201	0.633
1955	2,035	65,989	0.031	30,679	31,096	0.987
1956	858	59,326	0.041	10,615	25,030	0.424
1957	13,385	73,090	0.183	73,681	41,131	1.791

[1] No data collected during World War II (1941-1945).

TABLE 7

Yellowtail Catch per Day of Angling for April, May and June, 1936–1957, Based Upon Party Boat Records

an important role in determining the number of fish available to local anglers during any given period or year.

3.2. Sportcatch in Relation to Ocean Temperatures

Tagging experiments indicated most of the yellowtail caught at the Coronado Islands and off southern California came from central Baja California waters where a large population is present the year-around. Southern California anglers fish only the northern fringe of this population during a seasonal migration. Ocean temperature appears to be a major factor in limiting the number of fish making this migration.

Radovich (1960) shows a definite relationship between the magnitude of the yellowtail sportcatch on California fishing grounds and the average ocean temperature off Baja California during the first six months of the year. This period of the year was chosen because it is then that they begin their movement toward California. Radovich also shows that during 1957, the average ocean temperature off Baja California for January through June was about 2.2 degrees F. above the 1950–1956 average. The 1957 yellowtail sportcatch was the largest ever recorded by the sport-fishing fleet. The years 1926, 1931, and 1941 also were characterized by above average ocean temperatures and by northerly occurrences of many southern forms including yellowtail.

A comparison of monthly sportcatches by party boats at the Coronado Islands and average monthly sea surface temperatures at La Jolla for the period 1947–1955 showed best fishing occurred at temperatures between 58 and 65 degrees F. Usually this was in the spring of the year. By midsummer when temperatures reached their peaks, (67 to 71 degrees F.) the catch declined. Warming water does not seem responsible for their leaving the California fishing grounds because temperatures off Baja California, where a population of yellowtail is present the year-around, are several degrees higher than those off California.

A possible explanation for their leaving in July has to do with their spawning habits. The spawning season starts in July and observations made during this investigation and those reported by Walford (1937) indicate that yellowtail spawn some distance offshore. This would account in part for their virtual disappearance from the California fishing grounds during the period of warmest ocean temperatures.

3.3. The Commercial Fishery

3.3.1. Fishing Areas and Seasons

Prior to 1932, commercial yellowtail landings were made by a fleet of small bait boats operating off southern California and as far south as the Coronado Islands. Whitehead (1933) described this fishery and presented his interpretation of its condition. Results of his study indicated a decline in the population available to the fishermen on these local fishing grounds. This decline undoubtedly played a part in bringing about a complete change, geographically, in the principal fishing areas. Since about 1932, the commercial fishery has been predominantly south of the Mexican Boundary with the best catches made between Cedros Island and Magdalena Bay, Baja California. Rocky inshore areas and offshore pinnacles or banks appear most productive.

Yellowtail are of secondary commercial value, hence heaviest landings appear related to the absence of more desirable commercial species such as the tunas and sardines. For the hook and line fleet the fishery occurs during the spring months before albacore become available. The "netting" segments of the fleet seek yellowtail during the fall months just prior to the sardine fishing season. Vessels of all types may seek yellowtail during any month of the year to top off a load of more desirable species or to help defray expenses of an otherwise unproductive trip.

3.3.2. Gear and Methods

Yellowtail are caught commercially with round-haul nets, entangling nets, and by hook and line using various artificial and natural lures.

Round-haul nets are illegal for taking them in California waters but are used extensively south of the Mexican Boundary where purse seiners are responsible for catching the greatest amount.

Commercial hook and line fishing involves at least two different classes of boats: large tuna clipper-type vessels and smaller vessels 35 to 60 feet in length. Regular tuna fishing methods are used by the tuna clippers and for the most part by the smaller vessels. When surface biting schools cannot be located, these fishermen turn from pole and line to weighted handlines and fish near areas of rocky ocean bottom.

Trolling is the least important method for the small hook-and-liners. This consists essentially of towing an artificial lure, on the distal end of a line attached to the vessel. It is towed at such speed as to entice a fish to strike. As far as fishermen are concerned this is a "stop-gap" method to be used when all other types of gear fail. Albacore fishermen using trolling gear often make incidental catches of yellowtail.

Catches made by fishermen operating such gear as set lines, gill nets and lamparas are small. They generally seek whatever fish are available; hence their yellowtail landings are incidental. No single type of gear has consistently been the major contributor during the history of the fishery (Figure 6).

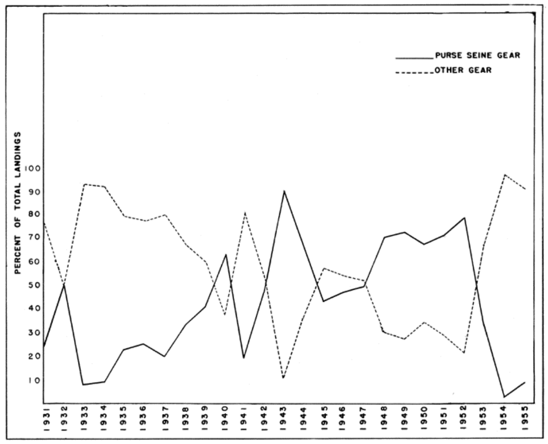

FIGURE 6. Relative amounts of yellowtail landed by commercial fishing vessels operating purse seine gear versus all other types from 1931 through 1955

3.3.3. Size of Fish in the Catch

Yellowtail landed by commercial fishermen average somewhat smaller than sport caught fish, ranging between 6 and 18 pounds each, with an average between 10 and 15.

3.3.4. Landings

Fish dealer records of commercial landings have been required by law since 1915 and are available since the 1916 calendar year. The catch, as noted from these records, is characterized by moderate to extreme fluctuations (Table 8). There is no evidence to indicate that the moderate fluctuations were caused by anything but the old American law of supply and demand. Records of the amount of yellowtail canned (case-pack) show fluctuations closely correlated to those of the landings, indicating variability in cannery demand and stability in fresh market demand (Fry, 1937). Outlets for the sale of canned yellowtail are very limited, primarily because of the lower quality of the pack compared to tuna. Thus, catches increase when it is necessary to meet the demands of a very limited market for the canned product.

Exact causes of the extreme fluctuations in a secondary fishery such as this defy specific explanation. It may be postulated, however, that general economic conditions within the country, e.g., inflation, depression and wartime, all contribute in turn.

Since the mid-1930's the price paid to fishermen for yellowtail has ranged between 2½ and 14 cents per pound. The cannery price has tended toward the lower end of the scale while the fresh market price has been toward the upper. In 1954, the cannery price dropped from a previous level of about nine cents a pound to four. By 1954, cannery demand was so light that no orders were placed even at the low price. Thus, an entire fishery virtually collapsed, apparently for purely economic reasons. During this same time the fresh market demand remained at its light but steady level, stabilizing the price at the higher level. Since 1954 the commercial catch has apparently adjusted itself to the fresh market demand.

An attempt was made to assess the condition of the stock throughout the range of the fishery in terms of catch-per-unit-of-effort. Unfortunately,

TABLE 8

Commercial Landings of Yellowtail in California, 1916–1957

Year	Landings, in Thousands of Pounds	Year	Landings, in Thousands of Pounds	Year	Landings, in Thousands of Pounds
1916	1,153	1930	4,771	1944	2,957
1917	2,746	1931	2,526	1945	3,534
1918	11,515	1932	1,796	1946	4,562
1919	5,005	1933	3,899	1947	9,953
1920	2,705	1934	2,347	1948	10,446
1921	2,491	1935	8,149	1949	7,319
1922	3,414	1936	10,092	1950	3,532
1923	4,063	1937	5,371	1951	4,691
1924	4,714	1938	6,812	1952	9,447
1925	3,180	1939	2,866	1953	5,212
1926	5,023	1940	5,957	1954	1,671
1927	4,225	1941	9,831	1955	164
1928	2,684	1942	2,726	1956	371
1929	3,075	1943	4,935	1957	511

TABLE 8

Commercial Landings of Yellowtail in California, 1916–1957

neither the specialized local fleet nor the economic position of the fish described by Whitehead (1933) existed during this study.

Since the early 1940's, the fishery has been pursued by a great variety of vessels operating many types of gear. This, plus the secondary nature of the fishery defied establishing a valid measure of effort essential for determining relative stock size. The almost complete collapse of the fishery in 1954 ended hope of establishing a suitable measure of effort during the limited term of the project.

One important fact was forthcoming from the study, however. It was found that the size of the catch was closely related to the number of vessels involved in the fishery. From this it was concluded that catches near the population center were probably more dependent on the amount of effort expended than on the size of the stock. If this be the case, future catch statistics should be watched carefully against the day which might bring an upward trend in economic value. This could result in an increase in effort that in turn would bring the harvest to a point at which the stock could not be maintained at the optimum for survival of this prized California gamefish. *William L. Craig*.

4. AGE AND RATE OF GROWTH

Early attempts to determine ages for yellowtail were mostly by trial and error. The most readily available material for this work was scales but preliminary studies gave inconclusive results. A variety of other anatomical structures was examined in hopes of discovering one valid means by which they could be aged. Otoliths, vertebrae, fin rays and opercular bones were boiled, dried, degreased, filed, sectioned and otherwise processed with little success. Further scale studies using various types of mounting media and the fabrication of an improved scale projector finally helped achieve the sought-after results.

4.1. Materials and Methods

When the first attempts were made to age by scales they were mounted dry between two glass slides. Mounted in this manner they were impossible to read, so a series of tests was conducted to find a medium that would aid in clarifying the scale structure. The requirements for a mounting medium were: ease of use, good optical properties, and legibility of scale structure.

of those tried (glycerin-jelly, Farrant's medium, "a water soluble modification of Sayer's medium," glycerin-water glass (sodium-silicate), and Karo syrup) glycerin-jelly was considered most suitable. It proved easy to use and, with but little practice, slides could be kept free of air bubbles. The slides hardened in three to four days, at which time they could be cleaned and filed or stored upright.

Karo syrup proved unsatisfactory because it refused to solidify. The other media, while possessing good qualities, either took too long to set up or were difficult to use because air bubbles formed in the finished slides.

A preliminary study showed yellowtail have a high percentage of regenerated scales. In order to insure that the best scales were obtained for age analysis, samples were taken from eight places on the left side of three different fish. The specific areas from which these were taken were: the preopercle, both dorsal and ventral to the anterior end of the lateral line, dorsal to the lateral line at mid-body, ventral to the lateral line just posterior to the pectoral fin, both dorsal and ventral to the lateral line in the caudal region and the belly.

Regeneration was observed in scales from all regions. Fewer regenerated scales were found on the preopercle; however, these were difficult to remove during tagging operations. Scales just posterior to the pectoral fin showed a relatively low level of regeneration, were of uniform size, and were easily removed, and this area was selected for routine sampling.

Systematic collecting began after the standard procedure had been decided upon. Eventually, several hundred random samples were taken from fish being tagged and from specimens brought to the laboratory. For each scale sample, fork length was noted to the nearest millimeter, and the date and place of capture were recorded. The scales were stored in marked vials containing a five percent solution of formalin buffered with borax.

For mounting, the scales were removed from their storage vials and soaked in water. Five or six of the best were cleaned with a small brush and put into a clean water bath. The remainder were stored in labeled coin envelopes. Several coats of warm glycerin-jelly were then applied to a slide with a glass rod. The clean scales were removed from their bath and placed external surface up on the glycerin-jelly coating and settled gently into the medium with a probe. A cover slip was then carefully set over them and pressed lightly to tease out air bubbles. The finished slide was placed on a flat surface until the medium hardened, when the excess material could be removed and the slide labeled. Data, such as fork length and time and area of capture, were left off the label to reduce bias by the reader. All slides were studied by two or more persons individually, again to avoid the possibility of bias. If, upon comparison of the readings, considerable disagreement was noted and could not be resolved for a given set of scales they were discarded. Two principal reasons for disagreement were: an excessive number of regenerated scales on some slides, and closely associated circuli and annuli on those of fish past their seventh winter. After the seventh winter the spaces between the circuli become increasingly narrow, so that in many cases it was impossible to differentiate between one year's growth and the next. As a result, 91 of the 876 samples were discarded.

Scales originally were read under a binocular microscope, but this was improved upon by the construction of a microprojection machine. The principles employed were basically the same as for the microprojector designed and described by Van Oosten, et al. (1943), differing in that a mirror-projected image went upon a horizontal white plastic mat, rather than a vertical surface. The scales were examined at an enlargement of 30 diameters.

4.2. Age

Yellowtail scales are cycloid, generally oblong, thin, and embedded deeply in the dermis of the skin with only a small amount of the posterior portion exposed. The circuli on the anterior end are interrupted with irregular imbrications or radii terminating as an irregular margin (Figure 7). The posterior end is wholly lacking in radii. The focus is located posterior to the middle, and the outer surface of the scale is divided by dense concentric growth rings or circuli. Slowing down or

FIGURE 7. Scale from a 1017 mm. yellowtail showing 12 annual rings. Note the radii and irregular margin on the anterior end.

FIGURE 7. Scale from a 1017 mm. yellowtail showing 12 annual rings. Note the radii and irregular margin on the anterior end

FIGURE 8. Yellowtail scale, age group 0.

FIGURE 8. Yellowtail scale, age group 0

FIGURE 9. Yellowtail scale, age group I.

FIGURE 9. Yellowtail scale, age group I

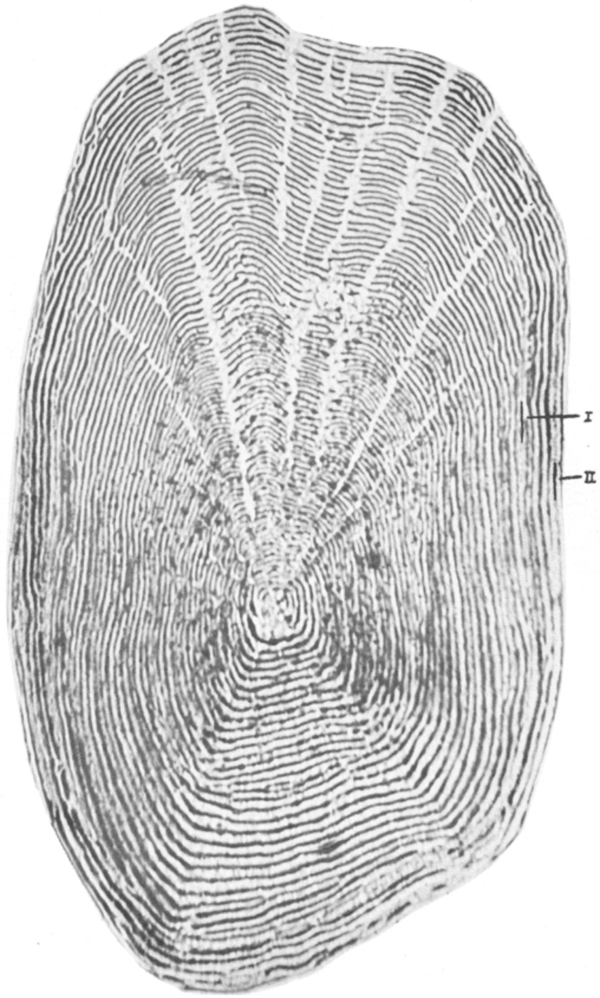

FIGURE 10. Yellowtail scale, age group II.

FIGURE 10. Yellowtail scale, age group II

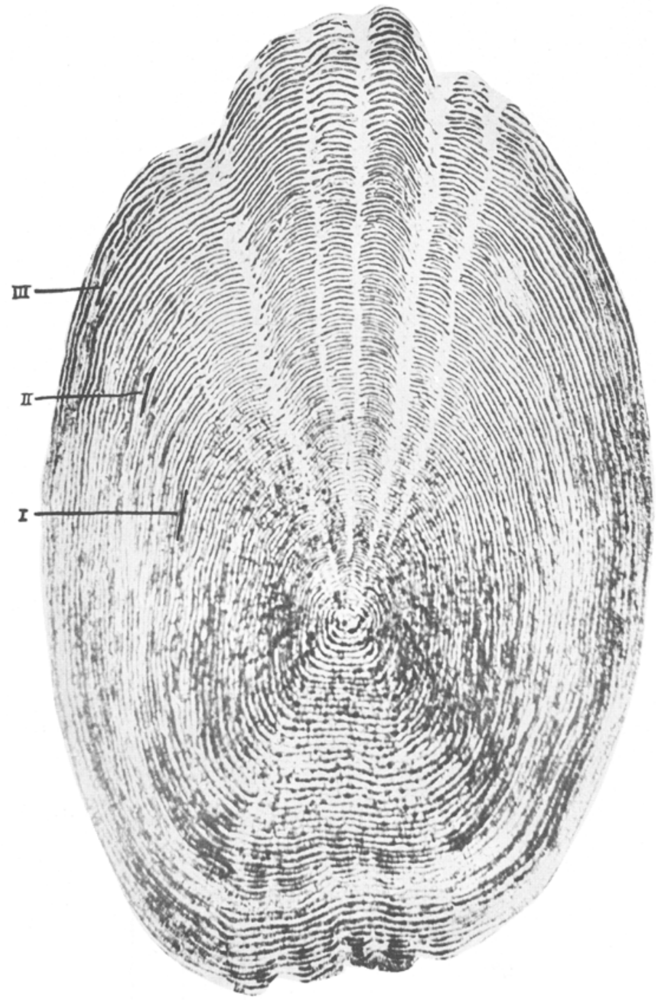

FIGURE 11. Yellowtail scale, age group III.

FIGURE 11. Yellowtail scale, age group III

cessation of growth occurs once a year, thereby causing the circuli to crowd and appear to form a solid line or annulus around the perimeter of the scale. The annulus is not readily detected however, until growth is again resumed. An examination of scales taken between August, 1954 and September, 1955, disclosed that the annulus is formed between November and January.

Annuli do not form on yellowtail scales until the second winter following hatching when they are 18 months old.

4.3. Growth

In order to establish a rate of growth, the age analysis data were arrayed to show the size range at ages I through XII (Table 9). The size ranges of the different age groups varied considerably but the greatest range was in age group I where the difference in length between the largest and smallest fish was 262 mm. The 52 mm. size range for fish in age group XII probably would increase with a larger sample. The growth curve (Figure 12) was fitted to von Bertalanffy's growth equation (Beverton and Holt, 1957). Only a moderately good fit was obtained. The mean length at each age was given equal weight in fitting the data to the least squares equation:

$$l_t = L_\infty \left[1 - e^{-K(t-t_0)}\right]$$

where t = age in years
l_t = fork length in mm. at age t
L_∞ = asymptotic length
K = a constant proportional to the coefficient of catabolism
t_0 = the age at which the theoretical length would have been zero if the growth pattern of later life were extrapolated back.

FORMULA

The equation with the fitted constants becomes: $l_t = 1291 \left[1 - e^{-0.136(t + 1.9)}\right]$

Some fish from which scales were removed at the time of tagging were recaptured as much as 31 months later. In these cases, information obtained from the two sets of scales, as well as the length measurements

TABLE 9

Sizes of Yellowtail at Ages I through XII As Determined from Scale Reading

Age Group	Size Range (mm)		Mean Fork Length (mm)	Sample Size	95% Confidence Interval (mm)	Lengths From Fitted Growth Curve (mm)
	Minimum	Maximum				
I	371	633	506	234	±5.9	488.3
II	520	709	634	122	±8.1	590.1
III	604	800	706	183	±6.7	679.2
IV	699	855	783	115	±13.4	756.8
V	747	899	831	61	±7.6	824.7
VI	820	934	872	18	±17.5	883.9
VII	854	940	893	11	±20.5	935.6
VIII	890	1053	958	14	±26.3	980.7
IX	982	1031	1008	5	±25.2	1020.2
X	1016	1072	1035	6	±23.5	1054.6
XI	1044	1152	1082	9	±28.7	1084.7
XII	1099	1151	1127	7	±16.7	1110.9

TABLE 9

Sizes of Yellowtail at Ages I through XII As Determined from Scale Reading

obtained before and after a known interval of time, proved invaluable in comparing actual growth against calculated growth.

At the time of tagging the fork length of each fish was obtained to the nearest millimeter. Measuring live, active fish to such a fine degree was setting the standards high; however, preliminary work had shown yellowtail were comparatively slow growing so fine measurements were necessary to correctly determine the yearly increment. While some of

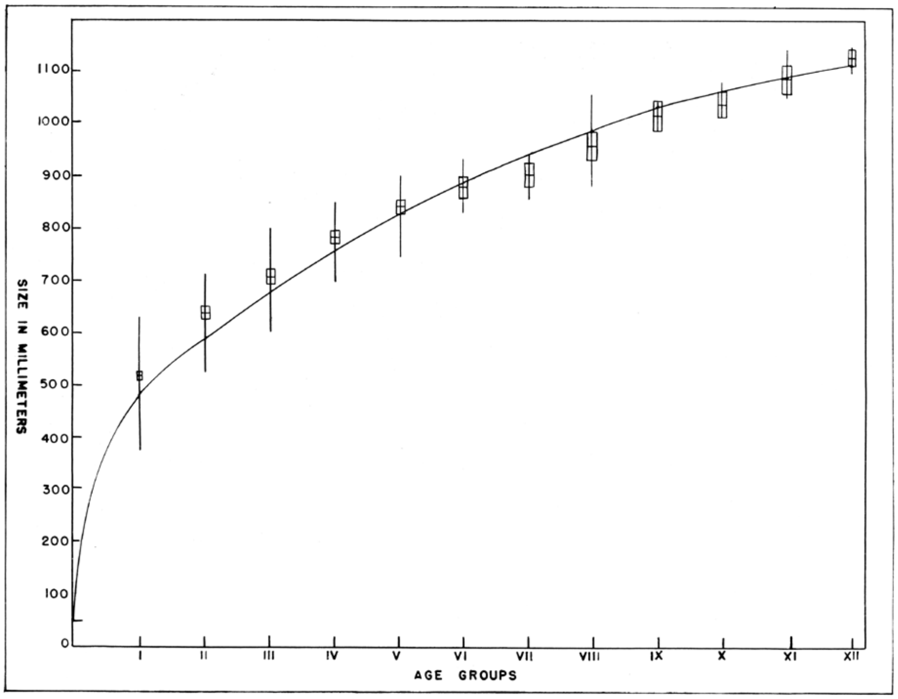

FIGURE 12. Growth rate of the yellowtail. The fine vertical line represents the size range, the horizontal line the mean, and the box the 95 percent confidence interval. The growth curve was fitted by von Bertalanffy's growth equation.

FIGURE 12. Growth rate of the yellowtail. The fine vertical line represents the size range, the horizontal line the mean, and the box the 95 percent confidence interval. The growth curve was fitted by von Bertalanffy's growth equation

the short-term tag recoveries (58 to 84 days) showed a negative growth, most of the returns showed the growth of the fish to fall well within the calculated range.

An important goal of the project was to examine as many whole tagged fish recovered from the commercial and sport fisheries as was possible, rather than accept what information could be obtained from tags returned by mail. Close contact was maintained with both the sport and commercial industries to enable project personnel to examine and measure marked fish before they were cleaned.

The 52 yellowtail used in a tagging growth study were at liberty for 243 to 488 days. Growth per day was calculated for each fish and this information was then used to adjust the growth for that fish to one year (365 days). The length at the time of tagging was plotted against the adjusted length a year later (Figure 13) and a trend line fitted by the method of least squares. The growth rate beyond the point of inflection was thus approximated by a straight line, essentially the technique employed by Walford (1946).

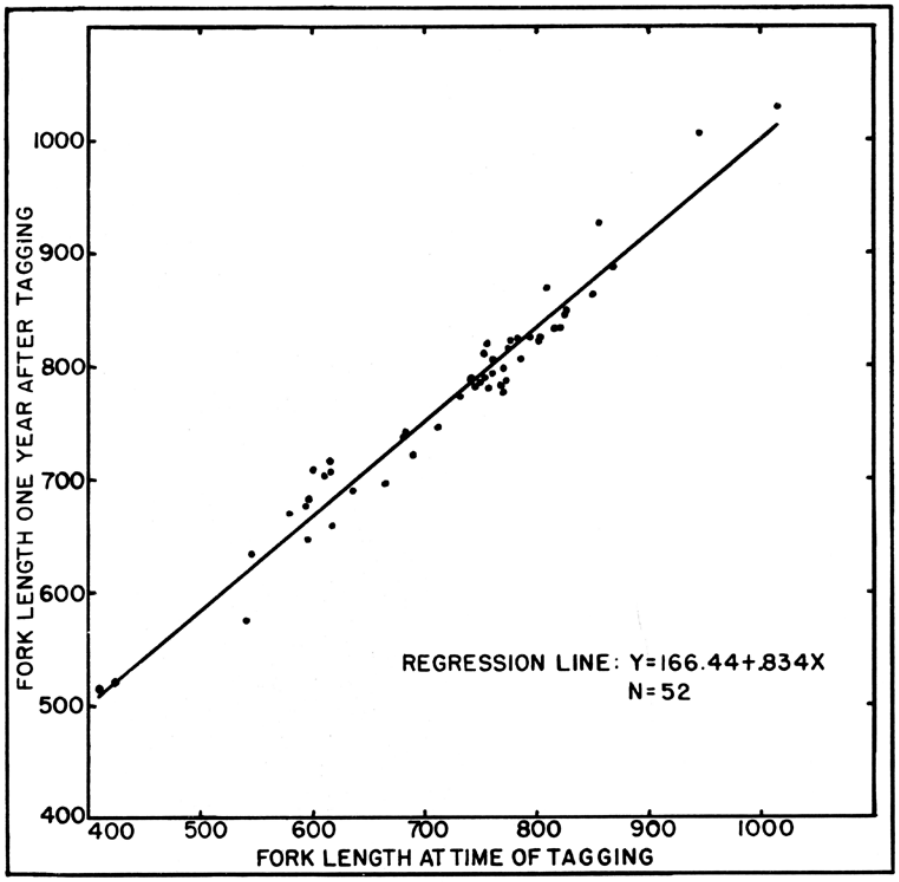

FIGURE 13. Yellowtail growth based on the increase in length of fish at liberty between 243 and 488 days. Length on return adjusted to 365 days against original fish length.

FIGURE 13. Yellowtail growth based on the increase in length of fish at liberty between 243 and 488 days. Length on return adjusted to 365 days against original fish length

The growth increments established by the tagging experiment varied considerably. The growth-per-year for age group I fish ranged from 34 to 109 mm., while that for age group VII ranged from 19 to 70. This was found in all age groups and tended to substantiate the results obtained from scale analysis showing a considerable variation in the lengths of the fish within each age group.

Although slightly lower, the trend line computed from the tagging study compared favorably with that derived from scale analyses. The lower values obtained from the tagging study can possibly be accounted for by the fact the fish were originally measured alive in the field, or tagging may have inhibited growth to some extent, or in some instances after the fish was recaptured it was frozen before being measured—a process known to have shortened some specimens.

The asymptotic length ([L8]) of 1,291 mm. might be regarded as the average maximum length achieved by this species. Mounted specimens of record-size yellowtail tend to substantiate this as the two largest specimens examined, originally weighing 63 and 80 pounds respectively, measured just slightly under 1,300 mm. fork length. The largest taken during the course of the investigation measured only 1,182 mm. *Emil J. Smith, Jr. and Harry M. Mekjian.*

5. WEIGHT-LENGTH RELATIONSHIP

This study was based on 3,377 fish, most of which were sampled at the canneries. Included are data for 1,654 males, 1,699 females and 24 sex undetermined.

Fork length measurements were grouped into one-centimeter intervals for each sex, and the average weight calculated for the midpoint of each interval (Table 10). The regression of weight in pounds on length in millimeters for each sex was then determined by the method of least squares using the exponential equation $W = CL^n$ in its logarithmic form: log W = log C + n log L. The resulting weight-length formula for males was: W = 0.00000005689 L2.89 (log W = [8].75507 + 2.89 log L); and for females: W = 0.00000007747 $L^{2.84}$ (log W = 8.88911 + 2.84 log L).

Differences between sexes were not significant so the data were combined resulting in a single weight-length curve (Figure 14) derived from the formula W = 0.00000007439 $L^{2.85}$ (log W = [8].87150 + 2.85 log L).

In general, the regression line fits the data quite well. Due to a wide variation in weight for a given length, the deviations from the line in the larger fish are attributed to small numbers of specimens rather than a difference in growth rate.

Because fork length is more standard and reliable it was used in preference to total length on all of the weight-length calculations. Size limit regulations on the other hand, generally specify overall or total length as it is more understandable and more commonly used by fishermen. For ease in converting these two measurements, the regression of fork length on total length was calculated. This regression is based

TABLE 10

Mean Weights per Centimeter of Fork Length

Interval of Fork Length (mm)	Males		Females		Sexes Combined	
	Mean Weight Pounds	No. of Fish	Mean Weight Pounds	No. of Fish	Mean Weight Pounds	No. of Fish
380-389	--	--	1.8	3	1.9	4
390-399	1.8	1	1.9	2	1.9	3
400-409	--	--	--	--	2.2	1
410-419	2.0	1	--	--	2.0	1
420-429	2.2	1	2.2	1	2.2	2
430-439	--	--	2.2	1	2.2	1
440-449	2.5	3	2.3	2	2.4	5
450-459	3.0	3	2.6	3	2.8	6
460-469	2.9	2	3.0	1	2.9	3
470-479	3.2	1	3.1	5	3.1	6
480-489	3.2	3	--	--	3.2	3
490-499	3.7	2	3.5	6	3.5	8
500-509	3.0	1	3.9	8	3.8	9
510-519	4.0	7	4.1	12	4.0	19
520-529	4.2	10	4.2	15	4.2	26
530-539	4.4	5	4.3	10	4.4	15
540-549	4.6	4	4.8	2	4.6	6
550-559	4.9	6	4.7	4	4.8	10
560-569	5.1	3	5.2	6	5.2	9
570-579	5.6	15	6.0	2	5.6	17
580-589	5.7	7	5.7	8	5.7	15
590-599	6.4	5	6.2	8	6.3	13
600-609	6.4	13	6.7	12	6.5	25
610-619	6.8	23	6.6	23	6.7	46
620-629	7.1	33	7.0	26	7.1	59
630-639	7.3	43	7.5	36	7.4	79
640-649	7.7	47	7.9	45	7.8	93
650-659	8.1	58	8.0	47	8.1	105
660-669	8.4	40	8.3	54	8.4	94
670-679	8.8	58	8.7	58	8.8	118
680-689	9.3	54	9.2	62	9.2	118
690-699	9.7	87	9.6	52	9.7	139
700-709	9.9	91	10.0	75	9.9	166
710-719	10.4	105	10.3	107	10.3	212
720-729	10.6	126	10.9	124	10.7	250
730-739	11.1	147	11.1	125	11.1	272
740-749	11.6	140	11.6	105	11.6	245
750-759	12.0	127	11.9	136	11.9	263
760-769	12.5	93	12.5	136	12.5	229
770-779	12.8	73	12.8	99	12.8	172
780-789	13.3	62	13.2	83	13.2	145
790-799	13.5	38	13.4	59	13.4	97
800-809	13.9	33	13.9	40	13.9	73
810-819	14.9	13	14.3	26	14.5	39
820-829	15.3	17	14.9	19	15.1	36
830-839	16.0	9	15.9	9	15.9	19
840-849	16.8	9	16.0	12	16.3	21
850-859	17.3	6	16.6	10	16.9	16
860-869	17.8	6	17.4	5	17.6	11
870-879	16.8	3	19.5	2	17.9	5
880-889	18.4	2	16.3	3	17.9	7
890-899	19.0	2	18.5	2	19.3	7
900-909	20.4	3	19.5	2	20.0	5
910-919	22.0	1	21.4	2	21.2	7
920-929	22.5	4	22.0	1	22.4	5
930-939	--	--	--	--	--	--
940-949	--	--	--	--	22.0	1
950-959	21.0	1	--	--	21.0	1
960-969	25.5	2	--	--	24.3	4
970-979	23.9	2	--	--	24.8	3
980-989	--	--	22.9	2	22.9	2
990-999	27.1	2	--	--	27.1	2

TABLE 10
Mean Weights per Centimeter of Fork Length

TABLE 10--Continued

Mean Weights per Centimeter of Fork Length

Interval of Fork Length (mm)	Males: Mean Weight Pounds	Males: No. of Fish	Females: Mean Weight Pounds	Females: No. of Fish	Sexes Combined: Mean Weight Pounds	Sexes Combined: No. of Fish
1000-1009	--	--	--	--	--	--
1010-1019	--	--	24.0	1	26.3	2
1020-1029	--	--	--	--	--	--
1030-1039	27.2	1	--	--	27.2	1
1040-1049	--	--	--	--	--	--
1050-1059	--	--	--	--	32.0	1
Totals	--	1,654	--	1,699	--	[1]3,377

[1] Includes specimens on which sex was not determined.

TABLE 10

Mean Weights per Centimeter of Fork Length

on 344 specimens and is described by the equation: *TL* = *FL* (1.119) + 15.45 where *TL* equals total length and *FL* equals fork length in millimeters. This conversion may also be approximated by considering the fork length to be roughly 87.3 percent of total length throughout the size range. *William L. Craig*.

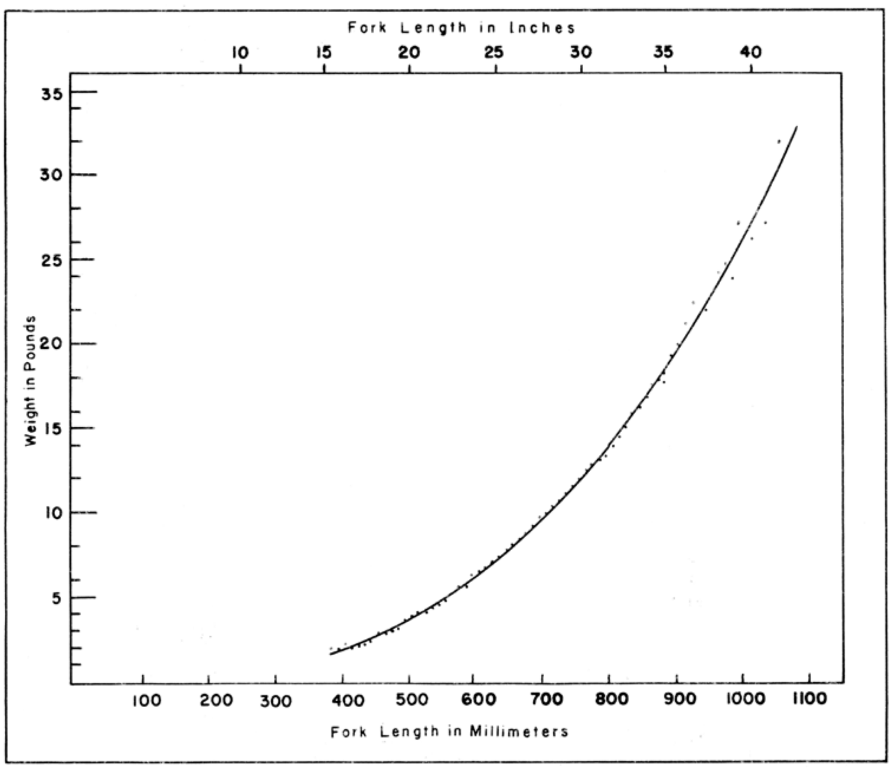

FIGURE 14. The weight-length relationship of yellowtail.

FIGURE 14. The weight-length relationship of yellowtail

6. FOOD AND FEEDING

This study was undertaken with a two-fold purpose in mind: as a phase of the general life history and to investigate the possibility that the decline in the local yellowtail fishery might be tied in with the apparent decline of the sardine population.

Some insight into the results may be gained from a knowledge of the bait used by sportfishermen to capture these fish. Cannon (1953) suggests the following: sardines, anchovies, butterfish, smelt, other fishes, squid and various artificial lures. Walford (1937) adds a few more species of similar habit to this list and summarizes beautifully by saying, "Yellowtail feed on schooling fishes smaller than themselves". Except for scattered notations such as these no detailed information was available on the food habits of this species or any near relative.

During the fall of 1952, 40 stomachs were collected from several sources. They were examined qualitatively and quantitatively in an attempt to develop methods and techniques for future handling of samples. Two decisions were reached:

1. Only stomachs from fish caught in a purse seine would be used. These, it was felt would·be the least influenced by bait and chum. Up to that time, purse seine landings surpassed landings from all other types of gear by a considerable margin, indicating ideal conditions for obtaining study material.
2. It did not seem necessary to collect a large number of stomachs from any one sample, for the contents of all stomachs within any one sample were practically identical.

Had economic conditions remained constant, this system would undoubtedly have yielded excellent data, for a few stomachs from many localities would then have been available. Unfortunately the character of the commercial fishery changed completely during the 1954 season. Most deliveries were made in small units by live bait boats rather than purse seiners. As this gear change became more obvious, the standards that had been established for taking stomach samples were revised to include live bait boats. After 1954, yellowtail landings dwindled to practically nothing and each year proportionally fewer fish were taken in purse seines.

6.1. Methods

Methods of collecting and preserving stomachs were identical in all cases. The stomach was exposed by carefully making a mid-ventral incision in the body wall. It was severed from the esophagus anteriorly and posteriorly from the intestine behind the pyloric valve, removed, and wrapped in gauze with an appropriate label. The entire package was then placed in a solution of 10 percent formalin and preserved until such time as a detailed examination could be made.

The intestines from several fish were examined early in the study to determine whether or not identifiable remains occurred in that portion of the alimentary tract. The contents of the intestine were examined first with the naked eye and then with the aid of a stereoscopic microscope. Only amorphous particles were found, hence, it was not included in later collections.

For detailed examination, the stomach contents were emptied into a dissecting pan, the organisms identified as completely as possible, a record made of their number, and volumes determined by the displacement of water in graduate cylinders.

The digestive process is very rapid in this species making identification of organisms very difficult. For example, a key character for identification of squid depends upon whether or not the membrane covering the eye is perforated (Berry, 1910). This character was not discernable in any squid specimen encountered during the course of the study. Even an occasional fish hook lodged in the wall of the stomach appeared to have been acted upon by a strong caustic. Bait ingested just prior to capture showed the beginning signs of digestion. Thus, a great many of the fish specimens could not be identified from external characteristics. In such cases the vertebral column was cleaned and use was made of a vertebral key (Clothier, 1950). On occasion the vertebral column was fragmented but the skull was intact making it possible to salvage the otoliths (sagittae) which were referred to a study collection conceived and maintained by Mr. J. E. Fitch. Several specimens were identified by this means.

The method of capture has been indicated by the terms "purse seine" and "other". "Purse seine" signifies stomach samples from fish taken with the common ring net used in capturing many species of schooling fish ranging in size from anchovies to tuna. "Other" signifies the stomach samples from fish taken primarily by hook and line but including any gear except the purse seine. The term "amorphous material" describes food organisms which were completely broken down and in the process of entering the intestine. Though the condition was such that nothing was recognizable, the amount was measurable and was recorded. Some stomachs contained single items representing animal, vegetable, or mineral matter. These were considered to have been ingested incidental to actual feeding and were titled "miscellaneous".

All three of the basic methods of presenting this type of data have been used in summarizing the results. The three are numerical, volumetric and frequency-of-occurrence. Stress was minimized on the numerical method due to its overemphasizing effect on stomachs containing a multitude of small organisms. It was felt that food organisms appearing frequently and in large quantities must be considered the most important to the food habits of the species.

6.2. Results

In all, 75 "purse seine" and 56 "other" stomachs from fish ranging in size from 40 to 105 cm. (fork length) were examined. These data clearly show yellowtail are carnivorous feeders (Table 11, Figures 15, 16, 17). Although squid (Loligo sp.) and red swimming crab (Pleuroncodes planipes), among the invertebrates, appear to be important, fish definitely predominated. In any group of stomachs from one sample, a single species was usually dominant. Since this dominant organism was consistently the same, the possibility is suggested that were the study continued indefinitely almost any food item listed (Table 11) could have been the most important.

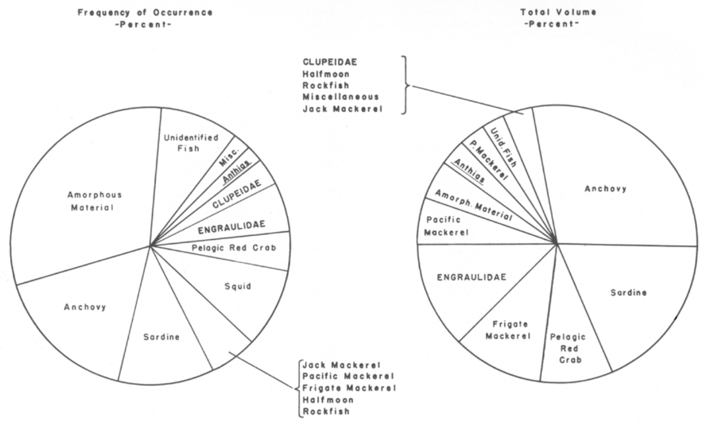

FIGURE 15. Frequency-of-occurrence and volume of various food items found in stomachs of 75 yellowtail caught by purse seine gear. Each of the species included in brackets represents less than two percent of the appropriate total.

FIGURE 15. Frequency-of-occurrence and volume of various food items found in stomachs of 75 yellowtail caught by purse seine gear. Each of the species included in brackets represents less than two percent of the appropriate total

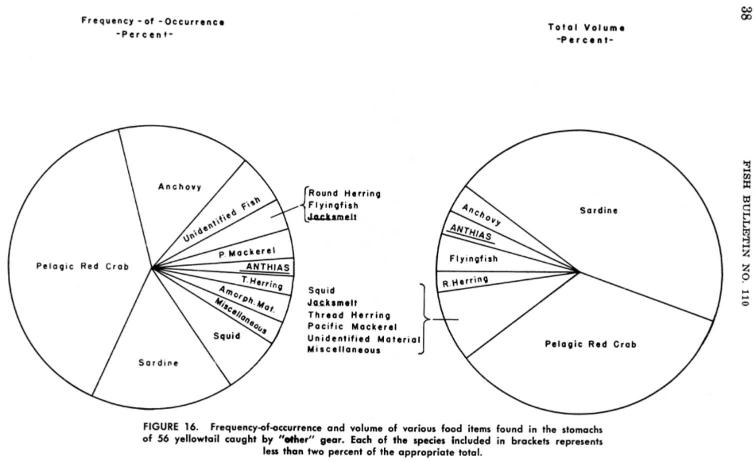

FIGURE 16. Frequency-of-occurrence and volume of various food items found in the stomachs of 56 yellowtail caught by "other" gear. Each of the species included in brackets represents less than two percent of the appropriate total

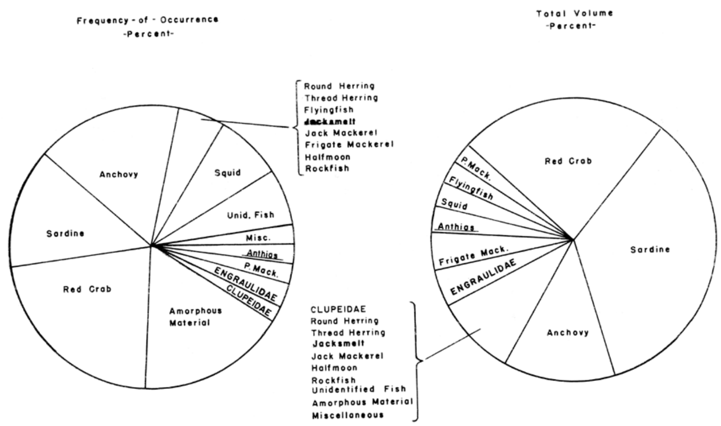

FIGURE 17. Data in Figures 15 and 16 combined to show "total" frequency-of-occurrence and volume of various food organisms found in yellowtail stomachs. Each item in brackets represents less than two percent of the appropriate total.

FIGURE 17. Data in Figures 15 and 16 combined to show "total" frequency-of-occurrence and volume of various food organisms found in yellowtail stomachs. Each item in brackets represents less than two percent of the appropriate total

TABLE 11

Food Items Encountered in the Stomachs of 172 Adult Yellowtail Showing Number, Volume and Frequency-of-Occurrence of Each Item

Food Item	Number					Frequency-of-Occurrence					Volume					
	Purse Seine		Other		Total No.	Purse Seine		Other		Total No.	Purse Seine		Other		Total cc.	Ave. Size of Organisms-cc.
	No.	Per-cent	No.	Per-cent		No.	Per-cent	No.	Per-cent		cc.	Per-cent	cc.	Per-cent		
CLUPEIDAE																
Round herring (*Etrumeus acuminatus*)	--	--	2	0.1	**2**	--	--	1	1.8	**1**	--	--	175	2.3	**175**	87.5
Sardine (*Sardinops caerulea*)	55	6.2	192	10.3	**247**	10	13.3	15	26.8	**25**	914	18.1	3534	45.5	**4448**	18.0
Thread herring (*Opisthonema libertate*)	--	--	8	0.4	**8**	--	--	2	3.6	**2**	--	--	158	2.0	**158**	19.8
Clupeids, unidentified	11	1.2	--	--	**11**	3	4.0	--	--	**3**	14	0.3	--	--	**14**	1.3
ENGRAULIDAE																
Northern anchovy (*Engraulis mordax*)	362	40.3	44	2.4	**406**	15	20.0	15	26.8	**30**	1414	28.0	225	2.9	**1639**	4.0
Engraulids, unidentified	142	15.8	--	--	**142**	5	6.7	--	--	**5**	633	12.5	--	--	**633**	4.5
EXOCOETIDAE																
California flyingfish (*Cypselurus californicus*)	--	--	2	0.1	**2**	--	--	1	1.8	**1**	--	--	345	4.4	**345**	172.5
SERRANIDAE																
Red serranid (*Anthias gordiensis*)	3	0.3	4	0.2	**7**	2	2.7	2	3.6	**4**	189	3.7	225	2.9	**414**	59.1
ATHERINIDAE																
Jacksmelt (*Atherinopsis californiensis*)	--	--	7	0.4	**7**	--	--	1	1.8	**1**	--	--	64	0.8	**64**	9.1

TABLE 11
Food Items Encountered in the Stomachs of 172 Adult Yellowtail Showing Number, Volume and Frequency-of-Occurrence of Each Item

CARANGIDAE Jack mackerel (*Trachurus symmetricus*)	2	0.2	--	--	**2**	1	1.3	--	--	**1**	100	2.0	--	--	**100**	50.0
SCOMBRIDAE Pacific mackerel (*Pneumatophorus diego*)	2	0.2	2	0.1	**4**	1	1.3	3	5.4	**4**	134	2.7	150	1.9	**284**	71.0
KATSUWONIDAE Frigate mackerel (*Auxis* sp.)	1	0.1	--	--	**1**	1	1.3	--	--	**1**	550	10.9	--	--	**550**	550.0
SCORPIDAE Halfmoon (*Medialuna californiensis*)	1	0.1	--	--	**1**	1	1.3	--	--	**1**	11	0.2	--	--	**11**	11.0
SCORPAENIDAE Rockfish (*Sebastodes* sp.)	9	1.0	--	--	**9**	1	1.3	--	--	**1**	35	0.7	--	--	**35**	3.9
UNIDENTIFIED FISH	11	1.2	9	0.5	**20**	8	10.7	4	7.1	**12**	123	2.4	98	1.3	**221**	11.1
CRUSTACEA Red crab (*Pleuroncodes planipes*)	277	30.8	1586	84.8	**1863**	4	5.3	36	64.3	**40**	424	8.4	2639	34.1	**3063**	1.6
MOLLUSCA Squid (Cephalopoda)	21	2.3	11	0.6	**32**	8	10.7	6	10.7	**14**	269	5.3	107	1.4	**376**	11.8
AMORPHOUS MATERIAL	--	--	--	--	--	28	37.3	3	5.4	**31**	231	4.6	11	0.1	**242**	--
MISCELLANEOUS ITEMS[1]	3	0.3	2	0.1	**5**	2	2.7	2	3.6	**4**	11	0.2	28	0.4	**39**	7.8
TOTAL	900	100	1869	100	**2769**	90	>100	91	>100	**181**	5052	100	7759	100	**12811**	60.8

[1] Algae, Seeds, Rocks, Flyingfish eggs, Kelp, Isopods, Copepods, Nematodes (Presumed Parasitic)

TABLE 11—Cont'd.

The validity of the high occurrence of sardine and anchovy in the "other" stomachs might well be questioned, for these are the two species most commonly used for chum and bait. Rather than attempt to differentiate and discount the influence of bait, the stomachs from this source were examined in the same way as those taken in purse seines. In comparing frequencies-of-occurrence of sardine and anchovy, only slight differences are to be noted between the two types of gear.

Another interesting point was the high incidence of amorphous material in the stomachs of fish taken with "purse seine" as compared to "other" gear (Figures 15, 16). The purse seine fishery is conducted primarily at night, the bait fishery during daytime. These points, together with the apparently rapid rate of digestion are indicative of a daytime feeding habit for yellowtail.

Several stomachs were examined qualitatively in the field. The organisms encountered have not been included in the analysis but further illustrate the wide diversity of yellowtail food. They were: mackerel scad (Decapterus sp.), cusk-eel (Otophidium sp.), blacksmith (Chromis punctipinnis), saury (Cololabis saira), and paper nautilus (Argonauta sp.).

6.3. *STELLA MARIS* Cruise

A tagging cruise aboard the commercial purse seiner *Stella Maris* in September 1955, (mentioned previously) provided an excellent sample of stomachs for separate analysis. They presented an opportunity to compare stomach contents from three individual school groups; the first, a daylight set at the San Benito Islands, the second and third, daylight and night sets respectively, at Cedros Island, Baja California. Ninety-eight stomachs collected on this trip were examined, and 58 of these were identifiable to a specific school. Unfortunately, the labels from the remainder (40) were lost during storage and could not be assigned to specific schools.

For each of the three school groups, bait or forage species predominated. In these cases jack mackerel *(* Trachurus symmetricus *)* and Pacific mackerel *(* Pneumatophorus diego *)* appeared most commonly (Tables 12, 13, 14) (Figure 18), further supporting the theory that any organism could dominate were the study continued indefinitely.

Although the stomach contents from the three different schools were similar, it was felt sufficient differences existed that one could identify with reasonable certainty, each of the stomachs from the sample of unknown origin (Table 15).

As noted earlier, the samples collected at night consisted largely of stomachs which were either totally empty or contained only a small amount of amorphous material, again indicating a tendency toward daytime feeding.

6.4. Conclusion

If the yellowtail has vital preferences in choice of food the phenomenon was not made manifest by this study. The term "opportunist feeder" perhaps best describes them. Although sardines, anchovies, jack mackerel and Pacific mackerel predominated, the rather impressive list of other species suggests that the schooling habits of the forage organisms rather than the specific item, are prime motivating factors. Should the primary bait species become less abundant, yellowtail

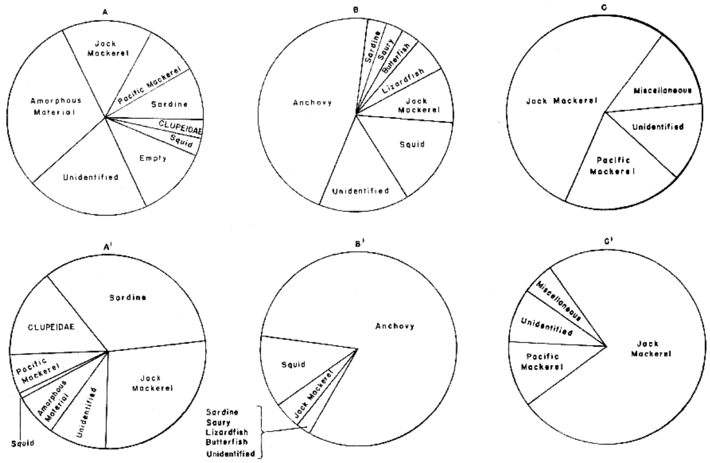

FIGURE 18. Frequency-of-occurrence (A, B, C) and volume (A', B', C') of food items found in 58 yellowtail stomachs collected from separate sets of a purse seine net during the *Stella Maris* tagging cruise. *Left* (A,A'): Cedros Island, night set, 29 stomachs. Center (B,B'): Cedros Island, daytime set, 18 stomachs. *Right* (C,C'): San Benito Islands, daytime set, 11 stomachs. Items in brackets represent less than two percent of appropriate total.

FIGURE 18. Frequency-of-occurrence (A, B, C) and volume (A', B', C') of food items found in 58 yellowtail stomachs collected from separate sets of a purse seine net during the Stella Maris tagging cruise. Left (A,A'): Cedros Island, night set, 29 stomachs. Center (B,B'): Cedros Island, daytime set, 18 stomachs. Right (C,C'): San Benito Islands, daytime set, 11 stomachs. Items in brackets represent less than two percent of appropriate total

probably would be able to survive on any of a number of other species.

While similar factors may have influenced the decline in catch of the sardine and the yellowtail in the waters of the State, the abundance of yellowtail does not appear to be dependent on the presence of sardines.

TABLE 12

Food Items Encountered in the Stomachs of 11 Yellowtail Taken by the *Stella Maris* During a Daylight Set at the San Benito Islands, Baja California

Food Item	Total Organism Count		Occurrence of Items in Stomach		Volume of Organisms		Avg. Size of Org. cc.
	No.	Percent	No.	Percent	cc.	Percent	
CARANGIDAE							
Jack mackerel (*Trachurus symmetricus*)	176	80.7	8	72.7	270	74.6	1.5
SCOMBRIDAE							
Pacific mackerel (*Pneumatophorus diego*)	22	10.0	3	27.3	41	11.3	1.9
UNIDENTIFIED FISH	18	8.3	2	18.2	32	8.8	1.8
MISCELLANEOUS ITEMS	2	1.0	2	13.3	19	5.3	9.5
Totals	218	100.0	15	100.0	362	100.0	--

TABLE 12

Food Items Encountered in the Stomachs of 11 Yellowtail Taken by the Stella Maris During a Daylight Set at the San Benito Islands, Baja California

TABLE 13

Food Items Encountered in the Stomachs of 18 Yellowtail Taken by the *Stella Maris* During a Daylight Set at Cedros Island, Baja California

Food Item	Total Organism Count		Occurrence of Items in Stomach		Volume of Organisms		Avg. Size of Org. cc.
	No.	Percent	No.	Percent	cc.	Percent	
CLUPEIDAE							
Sardine (*Sardinops caerulea*)	1	0.2	1	5.6	24	0.6	24.0
ENGRAULIDAE							
Northern anchovy (*Engraulis mordax*)	562	92.3	15	83.3	3148	81.0	5.6
SCOMBERESOCIDAE							
Saury (*Cololabis saira*)	1	0.2	1	5.6	21	0.6	21.0
SYNODIDAE							
Lizardfish (*Synodus* sp.)	2	0.3	2	11.1	18	0.5	9.0
STROMATEIDAE							
Butterfish (*Palometa* sp.)	1	0.2	1	5.6	3	0.1	3.0
CARANGIDAE							
Jack mackerel (*Trachurus symmetricus*)	22	3.6	3	16.7	175	4.5	8.0
MOLLUSCA							
Squid (Cephalopoda)	13	2.1	5	27.8	462	11.9	35.5
UNIDENTIFIED FISH	7	1.1	5	27.8	36	0.9	5.1
Totals	609	100.0	33		3887	100.0	

TABLE 13

Food Items Encountered in the Stomachs of 18 Yellowtail Taken by the Stella Maris During a Daylight Set at Cedros Island, Baja California

TABLE 14

Food Items Encountered in the Stomachs of 29 Yellowtail Taken by the *Stella Maris* During a Daylight Set at Cedros Island, Baja California

Food Item	Total Organism Count		Occurrence of Items in Stomach		Volume of Organisms		Avg. Size of Org. cc.
	No.	Percent	No.	Percent	cc.	Percent	
CLUPEIDAE	3	3.7	1	3.4	68	14.8	22.7
Sardine (*Sardinops caerulea*)	13	15.8	3	10.3	156	34.0	12.0
CARANGIDAE							
Jack mackerel (*Trachurus symmetricus*)	39	47.6	5	17.2	126	27.4	3.2
SCOMBRIDAE							
Pacific mackerel (*Pneumatophorus diego*)	16	19.5	3	10.3	31	6.8	1.9
MOLLUSCA							
Squid (Cephalopoda)	1	1.2	1	3.4	1	0.2	1.0
UNIDENTIFIED FISH	10	12.2	7	24.1	43	9.4	4.3
AMORPHOUS MATERIAL	--	--	10	34.5	34	7.4	--
EMPTY (Totally)	--	--	4	13.8	--	--	--
Totals	82	100.0	34		459	100.0	--

TABLE 14
Food Items Encountered in the Stomachs of 29 Yellowtail Taken by the Stella Maris During a Daylight Set at Cedros Island, Baja California

TABLE 15

Food Items Encountered in 30 Yellowtail Stomachs Taken by the *Stella Maris*. These Fish Were Taken in Several Different Sets and Could Not Be Identified With a Specific School

Food Item	Total Organism Count		Occurrence of Items in Stomach		Volume of Organisms		Avg. Size of Org. cc.
	No.	Percent	No.	Percent	cc.	Percent	
CLUPEIDAE							
Sardine (*Sardinops caerulea*)	4	0.7	3	7.5	147	3.6	36.8
ENGRAULIDAE							
Northern anchovy (*Engraulis mordax*)	490	81.4	20	50.0	2700	65.3	5.5
SYNODIDAE							
Lizardfish (*Synodus* sp.)	8	1.3	4	10.0	53	1.3	6.6
STROMATEIDAE							
Butterfish (*Palometa* sp.)	2	0.3	2	5.0	10	0.2	5.0
CARANGIDAE							
Jack mackerel (*Trachurus symmetricus*)	9	1.5	8	20.0	199	4.8	22.1
SCOMBRIDAE							
Pacific mackerel (*Pneumatophorus diego*)	13	2.1	4	10.0	197	4.7	15.2
EMBIOTOCIDAE							
Viviparous perch, unidentified	1	0.2	1	2.5	7	0.2	7.0
MOLLUSCA							
Squid (Cephalopoda)	21	3.5	10	25.0	626	15.2	29.8
UNIDENTIFIED FISH	53	8.8	11	27.5	125	3.0	6.0
AMORPHUS MATERIAL	--	--	5	12.5	67	1.6	--
MISCELLANEOUS ITEMS	1	0.2	1	2.5	1	0.1	1.0
EMPTY (Totally)	--	--	1	2.5	--	--	--
Totals	602	100.0	70		4132	100.0	--

TABLE 15
Food Items Encountered in 30 Yellowtail Stomachs Taken by the Stella Maris. These Fish Were Taken in Several Different Sets and Could Not Be Identified With a Specific School

6.5. Limitations of the Study

The limitations, or factors which detracted from the completeness of this study resulted largely from certain characteristics of the fishery. Three of these were: (1) both the sport and commercial fisheries are seasonal; (2) neither fishery is conducted over the entire range of the species; and (3) the sizes of the individuals harvested are limited to a narrow range.

No comparison of food habits relative to season of the year was possible. Neither the sport fishery nor the commercial fishery, even under ideal conditions, would contribute a full year of suitable stomach samples to relate changes in diet to changes in season.

Attempts to compare food items between geographical areas also proved unsuccessful. The majority of stomachs from commercially caught fish were from closely adjacent areas. The sportcatch was almost entirely from the Coronado Islands. Many stomachs from that source were examined grossly in the field. Anchovies *(* Engraulis mordax *)* were the only organisms encountered, though squid *(* Loligo opalescens *)* were reported commonly by party boat operators. Since anchovies were used almost exclusively for bait and chum by the sport-fishing fleet, these data were excluded from consideration in the analysis because of the obvious bias.

The sizes of fish whose stomach contents were examined ranged, as previously mentioned, from 40 to 105 cm. (fork length). Actually fewer than 20 percent represented fish smaller than 65 or longer than 85 cm. (fork length). This could hardly be called adequate for a detailed food study by size groups. It is indeed unfortunate that a generous sample of small fish, up to a length of about 15 inches, was not available for examination. A few specimens under six inches in length were collected but the stomachs were not examined for it was felt they would be of more value preserved in entirety. No transitional-sized fish, from about 6 to 15 inches, were taken during the course of the investigation. There is no doubt that fish of these sizes would exhibit differences in food constituents. *William L. Craig.*

7. MATURITY AND FECUNDITY

7.1. Methods

The results of this study are based entirely on ova diameter measurements. Gross observations are most difficult, particularly on males, and are seldom uniform. Therefore, no effort was made to evaluate the male maturity. Gross observations were taken for a time on females but were abandoned because of the inconclusiveness of the results.

Preserved gonads were blotted as dry as possible to remove excess external moisture and weighed to the nearest one-tenth gram. The two lobes of the ovary were separated and each section weighted to the nearest one-tenth gram. One lobe was then returned to 10 percent formalin for the maturity studies and the other processed in Gilson's fluid for fecundity studies.

After the ovary had hardened in the formalin, a small portion was removed and placed on a glass slide. Eggs were teased from it into three lines running longitudinally on the slide. Their diameters were measured with a micrometer eyepiece in a compound microscope at a magnification of 50 diameters. This gave 57 micrometer units to the millimeter or 0.0175 mm. per unit. Due to the effects of the preservation, the eggs were not always symmetrical and to obviate any selection of the longest or shortest diameter, the micrometer scale was placed in the eyepiece so that the graduations were at right angles to the lines of eggs on the slide. A mechanical stage was used and the ova were moved across the field in only one direction. Every distinct egg in the field was measured as the slide moved by. Thus, no egg could be measured twice. Some asymmetrical eggs were measured to their largest diameter, others to the smallest, so the overall samples probably were representative.

Tests were conducted with ova from the anterior, central and posterior portions of the ovary. No differences in the relative number of eggs in each size group were found from any of these regions. Therefore, eggs from the central portion were used throughout the study. Two hundred were measured at random from each of 140 samples collected over a period of five years.

7.2. Spawning

No female yellowtail with free flowing eggs was observed during the course of the investigation, but males with free flowing milt were noted on several occasions. A quotation from Walford (1937) based upon notes in a San Pedro purse seine fisherman's log for July 15, 1932 is the only recorded observation of yellowtail spawning available. "July 15, 1932. At Uncle Sam Bank, 70 miles offshore in 52 fathoms. From 11:00 A.M. to 4:00 P.M., hundreds of yellowtail were milling about on the surface and a foot below, making short circles. Eggs and milt were streaming out of the fish so thick that the water was made white by them. The boat passed through the school several times, but the fish did not scatter; they merely moved a little and kept their circling. Several caught on a jig were full of running roe."

During August 1929, yellowtail caught at the Coronado Islands for a San Diego fresh fish market were observed to have free flowing eggs and sperm. On August 20, 1931 a load of 12-pound yellowtail was landed at Terminal Island, San Pedro from Santa Cruz Island; although the eggs were not free-flowing, they were granular and loose and the testes of the males were large and soft. The presence of ripe fish in different parts of their range, during the same months of the year, is indicative that the time of spawning is fairly uniform throughout the known range of the species. An exception to this was noted among some females with maturing eggs, up to 1.0 mm. in diameter, taken during February 1955 from Cape San Lucas to as far north as San Jose Island in the Gulf of California. The earlier warming of the waters in the Gulf is thought to have been responsible for this variation.

Yellowtail are thought to spawn in California waters during some years because both sexually mature adults and juveniles have been taken in the area. The first conclusive evidence of successful local spawning was not forthcoming, however, until the summers of 1958 and 1959 when juvenile yellowtail were observed. On May 4, 1958, a 12-inch specimen, weighing exactly one pound was caught outside Los Angeles Harbor at Horseshoe Kelp by an angler (W. A. Nott, personal communication). During the succeeding several months innumerable others

TABLE 16

Size Progression of Ova Expressed in Percentage of Total Monthly Samples

Ova diameter (mm.)	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Maturity
1.71-1.80	--------	--------	--------	--------	--------	--------	0.01	--------	0.03				
1.61-1.70	--------	--------	--------	--------	--------	--------	0.01	0.01	0.1				
1.51-1.60	--------	--------	--------	--------	--------	--------	0.01	0.01	0.4				Mature
1.41-1.50	--------	--------	--------	--------	--------	--------	0.01	0.1	1.6	0.2			
1.31-1.40	--------	--------	--------	--------	--------	--------	0.9	0.7	4.7	0.6			
1.21-1.30	--------	--------	--------	--------	--------	--------	1.4	1.8	4.5	2.1			
1.11-1.20	No Sample	--------	--------	--------	--------	--------	1.2	1.6	1.1	2.9			
1.01-1.10		--------	--------	--------	--------	0.1	1.4	1.7	0.7	5.0			
0.91-1.00		--------	--------	--------	--------	1.9	3.1	1.7	0.5	5.1			
0.81-0.90		--------	--------	--------	0.1	8.6	5.9	4.7	3.9	3.4	0.1		Maturing
0.71-0.80	--------	--------	0.1	--------	0.1	9.3	11.6	10.0	11.0	5.6	0.8		
0.61-0.70	--------	--------	0.1	0.1	0.4	13.3	10.0	12.3	10.8	8.7	0.1		
0.51-0.60	--------	--------	0.2	0.4	0.5	7.1	5.8	8.5	5.6	5.1	0.1		
0.41-0.50	--------	--------	1.7	1.9	0.9	10.5	6.3	8.5	5.8	6.5	0.2		
0.31-0.40	--------	--------	3.1	8.4	5.9	10.1	5.9	10.0	6.8	7.9	0.2		
0.21-0.30	--------	--------	2.3	9.4	8.4	6.3	6.2	6.4	5.4	7.1	0.3		
0.00-0.20	--------	100.0	92.6	79.8	83.0	32.9	39.5	32.2	37.1	40.1	98.1	100.0	Immature
No. eggs in sample	--------	1,600	1,200	1,200	2,800	800	3,000	7,000	2,800	2,000	3,800	1,800	

TABLE 16
Size Progression of Ova Expressed in Percentage of Total Monthly Samples

of similar or smaller size were taken in the vicinity of Avalon, Santa Catalina Island according to Captain William Plett of the Department of Fish and Game patrol boat Marlin. These fish were undoubtedly survivors of local spawning during 1957. During the months of September and October, 1959 numerous small yellowtail ranging in fork length from 2# to 8¾ inches (56 to 231 mm.) were captured along the southern California coast. It is unlikely that fish as small as these would have moved north from Mexican waters. Ocean temperatures off California in 1957 averaged as much as three degrees C. higher than the 1949 to 1954 averages (Marine Research Committee, 1958). Occurrences of spawning off southern California are rare indeed and can be expected only under the most favorable conditions such as those present during 1957, 1958 and 1959.

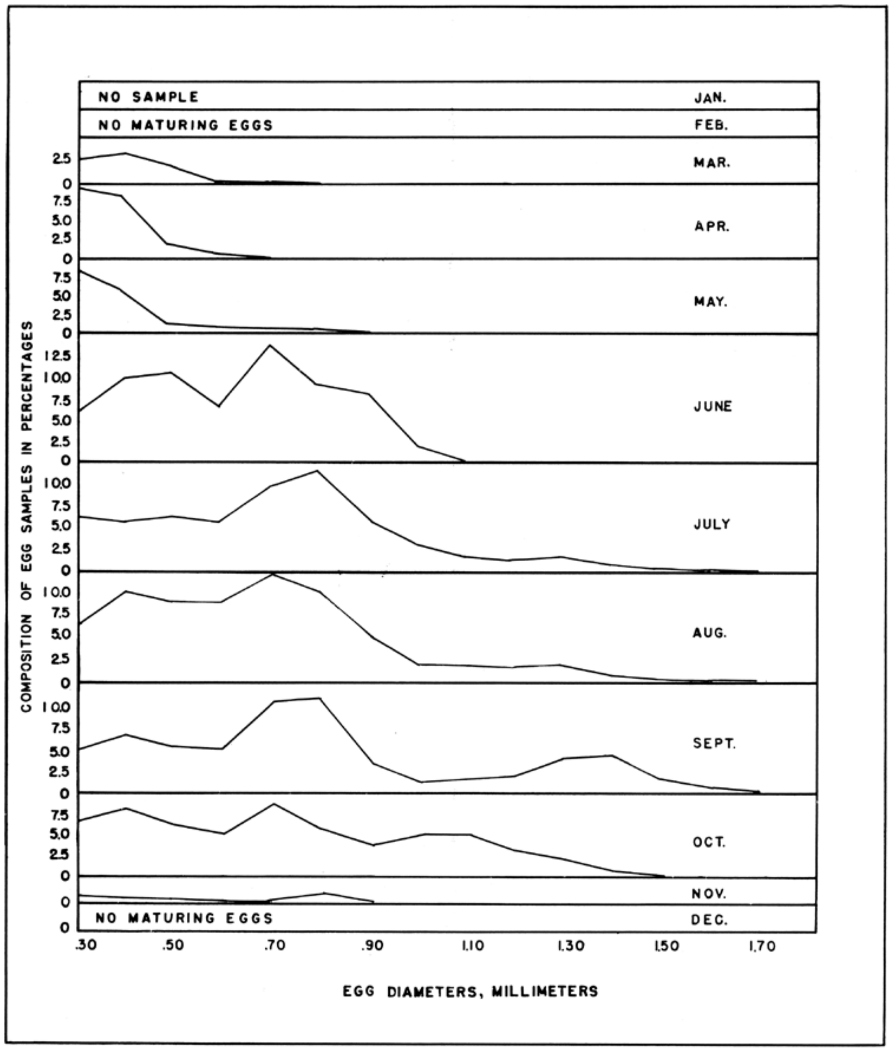

FIGURE 19. Ova diameter percentage frequency polygons showing monthly size progression of eggs.

FIGURE 19. Ova diameter percentage frequency polygons showing monthly size progression of eggs

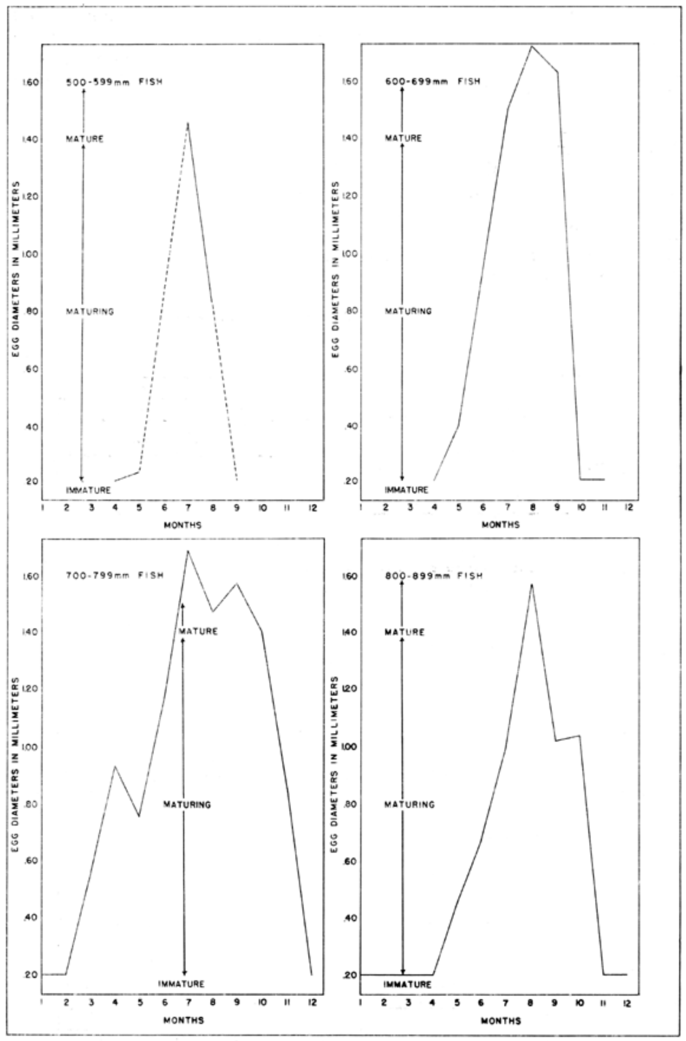

FIGURE 20. Ova diameter frequency polygons showing maximum monthly egg diameters for different sized yellowtail.

FIGURE 20. Ova diameter frequency polygons showing maximum monthly egg diameters for different sized yellow-tail

All yellowtail do not mature at the same time. The state of maturity was observed to vary greatly even among individuals from the same school of fish. It was not possible to trace modal groups through the various stages eggs must pass prior to spawning. To demonstrate the history of maturing eggs, the data were arrayed by month to show the percentage of eggs in each sample with diameters over 0.20 mm. (Table 16, Figure 19). Eggs smaller than 0.20 mm. were not plotted as they were present throughout the year. It was observed that the ova generally start developing in March and apparently reach maturity by late June. Spawning generally begins in July and continues until October. From December to February only the undeveloped eggs, 0.20 mm. or smaller in diameter were found.

7.3. Frequency of Spawning

The number of modes in the ova diameter frequency curves indicates that younger fish produce small numbers of eggs and probably spawn only once during their first year of maturity. Larger individuals apparently spawn a little at a time over at least a three-month period (Figure 19). Secondary modes do not carry over into succeeding years and only immature ova were present during the winter months. Apparently all ova larger than 0.20 mm. in diameter remaining in the gonads past the end of the spawning season are resorbed. This is strong evidence that eggs are continuously growing toward maturity during the summer months and that more than one batch of eggs is spawned each season.

7.4. Age and Size at First Maturity

The available data indicate that some fish spawn during their second summer when they are about 20 months old and 20 inches (506 mm.) long to the fork of the tail, and all spawn in their third summer, when they are about 25 inches (634 mm.) long (Figure 20).

TABLE 17

Calculated Number of Eggs in Ovaries of 35 Yellowtail

Date Caught	Fork length (mm.)	Weight in lbs.	No. of eggs in thousands	Date Caught	Fork length (mm.)	Weight in lbs.	No. of eggs in thousands
7-18-53	568	5.25	729	9-18-53	742	13.75	1,233
7-17-53	678	10.0	1,158	9-19-52	746	12.5	1,228
8-21-53	703	11.0	578	8-21-53	747	12.0	1,073
9-19-52	708	9.75	979	9-15-53	752	11.75	1,150
8- 9-53	713	10.75	933	8-21-53	752	12.0	726
8- 7-53	714	11.0	516	9-19-52	756	12.5	1,232
8- 7-53	715	10.5	903	8-21-53	760	12.75	1,485
8-21-53	717	11.0	1,070	8-21-53	761	12.5	1,938
8-21-53	723	10.75	1,057	8- 9-53	769	13.75	848
8-21-53	723	11.5	1,206	9-18-53	771	13.25	1,130
8-21-53	724	11.5	996	8-14-53	783	15.5	1,810
8-21-53	724	12.25	1,071	8-14-53	796	11.75	921
9-15-53	728	11.0	458	8-21-53	807	15.25	1,581
8-21-53	731	10.25	960	8-21-53	809	15.0	1,043
9-18-53	733	11.75	1,071	8-10-53	871	18.25	1,440
8-21-53	734	11.0	1,705	6-17-54	970	26.75	1,611
7-17-53	736	11.0	998	6- 2-54	1,053	32.0	3,914
9-18-53	742	12.0	1,157				

TABLE 17
Calculated Number of Eggs in Ovaries of 35 Yellowtail

7.5. Fecundity

Yellowtail ovary samples were treated with Gilson's fluid for fecundity studies, essentially following the techniques used by Franz (1910) and Simpson (1951). Gilson's fluid dissolved ovarian tissue leaving only the ova which were then dried and weighed.

Approximately 500 dried ova from each fish were counted and weighed to the nearest 0.1 mg. From these counts and weights total eggs were calculated by a simple ratio.

Fecundity estimates were made for 35 females ranging in fork length from 568 to 1,053 mm. and in weight from 5¼ to 32 pounds (Table 17). These ranged from 458,000 to 3,914,000 showing an increase in egg number with increasing weight of fish. A regression of the number of eggs in thousands on fish weight in pounds was calculated by least squares with the resulting equation $Y = -71 + 98 X$. *Emil J. Smith, Jr., and Clyde V. Paul*.

8. RESULTS OF TAGGING EXPERIMENTS

The first and foremost problem of the investigation was to determine if yellowtail travel from Mexican waters, where they are most abundant, into California waters. Fish migrations can best be determined by a tagging program; therefore, marking was the largest single undertaking of the investigation.

8.1. Materials and Methods

The types of tags used, the marking techniques and methods of capturing fish were for the most part described by Collyer (1954). There were, however, some subsequent developments.

The jaw tags previously described as "very satisfactory" proved much less desirable than plastic tubing or "spaghetti" tags and their use was discontinued. There were no long-term recoveries of jaw-tagged fish and the few that were recovered showed decided inflamation around the tag wound and were in a generally emaciated condition, indicating that the mark was interfering with normal feeding.

The "spaghetti" tag has proved very successful, especially for tagging of fastswimming pelagic species such as yellowtail and the various tunas. However, even this highly successful tag has had its drawbacks. Many companies manufacture plastic tubing and each company has many formulations. A variety of different lots of tubing was used and while some tags were still in excellent condition after having been affixed for over two years, the legend on others faded badly and on occasion the material became brittle and broke in a relatively short time. Unfortunately, there was no way of knowing which formula was used in any particular lot of the tubing. Tags that were inserted into a hard nylon outer jacket became badly abraded and showed the most breakage. In many cases the legend was worn off by friction. Those with monofilament nylon cores were also in poor condition after prolonged use.

"Spaghetti" tags are thought to be the most successful tag available for large fish such as yellowtail. A majority of the "problem" tags had been on yellowtail for from two to almost four years but the two longest term returns, 1,426 and 1,433 days, still bore legible tags and it is anticipated that readable tags will be received for some time to come.

FIGURE 21. Fishing for specimens for tagging aboard the Department's research vessel *N. B. Scofield. Photo by Claude M. Kreider.*

FIGURE 21. Fishing for specimens for tagging aboard the Department's research vessel N. B. Scofield. Photo by Claude M. Kreider

One lot of 2,946 Type G tuna tags (Wilson, 1953) gave the best results. The vinyl tubing remained flexible and the inscription perfectly legible on 43 tags which were on yellowtail from 34 to 1,374 days.

8.1.1. Evaluation of Fishing Methods

During the first four years of the tagging program, most of the fish were caught by conventional hook-and-line methods for two main reasons. First, yellowtail are very strong and being "played-out" by angling methods greatly eased the job of the tagging team and decreased the strain on the fish resulting from thrashing around out of water too long. Marking large numbers of such active fish can be rigorous and time-consuming if they are tagged while they still have all of their strength. Even when they were tired, an extra man was needed to hold it still for the tagger. Secondly, this was the method most adaptable for use on the State research vessels and on boats made available by interested individuals. However, these first four years of extensive effort yielded only a little more than 4,500 tagged fish. An additional 185 were caught for tagging in the "blanket net" used on the department's M/V *Yellowfin* (Radovich and Gibbs, 1954) and eight were taken with a lampara net.

In 1955, the commercial purse seine vessel *Stella Maris* was chartered, and between September 9 and 23, a total of 9,943 yellowtail was tagged and released from her in the vicinity of the San Benito Islands and Cedros Island.

The net, 350 fathoms long by 30 deep, was set 13 times. There were six successful hauls, five during daylight hours and one at night. The fish were held in the bag of the net between the *Stella Maris* and a

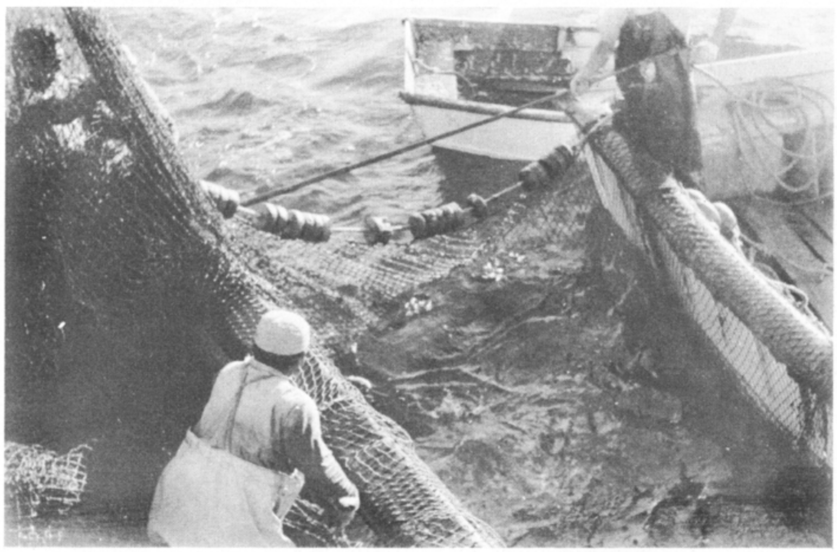

FIGURE 22. Fishing aboard the *Stella Maris.* The yellowtail were brailed from the bag of the net held between the net skiff on the right and the vessel, tagged and released. *Photo by Robert D. Collyer.*

FIGURE 22. Fishing aboard the Stella Maris. The yellowtail were brailed from the bag of the net held between the net skiff on the right and the vessel, tagged and released. Photo by Robert D. Collyer

large net skiff (Figure 22) and brailed aboard as fast as four tagging teams could handle them.

The length of time fish had to be held in the net seems to be critical. Those groups held for the longest time before the completion of tagging have showed poorest percentage return (Table 18, Figure 23). Time in the net was not the only factor contributing to decreasing return, but, it was the most easily measured. Tired tagging teams also contributed because of a tendency to work more slowly and less carefully. As an indication of this, the first day's tagging, September 9, shows a 6.60 percent overall return. The tagging crews were still fresh, best

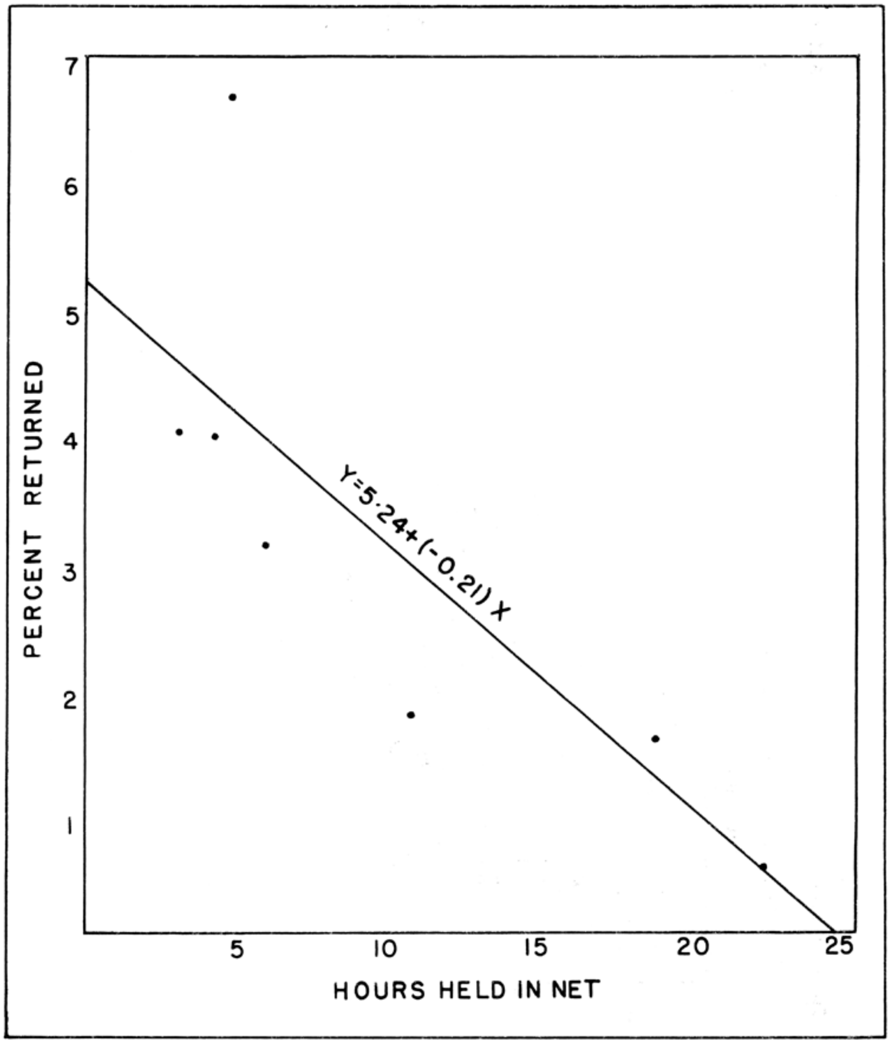

FIGURE 23. Percentage recovery rates of individual tagging lots plotted against the number of hours that lot was held in a purse seine net before tagging was completed. Straight line fitted by least squares.

FIGURE 23. Percentage recovery rates of individual tagging lots plotted against the number of hours that lot was held in a purse seine net before tagging was completed. Straight line fitted by least squares

TABLE 18

Comparison of Tag Recovery Rates of Drugged and Undrugged Fish Caught by Purse Seine, September, 1955 at Cedros and San Benito Islands

Date	Drugged Fish			Undrugged Fish			Total Fish (D. & Und.)			Time in Net[1]
	Tagged	Returned	Percent Returned	Tagged	Returned	Percent Returned	Tagged	Returned	Percent Returned	
Sept. 9	8	1	12.50	394	26	6.60	402	27	6.72	to 5 hrs.
Sept. 10	500	21	4.20	76	2	2.64	576	23	3.99	to 4½ hrs.
Sept. 11	498	2	0.40	588	19	3.23	1,086	21	1.93	to 10½ hrs.
Sept. 12	0	0	0.00	764	4	0.52	764	4	0.52	17½ to 22½ hrs.
Sept. 16	0	0	0.00	876	24	3.08	876	24	3.08	to 6 hrs.
Sept. 19	0	0	0.00	499	20	4.01	499	20	4.01	to 3 hrs.
Sept. 21	0	0	0.00	6	0	0.00	6	0	0.00	to 1 hr.
Sept. 23	198	6	3.03	5,523	90	1.63	5,721	96	1.68	to 19 hrs.
Total	1,204	30	2.49	8,726	185	2.12	[2]9,930	215	2.17	

[1] From log of *Stella Maris.*
[2] An additional 13 fish were released for which there is no record regarding status.

TABLE 18
Comparison of Tag Recovery Rates of Drugged and Undrugged Fish Caught by Purse Seine, September, 1955 at Cedros and San Benito Islands

care probably was taken of the fish and they were tagged and released as rapidly as possible. The poorest return came from 764 fish tagged on September 12. Field notes show that this group was from a school that had been caught on the afternoon of September 11 when 1,086 were tagged. The tagging crews worked until about midnight and then retired. The following morning, September 12, after the fish had been held for 17½ hours the crews went to work again and tagged the remaining fish. In this case, the time in the net apparently was the major factor involved in a reduced return. The poorest rate for the entire trip, 0.52 percent, came from this group of fish.

During the same period (September 9 to 23), 77 hook-and-line caught fish were tagged in the same general area. Five of these, 6.49 percent, were subsequently recaptured, a further indication that the rapidity with which fish are tagged and returned to open water is important.

8.1.2. The Use of Chlorobutinal to Anesthetize Yellowtail

Handling thousands of net-caught yellowtail, many of which would be fresh and full of fight, presented a problem. To alleviate some of the difficulties, a drug, Chlorobutinal, $Cl_3C(OH_3)_2OH$, was used. Four ounces of the drug were dissolved in one quart of ethyl alcohol and a quart of solution was used in 30 gallons of sea water.

A 30-gallon portable canvas tank, approximately 20 inches wide, 40 long and 30 deep was made. Up to 10 fish at a time, averaging around 10 pounds each, were brailed into the tank. After exposure to the drug for about one minute, they were removed and tagged immediately. A section of the purse seine net was tied off and used as a holding pen in which the tagged, drugged fish could be placed to recover without being endangered by predators. The fish placed in the holding pen, appeared to be fully recovered in about one hour and could be released.

The drugging greatly eased the job of tagging. The tags could be more carefully placed, the lengths of the fish more carefully read and personnel normally required as "holders" were free to carry on other work. Anesthetized fish were much less bruised or otherwise marked than those tagged without anesthesia.

of the 9,943 tagged during this two-week period, 1,204 were anesthetized (Table 18). The difference in the overall return rate (2.49 percent for the drugged fish versus 2.12 percent for undrugged ones) does not appear significant when one considers that the numbers tagged drugged and undrugged are not comparable. Drugging such strong active fish helps the tagger but apparently neither improves nor lowers the return rate compared to that from undrugged ones.

8.2. Releases and Recoveries

To best illustrate the movements of yellowtail throughout their range, seven arbitrary areas were created (Table 19). They are essentially the same as those used in the racial studies (Table 1).

In all 15,161 yellowtail were tagged throughout these areas, mostly in the vicinity of Guadalupe Island (Area 3), Cedros Island (Area 4), and the 13-Fathom Bank (Area 5) (Figure 24). From these, 532 were returned up through August, 1959.

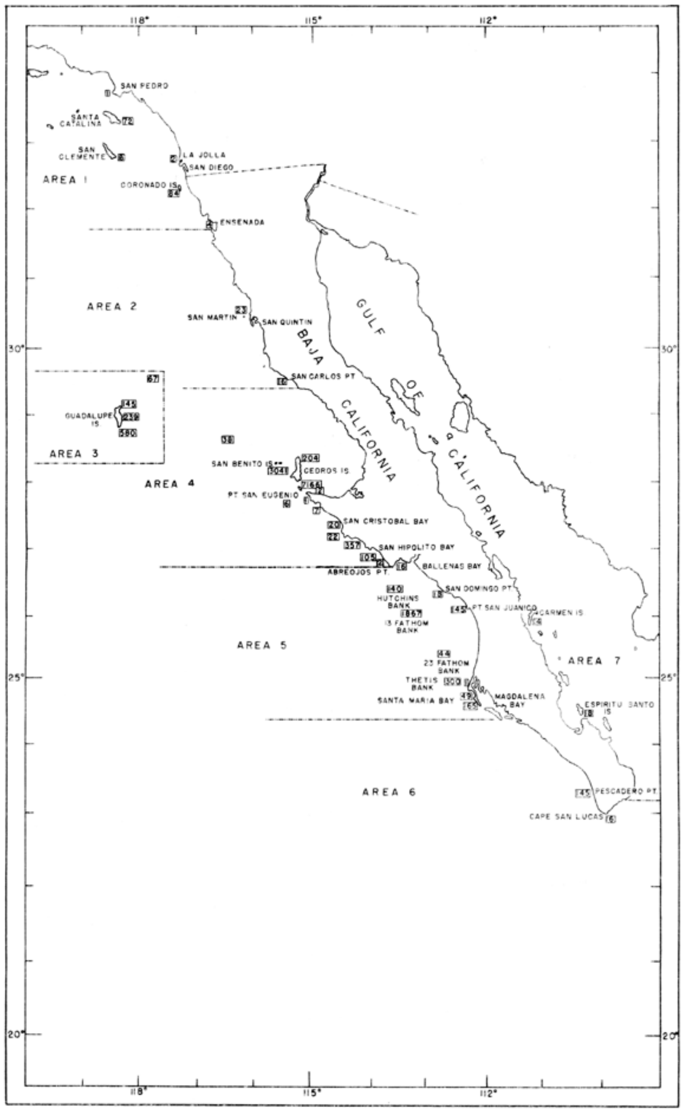

FIGURE 24. Outline map of southern and Baja California showing arbitrary areas and localities within these where tagged yellowtail were released.

FIGURE 24. Outline map of southern and Baja California showing arbitrary areas and localities within these where tagged yellowtail were released

TABLE 19

Arbitrary Boundaries of Areas Used to Assess Magnitude and Importance of Migrations as Shown by Tagging

Area number	Boundaries	General Designation
1	Southern Calif. to Los Coronados Is.	Southern California
2	Ensenada to Point Canoas	Ensenada
3	Guadalupe Island	Guadalupe
4	Point Canoas to Abreojos Point	Cedros Island
5	Abreojos Point to Magdalena Bay	13-Fathom Bank
6	Magdalena Bay to Cape San Lucas	Cape San Lucas
7	Gulf of California	Gulf

TABLE 19

Arbitrary Boundaries of Areas Used to Assess Magnitude and Importance of Migrations as Shown by Tagging

8.2.1. Area 1—Southern California to Los Coronados Islands (Southern California)

During the course of the project, 95 fish were caught and tagged in the southern California area (Area 1). An additional 72, transported by the Department research vessel *N. B. Scofield* from Guadalupe Island (Area 3), were tagged and released at Santa Catalina Island.

From the 72 tagged at Santa Catalina Island, there have been 17 recoveries, 13 in the area of release. Two were retaken at the Coronado Islands and two back at Guadalupe Island (Figure 25).

Eight fish were tagged and released at San Clemente Island. They were taken with a lampara net on the Marineland of the Pacific boat *Geronimo*. There have been four returns, all in the area of release.

One of two tagged off La Jolla was later caught at San Onofre.

Between 1951 and 1957, 84 were tagged at the Coronado Islands. This has long been the most productive yellowtail fishing area for California party boats, consistently supplying between 50 and 95 percent of the California sport catch. of 37 recaptures, 23 were in the area of tagging. Seven fish moved north; three to La Jolla, two to San Clemente (town), and two to Santa Catalina Island. Six moved southward; five to Ensenada, and one to San Martin Island, (Figure 25). Data accompanying one return were insufficient to determine locality of capture.

The tag recoveries indicate that fishing in California takes a high toll of the available fish. Sixty of the 167 tagged yellowtail released in southern California waters were recovered. There was a 35.8 percent return within southern California of fish tagged at the Coronado Islands. From some small tagging lots released at the Coronado Islands, there was a 100 percent return. This shows rather decisively that a high percentage of the fish migrating into the area fished by California-based party boats are destined to be caught.

8.2.2. Area 2—Ensenada to Canoas Point (Ensenada)

Although only 43 were tagged and released in this area, the three returns were quite revealing. Two showed southward movements and one was recaptured to the north. of 16 tagged at San Carlos Point, two were subsequently recaptured. One had moved to the Coronado Islands and one to Cedros Island. One of 23 tagged at San Martin Island was recaptured at San Cristobal Bay, 200 miles to the south. There were no returns from four tagged at Ensenada.

These three returns would indicate movement of Area 2 (Ensenada) fish to both the southern California and Cedros Island areas. This interchange theory is further supported by returns taken in Area 2, which moved there from other areas. A goodly portion of the California catch must certainly come from fish which spend much of their life within the Ensenada area.

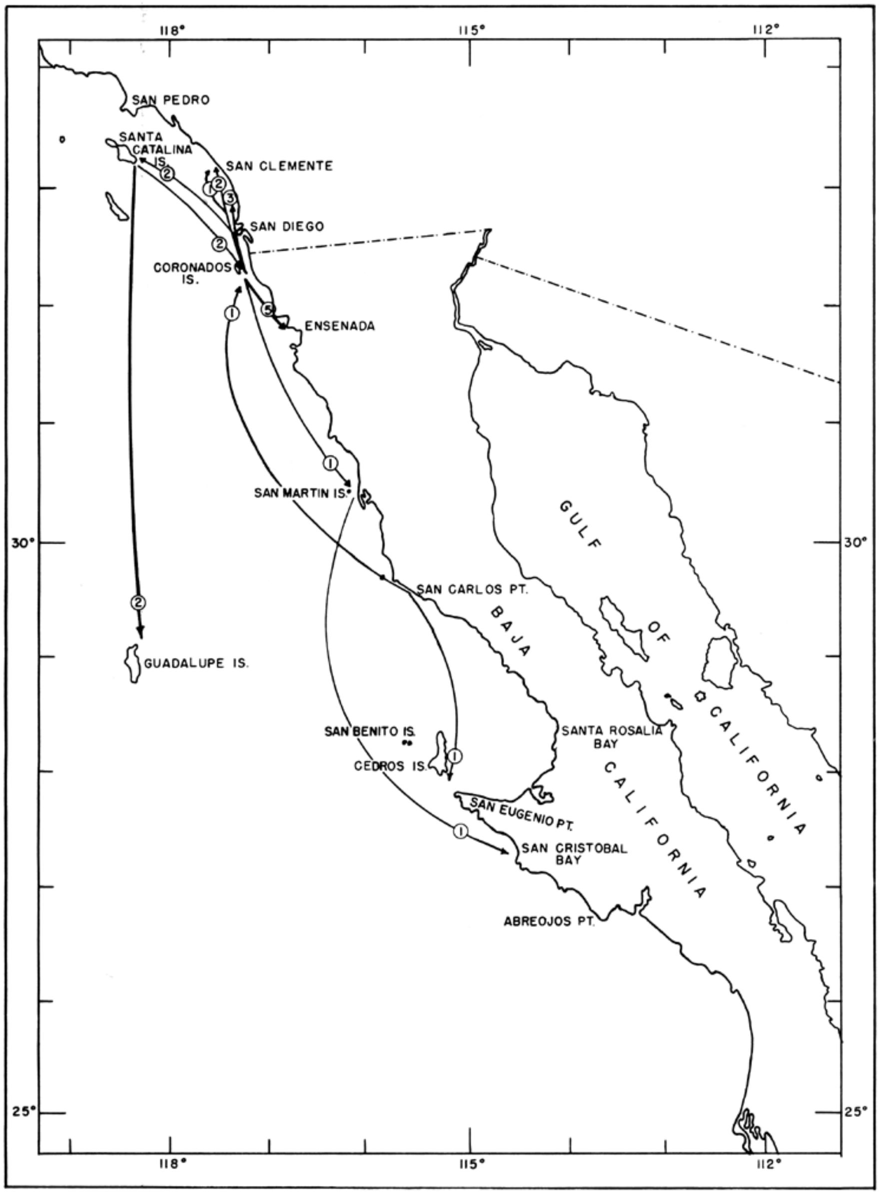

FIGURE 25. Summary of movements of yellowtail tagged in the southern California (Area 1) and Ensenada (Area 2) areas. Base of arrow is release area, arrow head is recovery area. Number in circle is the number of recoveries.

FIGURE 25. Summary of movements of yellowtail tagged in the southern California (Area 1) and Ensenada (Area 2) areas. Base of arrow is release area, arrow head is recovery area. Number in circle is the number of recoveries

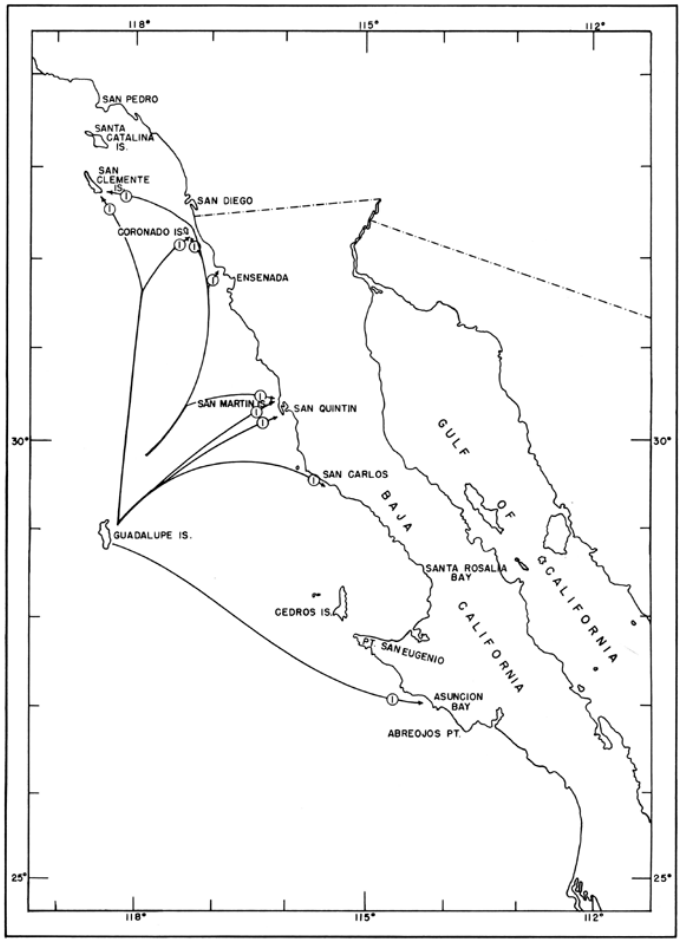

FIGURE 26. Summary of movements of yellowtail tagged in the Guadalupe Island (Area 3) area.

FIGURE 26. Summary of movements of yellowtail tagged in the Guadalupe Island (Area 3) area

8.2.3. *Area 3—Guadalupe Island*

This 20-mile long, mountainous, volcanic island, located 140 miles off the coast of Baja California and 215 miles south of San Diego, California, supports a considerable population of yellowtail. Between September, 1951 and August, 1955, 964 were tagged around the island and 67 were released 45 miles northeast of it. There have been 86 recaptures, 76 in the vicinity of tagging.

of the 10 recaptured away from Guadalupe Island, four were taken in the area of the California sportfishery: two at San Clemente Island and two at the Coronado Islands (Figure 26). Five were recaptured in the Ensenada area: two at San Martin Island, one at San Quentin Point, one at San Carlos Point, and one at Ensenada. One yellowtail moved to Asuncion Island in the Cedros Island area.

Most of the 76 tagged fish recaptured at Guadalupe Island were taken in the fall of the year, a time when sportfishing boats from California ports make week-long trips to the island for yellowtail fishing.

Although Guadalupe Island apparently supports a year-around population of yellowtail, there is also some mixing of these fish with those in the southern California, Ensenada, and Cedros Island areas.

8.2.4. *Area 4—Canoas Point to Abreojos Point (Cedros Island)*

This area, along with the 13-Fathom Bank (Area 5), is probably the center of abundance for yellowtail. These are also the areas where heaviest tagging was accomplished. It was in the Cedros Island area during the cruise of the *Stella Maris* that 9,943 were captured by purse seine, tagged, and released. Altogether, 10,981 were tagged in Area 4 between 1952 and 1956, all but 774 around Cedros and the San Benito Islands.

There were 254 recaptures of yellowtail tagged in this area. One hundred and sixty-nine showed up in southern California (Area 1): 167 from tagging at Cedros Island or the San Benito Islands (Figure 27); one from Asuncion Island, and one from San Hipolito Bay (Figure 28). They were made throughout southern California: 119 at the Coronado Islands, four at La Jolla, three at Oceanside, seven at San Clemente (town), seven at Dana Point, 17 at Horseshoe Kelp, eight at Point Vicente, one at Point Dume and one each at Santa Catalina, San Clemente and Anacapa Islands. Those from Asuncion Island and San Hipolito Bay were recaptured at the Coronado Islands. San Hipolito Bay is the most southerly point of tagging for a fish recaptured in the southern California area. Anacapa Island is the most northerly point of recapture of any tagged yellowtail.

of the 47 Cedros Island area tagged fish that moved to Area 2 (Ensenada) 46 had been tagged at Cedros and the San Benito Islands and one at Asuncion Island. The Asuncion Island fish was recovered at Ensenada as were 43 of those from Cedros and the San Benito Islands. Single recoveries were made at Santo Tomas Point, Cape Colnett, and San Geronimo Island.

Thirty-one were recaptured within the boundaries of the Cedros Island area where they were tagged. Twenty of these 31, 19 at Cedros and the San Benito Islands and one at San Hipolito Bay, did not

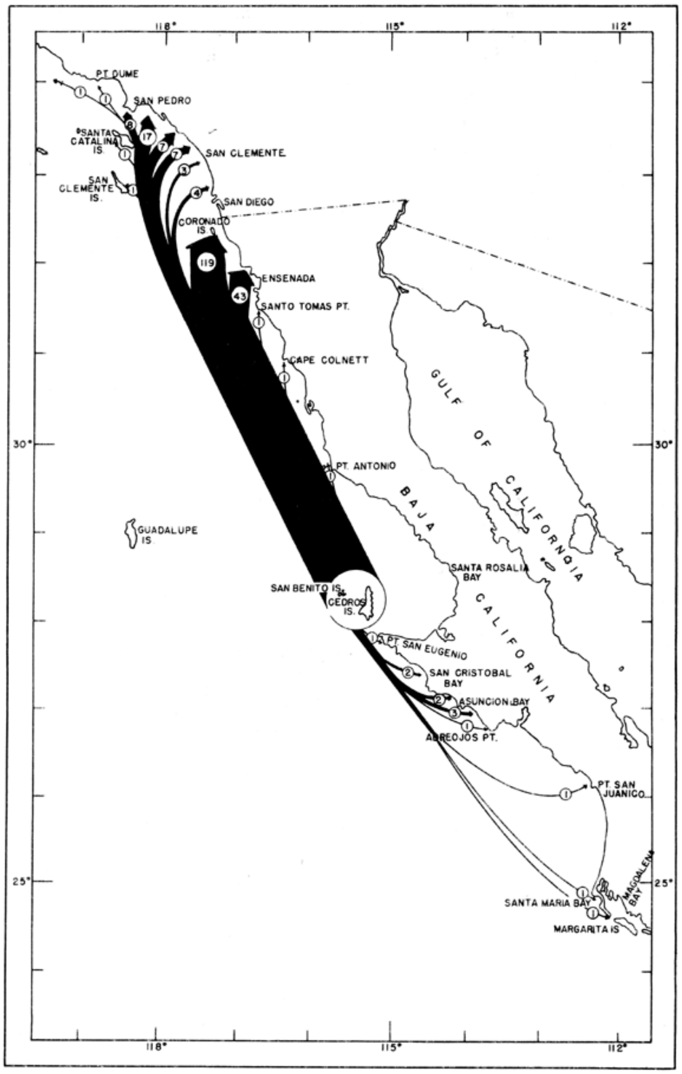

FIGURE 27. Summary of movements of yellowtail tagged in the Cedros-San Benito Islands portion of the Cedros Island area (Area 4).

FIGURE 27. Summary of movements of yellowtail tagged in the Cedros-San Benito Islands portion of the Cedros Island area (Area 4)

move from the locality of tagging. of the remaining 11, nine moved south from Cedros-San Benito into the offshore waters between Pt. Eugenia and Abreojos Pt., and two moved northward to San Pablo Bay and to Cedros Island from Asuncion Island.

Four moved from the Cedros Island area to Area 5 (13-Fathom Bank). One each, recaptured at Point San Juanico, Santa Maria Bay, and Magdalena Bay, had been tagged at Cedros and the San Benito Islands and one taken at Ballenas Bay had moved from Asuncion Island.

Area 4 undoubtedly is the "home" for most of the fish upon which California anglers depend. The returns from fish tagged there showed that yellowtail from at least as far south as San Hipolito Bay may eventually migrate into the area fished by California anglers.

8.2.5. *Area 5—Abreojos Point to Magdalena Bay (13-Fathom Bank)*

Most of those tagged in this area were caught and released at banks as far offshore as 70 miles. These shoals are predominantly areas of rocky pinnacles some rising to within 40 feet of the surface from a surrounding depth of about 600 feet on the inshore side and 1800 to 2000 feet on the offshore side.

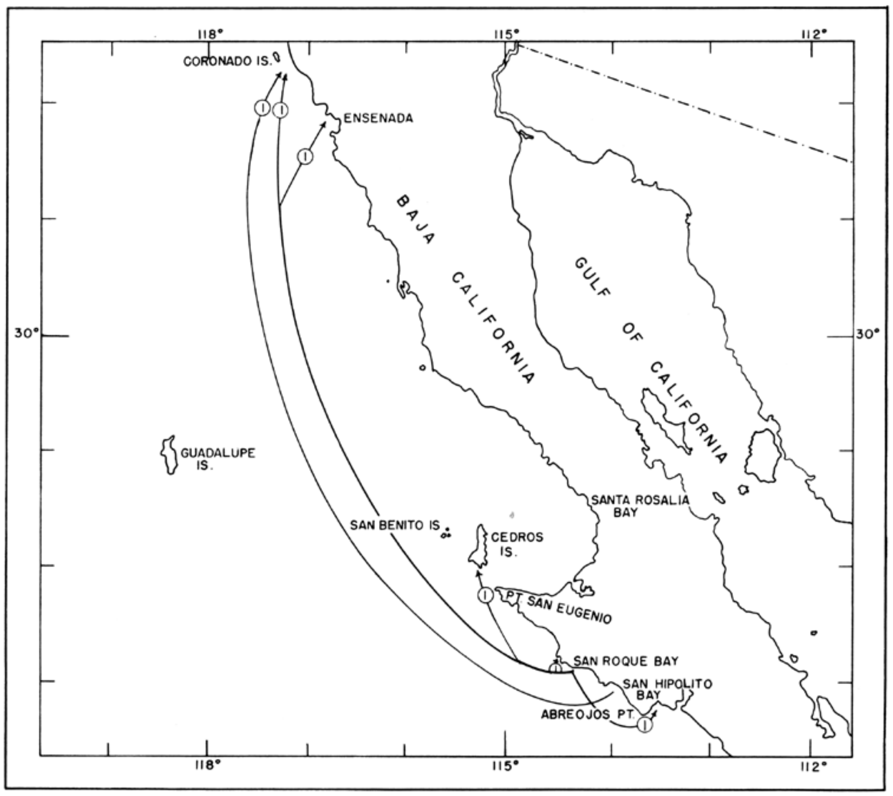

FIGURE 28. Summary of movements of yellowtail tagged in the portion of Area 4 between Point San Eugenia and Abreojos Point.

FIGURE 28. Summary of movements of yellowtail tagged in the portion of Area 4 between Point San Eugenia and Abreojos Point

This appears to be an important nursery area for young fish. Most of the yellowtail taken on the offshore banks ranged from one to one and one-half years of age.

Project personnel tagged 2,746 fish in the 13-Fathom Bank area. To date there have been 110 recoveries, 103 in the release area, one at Cedros Island and six in areas of uncertain origin, but probably where released. Six of the 103 showed some movement within Area 5 (13-Fathom Bank): two from Thetis Bank to Alijos Rocks, one from Thetis Bank to the 23-Fathom Bank, one from the 13-Fathom Bank to Thetis Bank, one from Hutchins Bank to San Juanico Point and one from Hutchins Bank to Ballenas Bay (Figure 29).

The remaining 97 were recovered in the area of original tagging, as long as 802 days later. There were very few returns from 13-Fathom Bank area fish after 1954, the last year in which there was a commercial fishery of any magnitude. Most of the fish were tagged there during a period when there was a moderate commercial fishery for yellowtail.

Whether, and to what extent, this area contributed to the California sportfishery is not known. Only one tagged fish moved from the area. However, the fact that this fish did move into the Cedros Island area plus the fact that Cedros Island area fish moved into the 13-Fathom Bank area indicates a limited interchange between the two. From this it may be assumed that some fish probably reach the California fishing grounds from this area.

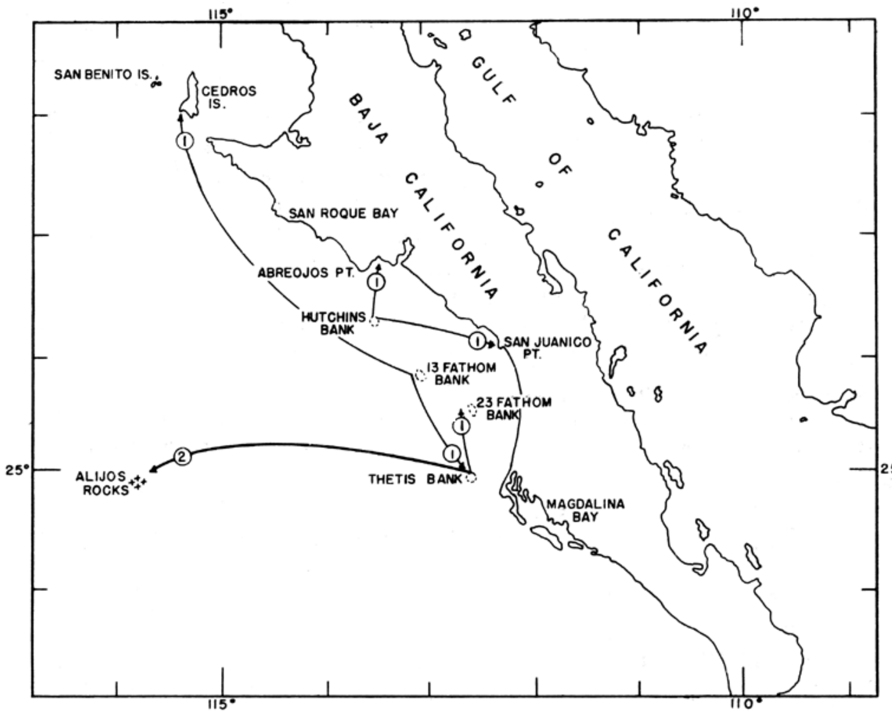

FIGURE 29. Summary of movements of yellowtail tagged in the 13-Fathom Bank area (Area 5).

FIGURE 29. Summary of movements of yellowtail tagged in the 13-Fathom Bank area (Area 5)

8.2.6. *Area 6—Magdalena Bay to Cape San Lucas*

One hundred and sixty-one yellowtail were tagged in Area 6: 16 at Cape San Lucas and 145 at Pescadero Point. No concentrated effort was made to tag in the area, mainly because it had never been the center of any large-scale fishery.

No yellowtail tagged in this area has ever been recovered and none tagged elsewhere has been taken in this area. One tagged fish was reported caught at Cape San Lucas, but was lost when the boat sank. The degree to which, or the possibility that fish from this area contribute to the California fisheries are unknown. Available data indicate it is of very little or no importance to California fisheries.

8.2.7. *Area 7—Gulf of California*

Despite the presence of great numbers of yellowtail in the Gulf of California, the project was unable to catch any quantity for tagging. Two trips were made into the Gulf, but only 32 fish were marked, 14 at Carmen Island and 18 at Espiritu Santo Island. There have been no recaptures from these few fish. The extent of intermingling of Gulf yellowtail with those of the outer coast is unknown. The morphometric study did not show any significant anatomical differences between Gulf fish and those ranging along the outer coast of Baja California and into California waters.

8.3. Seasonal Occurrence

Yellowtail are found in abundance in the Guadalupe Island (Area 3), the Cedros Island (Area 4), and 13-Fathom Bank (Area 5) areas the year-around. Sportfishing in southern California (Area 1) usually begins in March or April, reaches a peak in May or June and then tapers off in July and August. During some years, there is a period of good fishing in September and October but few are found after that until the following spring. If yellowtail are in our waters, there are always anglers to fish for them. Until the warm water years (1957–1959), the records kept by the owners and operators of party fishing vessels showed virtually no yellowtail catches during the winter. Divers from Scripps Institution of Oceanography, La Jolla, California, also reported that they very seldom saw them at either La Jolla or the Coronado Islands during the winter.

In September 1955, 9,943 purse seine-caught yellowtail were tagged at Cedros and the San Benito Islands, from which 215 subsequently were recaptured. Assuming many remained schooled together, the time and area of recapture should reveal a seasonal movement pattern if such exists. To illustrate the seasonal occurrence of this particular group, each year was divided into four periods.

The months of September, October and November were designated as fall; December, January and February as winter; March, April and May as spring; and June, July and August as summer.

During the fall and winter following tagging (1955), all recaptures were made to the south of the tagging area (Figures 30 and 31). In the spring of 1956 there were two recaptures at the Coronado Islands and one at the San Benito Islands (Figure 32). During the summer of 1956, 22 recaptures were made at the Coronado Islands, 10 at Ensenada, one at San Geronimo Island, and three at Cedros Island (Figure 33).

A good percentage of fish had now moved into the southern California area. In the fall of 1956, 15 recaptures were made at the Coronado Islands, 12 at Ensenada, and one at Santo Tomas Point (Figure 34). The increased percentage of recaptures south of the Coronado Islands indicates the beginning of a shift toward the south.

No winter, 1956–57, recaptures were made north of Ensenada, but one was made at San Hipolito Bay south of Cedros Island (Figure 35). The bulk of the fish were probably somewhere south of Ensenada.

Spring of 1957 again brought an influx of yellowtail to the Coronado Islands and 25 tagged fish were recaptured. Six were taken at Ensenada and one at Magdalena Bay, far to the south (Figure 36). Summer saw few tags returned (Figure 37) but three were taken at the Coronado Islands, one at Ensenada, and one at La Jolla. During the fall of 1957, tagged yellowtail were recaptured as far north as Point Vicente, near San Pedro (Figure 38). Altogether 61 were caught in the southern California area, two at Ensenada, and one at Cape Colnett. Yellowtail remained in California during the winter of 1957–1958 and two tagged fish were reported, one from Point Vicente, and one from Point Dume (Figure 39).

The year 1957 ocean-wise was atypical compared to the previous 10 or more. Ocean temperatures averaged as much as three degrees Centigrade warmer than the average for the period 1949–1954 (Marine Research Committee, 1958). Yellowtail did not demonstrate the expected movement pattern. Instead, encouraged by warmer water, they not only moved into southern California in greater numbers than ever before but they remained throughout the winter.

The years 1958 and 1959 were also characterized by above-average ocean temperatures (Radovich, manuscript). During the spring, summer, and fall of 1958, tagged yellowtail were caught from Ensenada to as far north as Rocky Point (Figures 40, 41 and 42). During the winter of 1958–59 the only tagged yellowtail caught were two from Ensenada, indicating a southward shift (Figure 43). Again, in the spring and summer of 1959 tagged fish were caught in southern California, one as far north as Anacapa Island (Figures 44 and 45).

The expected yellowtail movement pattern calls for a migration into Southern California from the south in the spring months, and a return to the south during the late fall and winter months. In some years, depending on the ocean climate, they may move south as far as Magdalena Bay, and north as far as Anacapa Island.

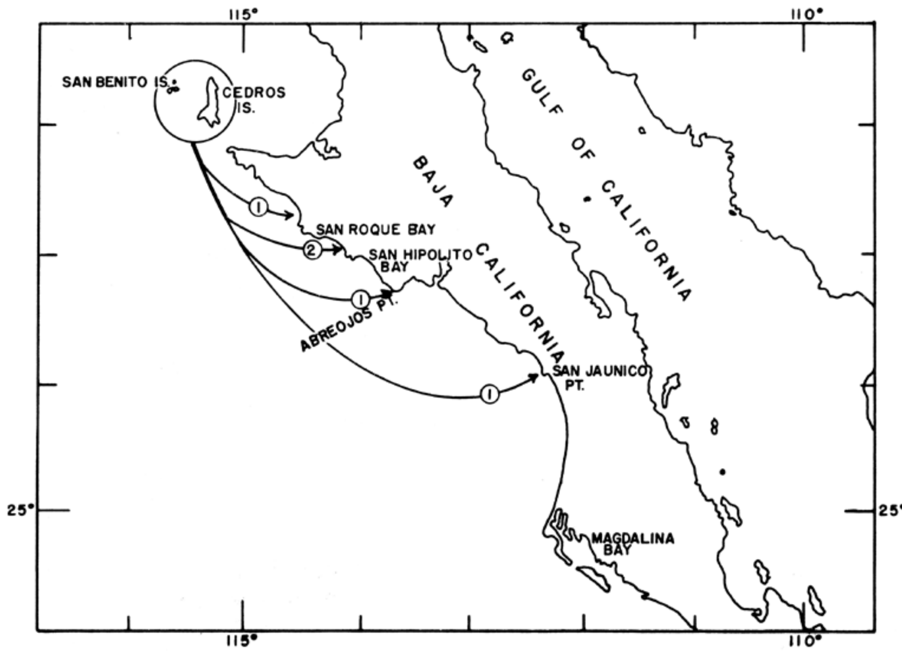

FIGURE 30. Recovery locations of tagged yellowtail caught during the fall (September, October, November) of 1955. Fish were tagged during the *Stella Maris* cruise of September, 1955 at Cedros and the San Benito Islands.

FIGURE 30. Recovery locations of tagged yellowtail caught during the fall (September, October, November) of 1955. Fish were tagged during the Stella Maris cruise of September, 1955 at Cedros and the San Benito Islands

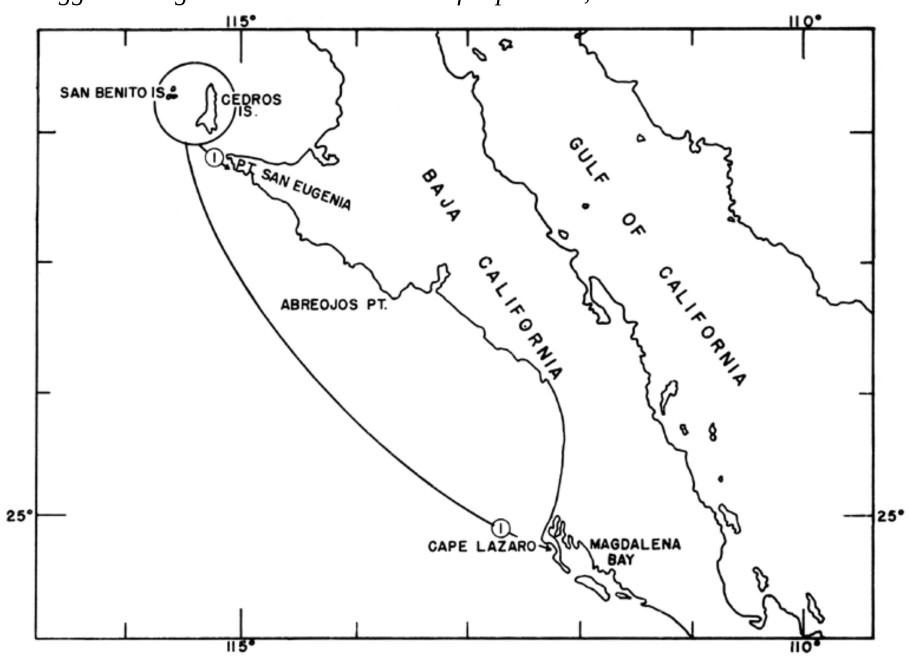

FIGURE 31. Recovery locations of tagged yellowtail caught during the winter of 1955-56 (December, January, February). Fish were tagged during the *Stella Maris* cruise of September, 1955 at Cedros and the San Benito Islands.

FIGURE 31. Recovery locations of tagged yellowtail caught during the winter of 1955–56 (December, January, February). Fish were tagged during the Stella Maris cruise of September, 1955 at Cedros and the San Benito Islands

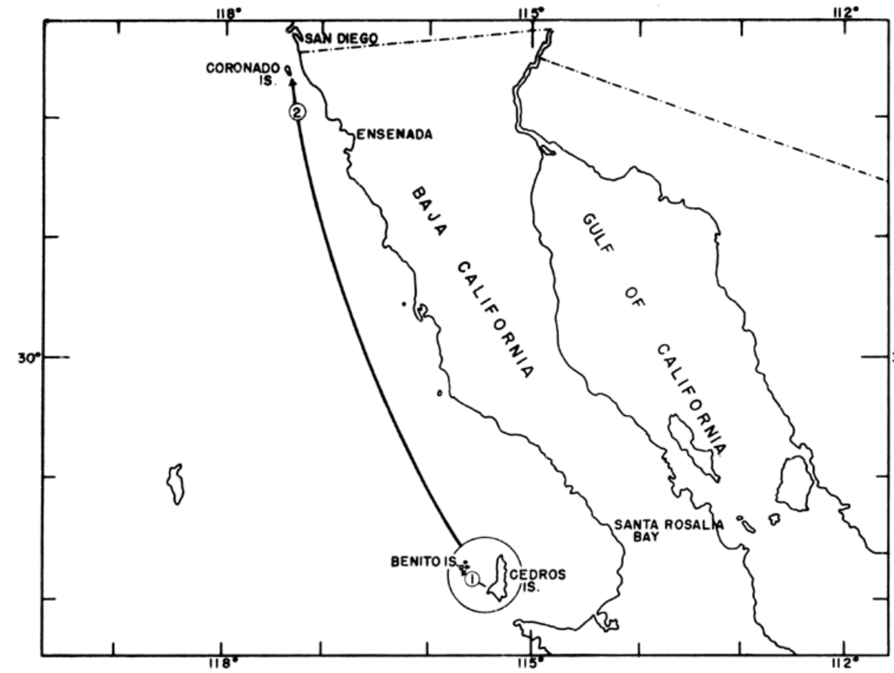

FIGURE 32. Recovery locations of tagged yellowtail caught during the spring of 1956 (March, April, May). Fish were tagged during the September, 1955 cruise of the *Stella Maris* at Cedros and the San Benito Islands.

FIGURE 32. Recovery locations of tagged yellowtail caught during the spring of 1956 (March, April, May). Fish were tagged during the September, 1955 cruise of the Stella Maris at Cedros and the San Benito Islands

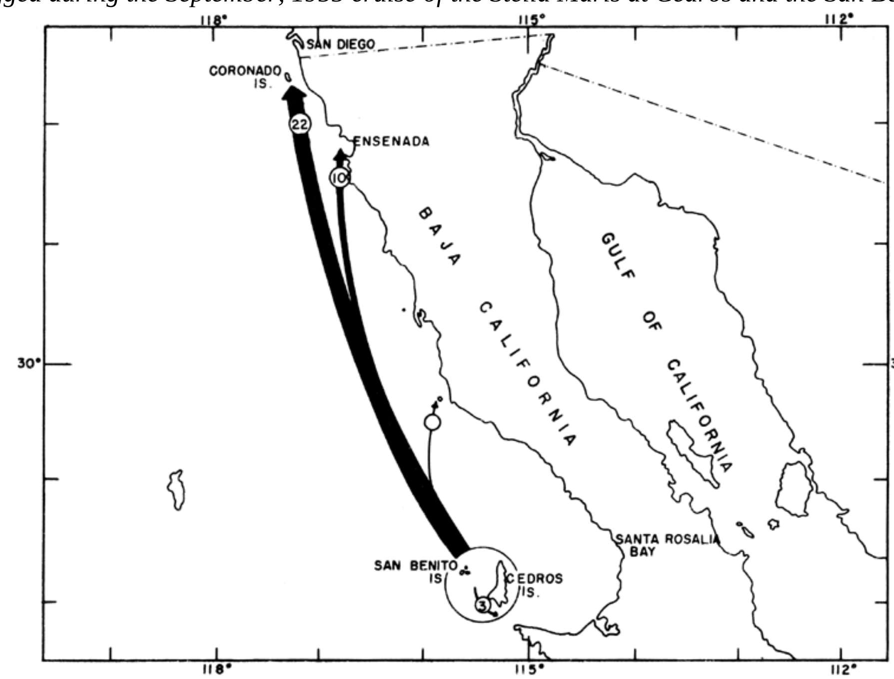

FIGURE 33. Recovery locations of tagged yellowtail caught during the summer of 1956 (June, July, August). Fish were tagged during the September, 1955 cruise of the *Stella Maris* at Cedros and the San Benito Islands.

FIGURE 33. Recovery locations of tagged yellowtail caught during the summer of 1956 (June, July, August). Fish were tagged during the September, 1955 cruise of the Stella Maris at Cedros and the San Benito Islands

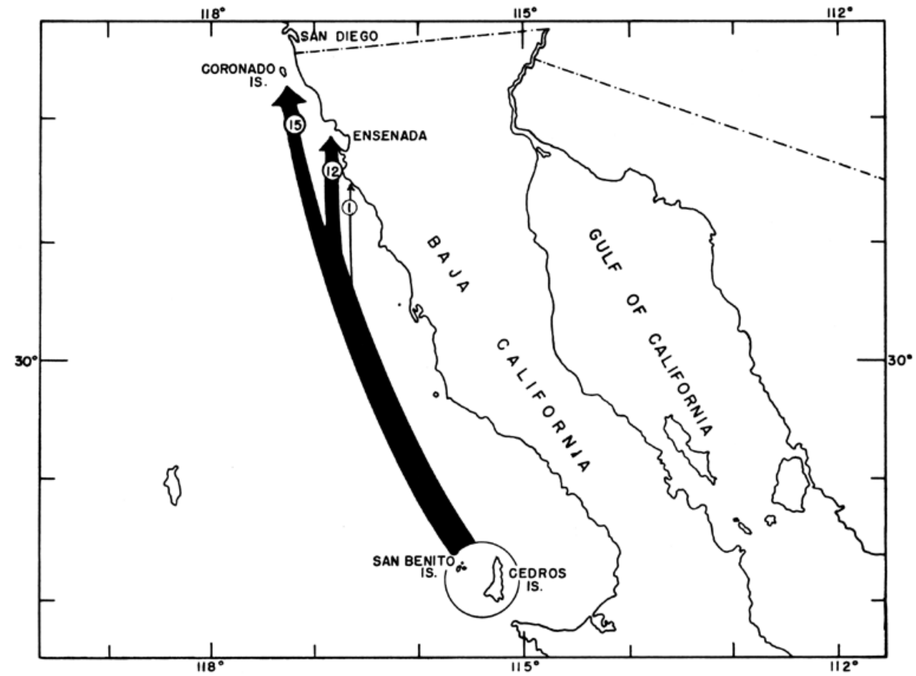

FIGURE 34. Recovery locations of tagged yellowtail caught during the fall of 1956. Fish were tagged during the September, 1955 *Stella Maris* cruise at Cedros and the San Benito Islands.

FIGURE 34. Recovery locations of tagged yellowtail caught during the fall of 1956. Fish were tagged during the September, 1955 Stella Maris cruise at Cedros and the San Benito Islands

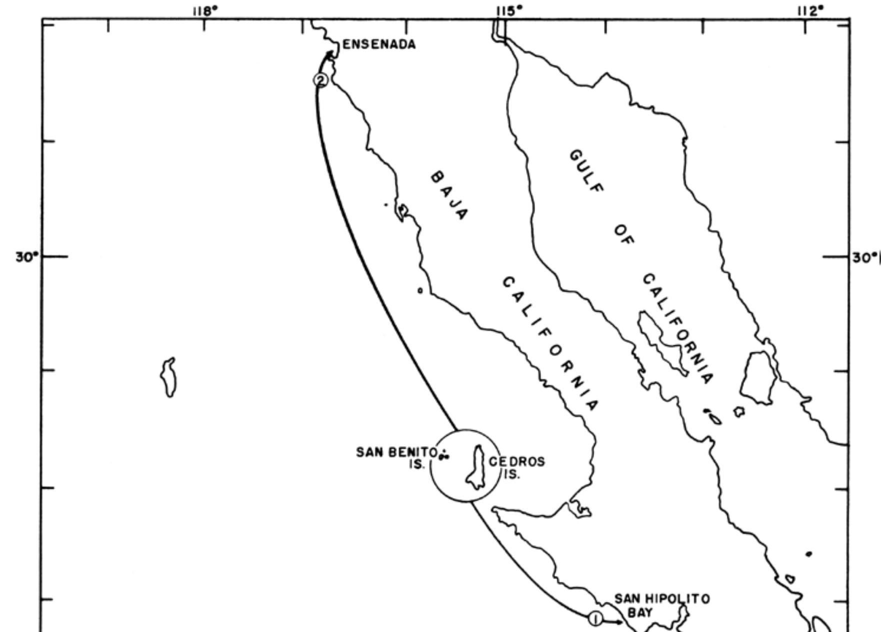

FIGURE 35. Recovery locations of tagged yellowtail caught during the winter of 1956-57. Fish were tagged during the September, 1955 *Stella Maris* cruise at Cedros and the San Benito Islands.

FIGURE 35. Recovery locations of tagged yellowtail caught during the winter of 1956–57. Fish were tagged during the September, 1955 Stella Maris cruise at Cedros and the San Benito Islands

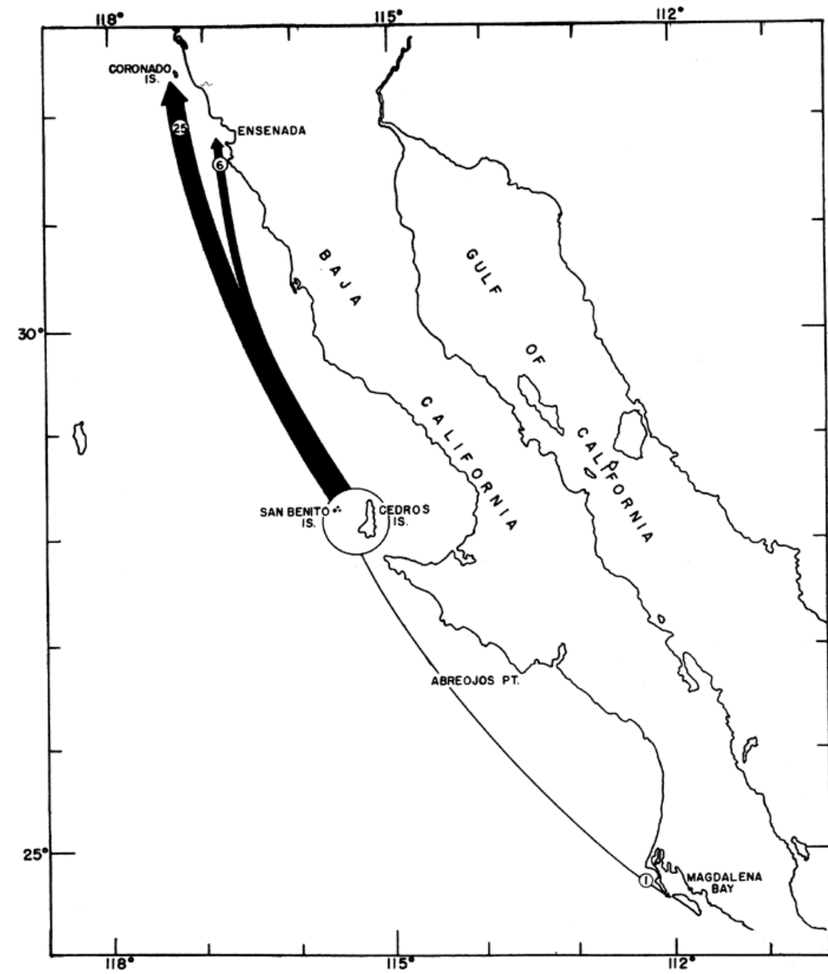

FIGURE 36. Recovery locations of tagged yellowtail caught during the spring of 1957. Fish were tagged during the September, 1955 Stella Maris cruise at Cedros and the San Benito Islands

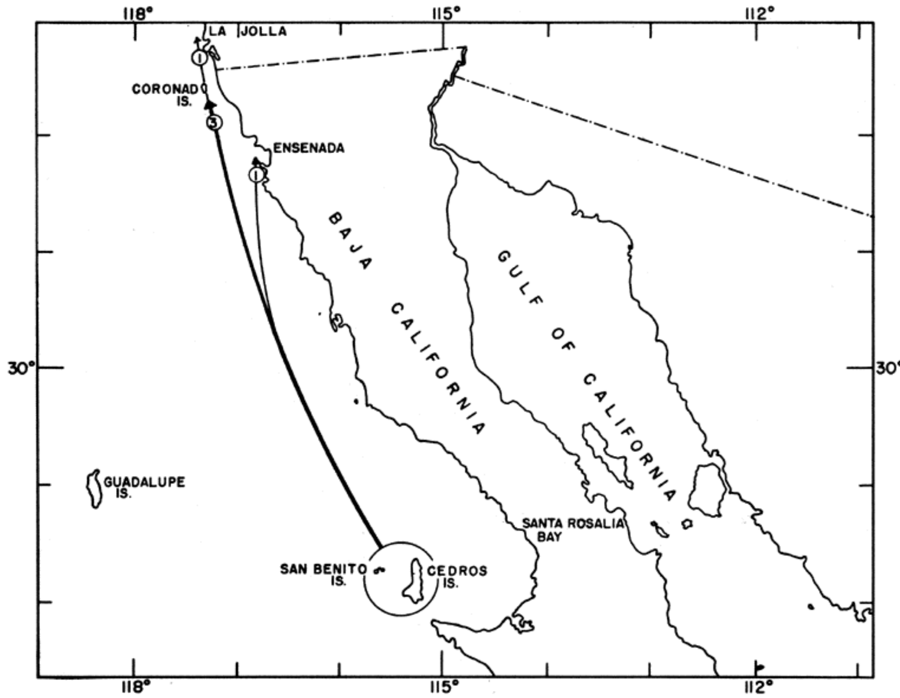

FIGURE 37. Recovery locations of tagged yellowtail caught during the summer of 1957. Fish were tagged during the September, 1955 Stella Maris cruise at Cedros and the San Benito Islands

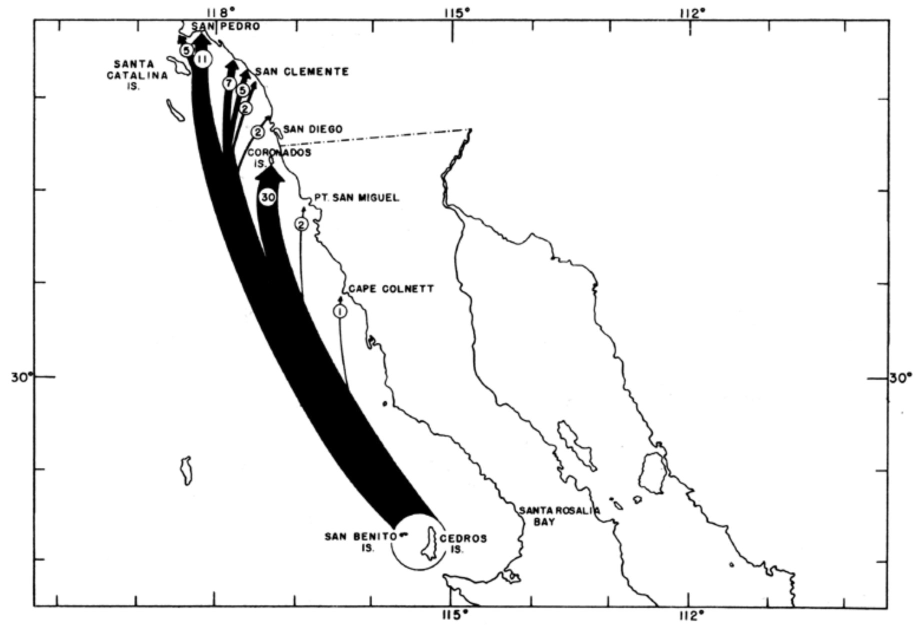

FIGURE 38. Recovery locations of tagged yellowtail caught during the fall of 1957. Fish were tagged during the September, 1955 *Stella Maris* cruise at Cedros and the San Benito Islands.

FIGURE 38. Recovery locations of tagged yellowtail caught during the fall of 1957. Fish were tagged during the September, 1955 Stella Maris cruise at Cedros and the San Benito Islands

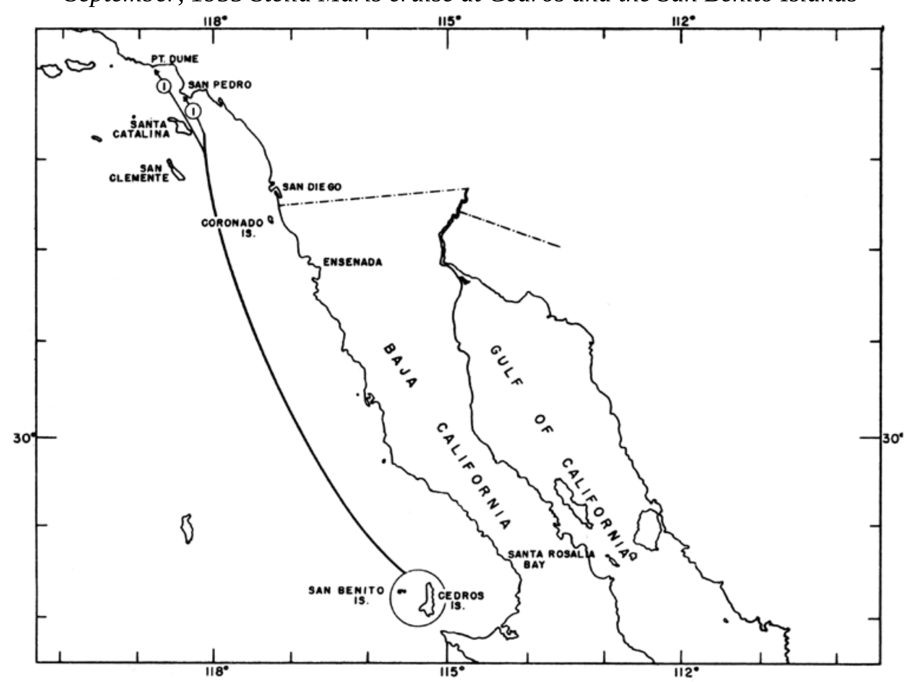

FIGURE 39. Recovery locations of tagged yellowtail caught during the winter of 1957-58. Fish were tagged during the September, 1955 *Stella Maris* cruise at Cedros and the San Benito Islands.

FIGURE 39. Recovery locations of tagged yellowtail caught during the winter of 1957–58. Fish were tagged during the September, 1955 Stella Maris cruise at Cedros and the San Benito Islands

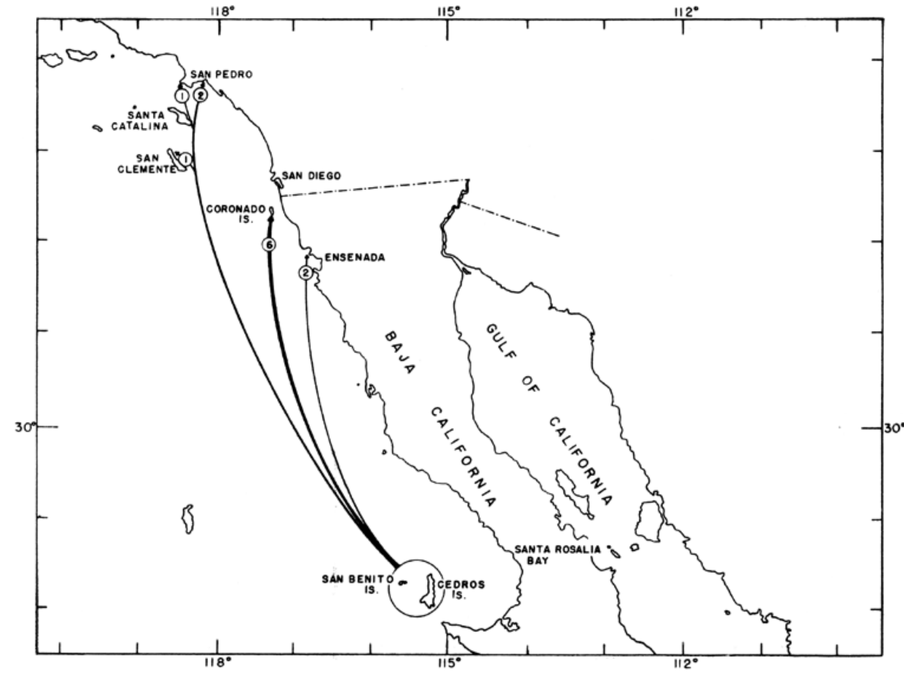

FIGURE 40. Recovery locations of tagged yellowtail caught during the spring of 1958. Fish were tagged during the September, 1955 *Stella Maris* cruise at Cedros and the San Benito Islands.

FIGURE 40. Recovery locations of tagged yellowtail caught during the spring of 1958. Fish were tagged during the September, 1955 Stella Maris cruise at Cedros and the San Benito Islands

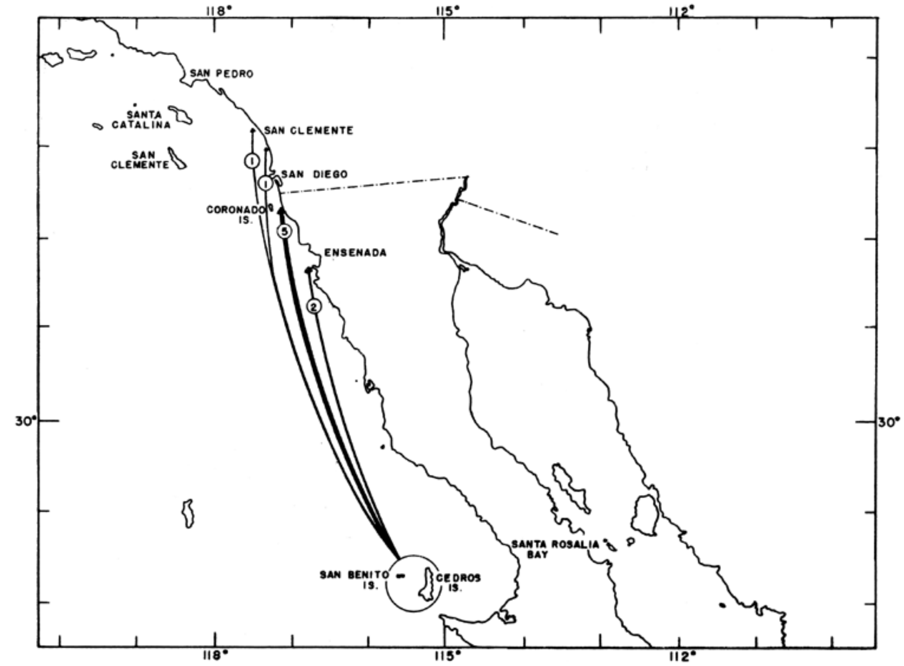

FIGURE 41. Recovery locations of tagged yellowtail caught during the summer of 1958. Fish were tagged during the September, 1955 *Stella Maris* cruise at Cedros and the San Benito Islands.

FIGURE 41. Recovery locations of tagged yellowtail caught during the summer of 1958. Fish were tagged during the September, 1955 Stella Maris cruise at Cedros and the San Benito Islands

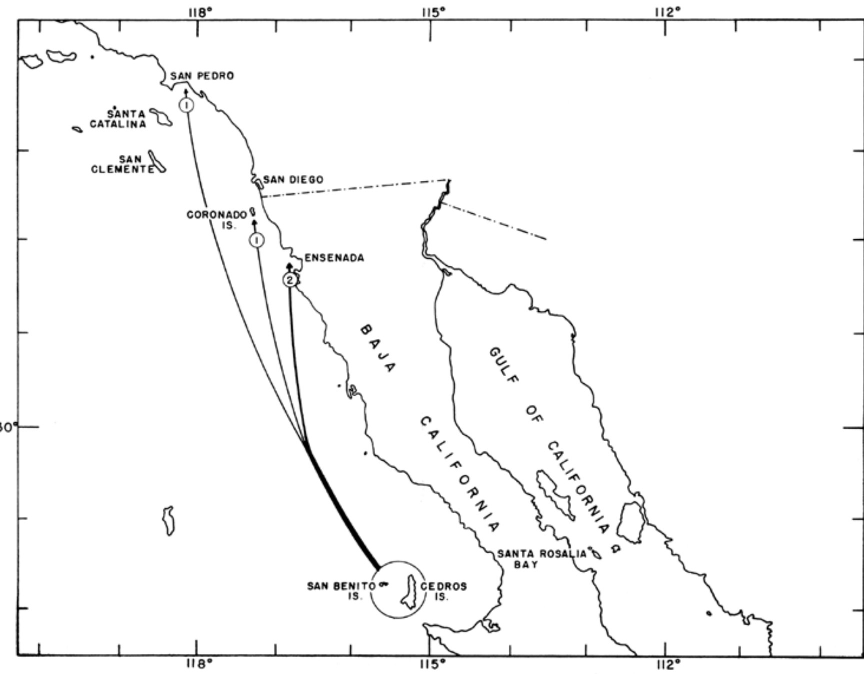

FIGURE 42. Recovery locations of tagged yellowtail caught during the fall of 1958. Fish were tagged during the September, 1955 *Stella Maris* cruise at Cedros and the San Benito Islands.

FIGURE 42. Recovery locations of tagged yellowtail caught during the fall of 1958. Fish were tagged during the September, 1955 Stella Maris cruise at Cedros and the San Benito Islands

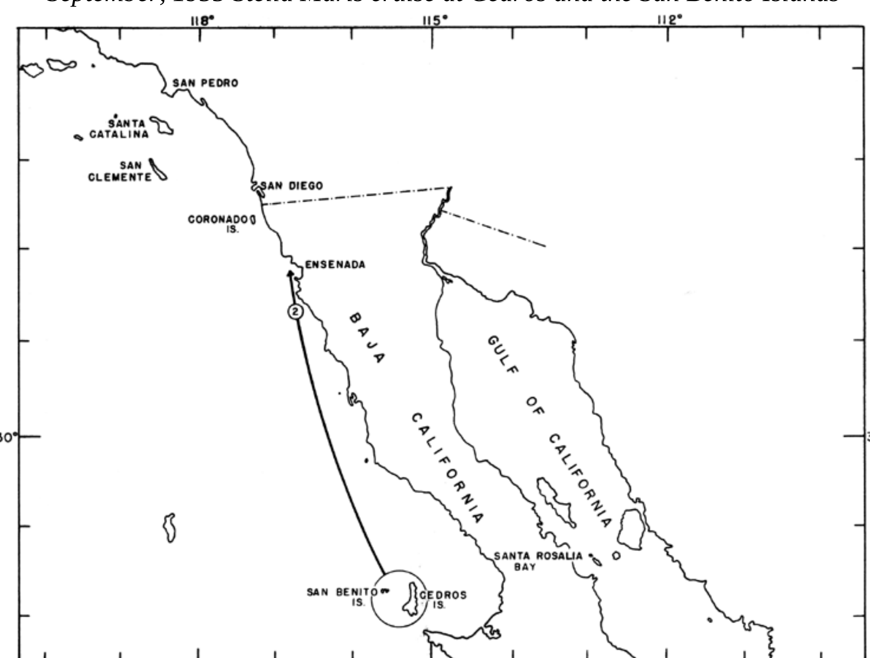

FIGURE 43. Recovery locations of tagged yellowtail caught during the winter of 1958-59. Fish were tagged during the September, 1955 *Stella Maris* cruise at Cedros and the San Benito Islands.

FIGURE 43. Recovery locations of tagged yellowtail caught during the winter of 1958–59. Fish were tagged during the September, 1955 Stella Maris cruise at Cedros and the San Benito Islands

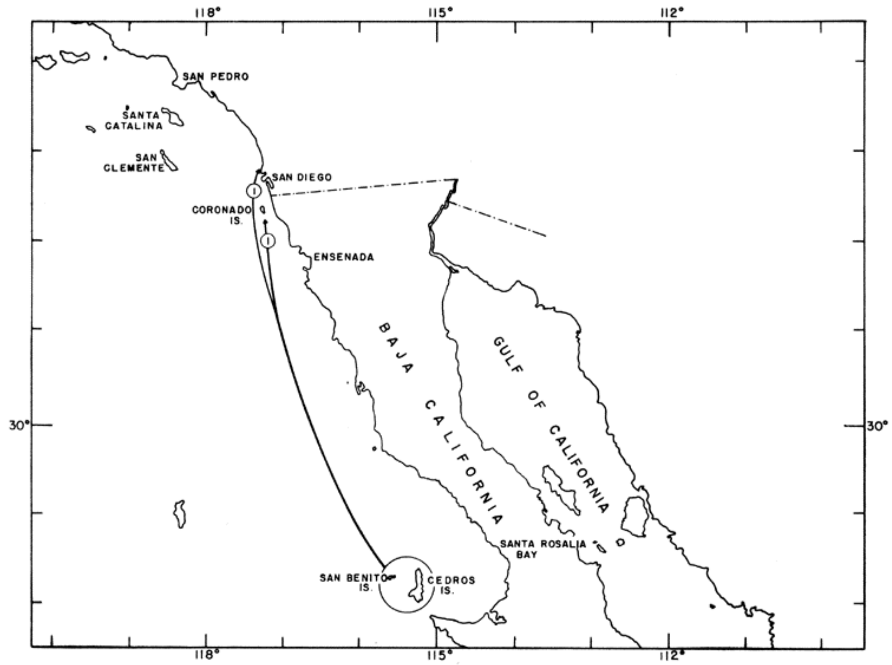

FIGURE 44. Recovery locations of tagged yellowtail caught during the spring of 1959. Fish were tagged during the September, 1955 Stella Maris cruise at Cedros and the San Benito Islands

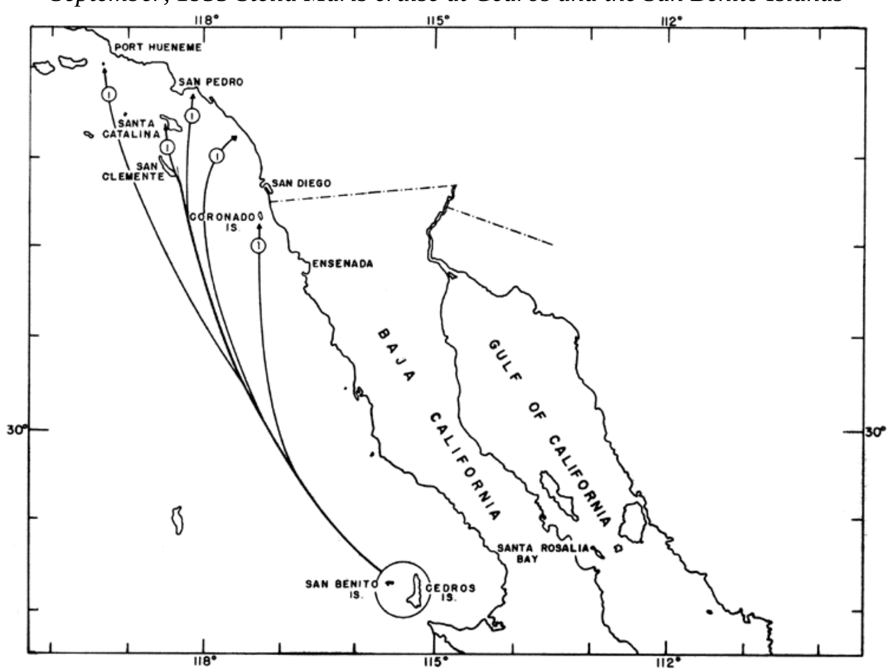

FIGURE 45. Recovery locations of tagged yellowtail caught during the summer of 1959. Fish were tagged during the September, 1955 Stella Maris cruise at Cedros and the San Benito Islands

8.4. Differential Movements by Size of Fish

Tag returns through 1957 were separated into two groups, those which moved between 50 and 404 miles and those having moved fewer than 50 miles, or not at all.

TABLE 20

Differential Movement of Tagged Yellowtail Determined from Size at Tagging and Season of Recapture[1]

Fork Length (cm.)	Number Tagged	Total Recaptures	Recaptures Having Moved 49 Miles or Less			Recaptures Having Moved From 50 to 404 Miles			
			Season 1	Season 2	Season 3	Season 1	Season 2	Season 3	Season 4
0-60	2,643	94	80	10		1	2	1	
61-90	12,064	335	84	41	1	20	77	106	6
91 and over	264	23	16	4	3				
Not measured	190	6		1			5		
Totals	15,161	[2]483	180	56	4	21	84	107	6

[1] Only tags returned through February, 1958 used.
[2] Includes 25 with inadequate return data.

TABLE 20
Differential Movement of Tagged Yellowtail Determined from Size at Tagging and Season of Recapture

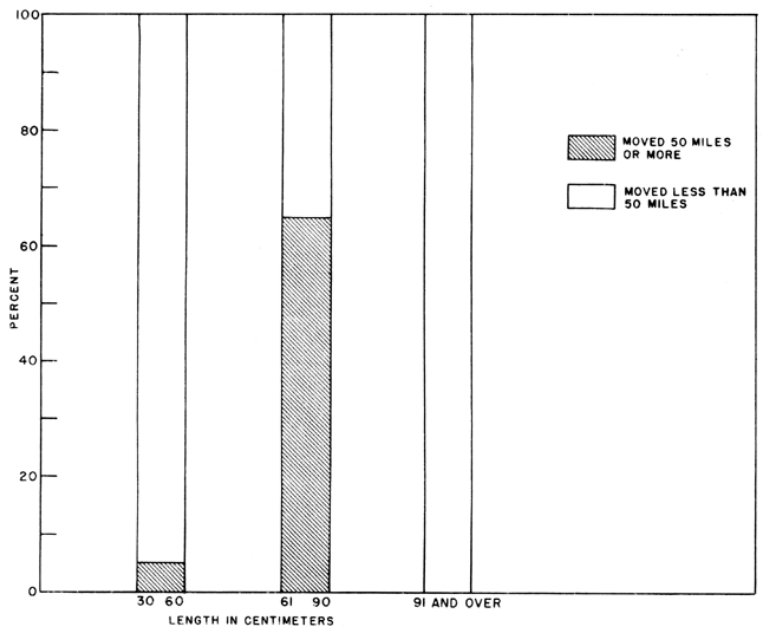

FIGURE 46. Differential movement of tagged yellowtail according to size at time of tagging expressed as percent of total returns per size group.

FIGURE 46. Differential movement of tagged yellowtail according to size at time of tagging expressed as percent of total returns per size group

A further breakdown by size at time of tagging revealed three somewhat distinct groups, each with a more or less different degree of movement (Table 20), (Figure 46).

The first group, comprised of fish 60 cm. fork length or less, showed very little movement. of the 2,643 fish within this size range when tagged, 94 were recaptured, all except four within 50 miles of the point of release.

Those ranging from 61 to 90 cm. fork length traveled the greatest amount. Within this group 12,064 were tagged and 335 were recovered, 62 percent of which moved at least 50 miles. Most of the fish moved between 200 and 300 miles and one traveled 404.

In the third size group, fish longer than 90 cm. in fork length, 264 were tagged and 23 were recovered, all very close to the point of initial release. *John L. Baxter and Robert D. Collyer*.

9. CONCLUSIONS AND RECOMMENDATIONS

Although there are undoubtedly a few year-around "residents" and, during favorable years, there is some spawning success in southern California waters, yellowtail fishing is almost entirely dependent upon a yearly influx of fish from central and northern Baja California waters. Few, if any, from the area south of Abreojos Point some 390 miles below San Diego, contribute to the California sportfishery.

Yellowtail normally move north into southern California in the early spring and south again in the late summer and fall. They probably spend their first two years of life in one location, not traveling great distances. Between the ages of three and eight they appear to school with others of similar size and move around throughout much of their geographical range. Large fish, eight years of age and older are seldom found in dense schools and apparently take up a somewhat sedentary existence. Most of the so-called "homeguards" are of this group.

Since the yellowtail population appears to be in a healthy state there is no present need for further restrictions. However, the fishery should be kept under surveillance so that we may be cognizant of any adverse changes. Because of the dependency of the California sportfishery upon the movement of fish from central Baja California, a future increase in the economic value of yellowtail could result in an expansion of the commercial fishery and thus have a serious effect upon the magnitude of the local sportfishery. *John L. Baxter*.

10. SUMMARY

1. This work was performed as part of Dingell-Johnson Project California F-1-R "Yellowtail Study" supported by Federal Aid to Fish Restoration Funds.
2. Yellowtail have been recorded from southern Washington south to Cape San Lucas, Baja California, and north again throughout much of the Gulf of California.
3. Racial studies indicate there is but one randomly intermingling population of yellowtail, Seriola dorsalis, on the west coast of the United States and Mexico. A detailed redescription of the species was based on morphometric measurements and meristic counts taken from the 210 specimens, 357 to 970 mm. standard length, used in the racial study.
4. An extremely abundant yellowtail population exists along the central Baja California coast and it is the vagaries of the environment and not the fishing pressure that currently limits their availability to California anglers. Yellowtail have always been of secondary commercial value and at present there is virtually no commercial fishery for them.
5. Yellowtail were aged by means of scales through the seventh year, after which aging became increasingly difficult. The mean fork lengths in inches for age groups one through seven are: I—19.9; II—25.0; III—27.8; IV—30.8; V—32.7; VI—34.3; VII—35.2. The rate of growth calculated from tag return data compared favorably with that determined by scale analysis.
6. Differences in the weight-length relationship between sexes were insignificant so the data were combined with the resulting formula $W = 0.00000007439L^{2.85}$.
7. Yellowtail are predominantly daytime feeders. Their selection of food items indicate they are "opportunists," feeding on whatever is most abundant at the time and place they happen to be. Squid and pelagic red crabs were most often observed of the invertebrates. Sardines, anchovies, jack mackerel, and Pacific mackerel were the most important forage fishes.
8. Some fish will spawn in their second year and all are mature in their third. The spawning season extends from July through October and after their first spawning season yellowtail will spawn more than once within this period each year.
9. The number of eggs produced for one spawning was found to vary with the weight of the fish. It was estimated that a 10-pound fish spawns 450,000 eggs; a 15-pound fish 700,000; and a 20-pounder 940,000.
10. From 1951 to 1957 15,161 yellowtail were tagged throughout their known range and 532 subsequently were recovered. Tag returns indicated that most fish caught in our waters migrated there from central Baja California. Fish from the lower peninsula and the Gulf of California probably do not enter our fishery.
11. The present population appears to be in a healthy state and there is no need for further restrictions so long as it remains that way. The fishery should be checked periodically in order to determine whether or not any changes have occurred that could produce an adverse effect on the status of the population.

11. REFERENCES

Barnhart, Percy Spencer 1936. Marine fishes of Southern California. Berkeley, Univ. Calif. Press, 209 p.

Berry, S. Stillman 1912. A review of the cephalopods of western North America. U. S. Bur. Fish., Bull., vol. 30, p. 267–336.

Beverton, R. J. H. 1954. Notes on the use of theoretical models in the study of the dynamics of exploited fish populations. U. S. Fisheries Lab., Beaufort, Misc. contrib., no. 2, 181 p.

Beverton, R. J. H., and S. J. Holt 1957. On the dynamics of exploited fish populations. Min. Agric., Fish and Food. Fish. Invest., ser. 2, vol. 19, 533 p.

Brown, C. J. D., and Gertrude C. Kamp 1942. Gonad measurements and egg counts of brown trout. Amer. Fish. Soc., Trans., vol. 71, p. 195–200.

Cannon, Raymond 1953. How to fish the Pacific coast. Menlo Park, Lane Pub. Co., 337 p.

Clark, Frances N. 1928. The weight-length relationship of the California sardine (Sardina caerulea) at San Pedro. Calif. Div. Fish and Game, Fish Bull. 12, 58 p.

1934. Maturity of the California sardine (Sardina caerulea), determined by ova diameter measurements. Calif. Div. of Fish and Game, Fish Bull. 42, 49 p.

Clothier, Charles R. 1950. A key to some Southern California fishes based on vertebral characters. Calif. Div. Fish and Game, Fish Bull. 79, 102 p.

Collyer, Robert D. 1954. Tagging experiments on the yellowtail, Seriola dorsalis (Gill). Calif. Fish and Game, vol. 40, no. 3, p. 295–312.

Creaser, Charles W. 1926. The structure and growth of the scales of fishes in relation to the interpretation of their life history, with special reference to the sunfish, Eupomotis gibbosus. Univ. Mich. Misc. Publ., no. 17, 82 p.

Creaser, C. W., and W. J. Clench 1923. The use of sodium silicate as a mounting medium. Amer. Micro. Soc., Trans., vol. 42, p. 69–71.

Franz, V. 1910. Die Eiproduktion der Scholle (Pleuronectes platessa L.). Wissenschaftl. Meeresunters., Helgoland, N. F., vol. 9, p. 217–224.

Fry, Donald H., Jr. 1931. Yellowtail. *In* The commercial fish catch of California for the year 1929. Calif. Div. Fish and Game, Fish. Bull. 30, p. 44–48.

1937. Yellowtail. *In* The commercial fish catch for the year 1935. Calif. Div. Fish and Game, Fish Bull. 49, p. 33–36.

Fry, Donald H., Jr., and Phil M. Roedel 1949. Tagging experiments on the Pacific Mackerel. Calif. Div. Fish and Game, Fish Bull. 73, 64 p.

Gill, Theodore 1863. Catalogue of the fishes of Lower California, in the Smithsonian Institution, collected by Mr. J. Xantus. Phila. Acad. Nat. Sci., Proc., no. 2, p. 465.

Godsil, H. C. 1938. The high seas tuna fishery of California. Calif. Div. Fish and Game, Fish Bull. 51, 41 p.

Grey, Peter 1952. Handbook of basic microtechnique. New York, Blakiston, Co., 141 p.

Hickling, C. F. 1930. The natural history of the hake. Pt. 3. Seasonal changes in the condition of the hake. Min. Agric. and Fish., Fish. Invest., ser. 2, vol. 12, no. 1, 18 p.

Hubbs, Carl L. 1948. Changes in the fish fauna of western North America. Jour. Mar. Res., vol. 7, no. 3, p. 459–481.

Hubbs, Carl L., and Karl F. Lagler 1947. Fishes of the Great Lakes region. Cranbrook Inst. Sci., Bull. 26, 186 p.

Hubbs, Carl L., and Robert L. Wisner 1953. Food of the marlin in 1951 off San Diego, California. Calif. Fish and Game, vol. 39, no. 1, p. 127–131.

Jordan, David Starr, and Barton Warren Evermann 1896. The fishes of north and middle America. U. S. Nat. Mus., Bull. 47, vol. 1, p. 902.

Jordan, David Starr, and Charles H. Gilbert 1882. Synopsis of the fishes of North America. U. S. Nat. Mus., Bull. 16, p. 444.

1883. Catalogue of the fishes collected by Mr. John Xantus at Cape San Lucas, which are now in the United States National Museum, with descriptions of eight new species. U. S. Nat. Mus., Proc., vol. 5, p. 353–371.

Kimura, Kinosuke 1937. On the size and form of the yellowtail (Seriola quinqueradiata Temminck & Schlegel) fished in Sagami Bay and the eastern portion of Suruga Bay. Tokyo, Imperial Fish. Exper. St., Jour., no. 8, pap. 63, p. 71–87.

1940. Hydrography and fisheries of yellowtail in Sagami Bay. Tokyo, Imperial Fish. Exper. Sta., Jour., no. 10, p. 38–230.

Lagler, Karl F. 1950. Studies in freshwater fishery biology. Ann Arbor, J. W. Edwards, 231 p.

Lewis, William M., and Kenneth D. Carlander 1949. A simple method of mounting scales. Prog. Fish. Cult., vol. 11, no. 4, p. 263.

Mayr, Ernst, E. Gorton Linsley and Robert L. Usinger 1953. Methods and principles of systematic zoology. New York, McGraw-Hill Bk. Co., 368 p.

MacGregor, John S. 1957. Fecundity of the Pacific sardine *(* Sardinops caerulea *)*. U. S. Fish and Wildl. Serv., Fish. Bull., vol. 57, no. 121, 22 p.

McHugh, J. L. 1952. The food of the albacore *(* Germo alalunga *)* off California and Baja California. Scripps Inst. Oceanog., Bull., vol. 6, no. 4, p. 161–172.

McLungs, C. E. 1929. Handbook of microscopical technique. New York, Paul B. Hoeber, Inc., 495 p.

Meek, Seth E., and Samuel F. Hildebrand 1925. Marine fishes of Panama. Field Mus. Nat. Hist., Publ. no. 215, Zool. ser., vol. 15, pt. 2, p. 331–707.

Mitani, Fumio 1955. Relation between the scale of the yellowtail, Seriola quinqueradiata T. et S., and fork length and age. Jap. Soc. Sci. Fish., Bull., vol. 21, no. 7, p. 463–466.

Orcutt, Harold G. 1950. The life history of the starry flounder, Platichthys stellatus (Pallas). Calif. Div. Fish and Game, Fish. Bull. 78, 64 p.

Pacific Marine Fisheries Commission 1954. The sablefish fishery of the Pacific Coast. Pac. Mar. Fish. Comm., Bull. 3, 130 p.

Radovich, John 1960. Relationships of water temperatures to marine organisms of the northeast Pacific, particularly during 1957 through 1959 (manuscript).

Radovich, John, and Earl D. Gibbs 1954. The use of a blanket net in sampling fish populations. Calif. Fish and Game, vol. 40, no. 3, p. 353–365.

Raitt, D. C. 1933. The fecundity of the haddock. Scotland Fish. Bd., Sci. Invest., 1932, no. 1, 42 p.

Reintjes, John W., and Joseph E. King 1953. Food of yellowfin tuna in the central Pacific. U. S. Fish and Wildl. Serv., Fish. Bull. 81, vol. 54, p. 91–110.

Roedel, Phil M. 1953. Common ocean fishes of the California coast. Calif. Dept. Fish and Game, Fish Bull. 91, 184 p.

1954. California's tuna and yellowtail tagging programs. Nineteenth No. Amer. Wildl. Conf., Trans., p. 404–417.

Schmitt, Waldo L. 1921. The marine decapod crustacea of California. Berkeley, Univ. Calif. Publ. Zool., vol. 23, 470 p.

Simpson, A. C. 1951. The fecundity of the plaice. Min. Agric. and Fish., Fish. Invest., ser. 2, vol. 17, no. 5, 27 p.

Smith, Stanford H. 1956. Life history of lake herring of Green Bay, Lake Michigan. U. S. Fish and Wildl. Serv., Fish. Bull., vol. 57, no. 109, 124 p.

Uphoff, Delta E. 1948. A new mounting medium for fish scales. Copeia, no. 1, p. 62.

Van Oosten, John, H. J. Deason and Frank W. Jobes 1934. A microprojector machine designed for the study of fish scales. Cons. Perm. Internat. Explor. Mer. Jour., vol. 9, no. 2, p. 241–248.

Wade, Charles B. 1955. New fishes in the collections of the Allan Hancock Foundation. Allan Hancock Pac. Exped., vol. 9, no. 8, p. 215–237.

Walford, Lionel A. 1932. The California barracuda *(Sphyraena argentea)*. Calif. Div. Fish and Game, Fish Bull. 37, 120 p.

1937. Marine game fishes of the Pacific coast from Alaska to the Equator. Berkeley, Univ. Calif. Press, 205 p.

1946. A new graphic method of describing the growth of animals. Biol. Bull., vol. 90, no. 2, p. 141–147.

Whitehead, S. S. 1933. Condition of the yellowtail fisheries. Calif. Fish and Game, vol. 19, no. 3, p. 199–203.

Wilson, Robert C. 1953. Tuna marking, a progress report. Calif. Fish and Game, vol. 39, no. 4, p. 429–442.

12. APPENDIX

APPENDIX

Tagged Yellowtail Releases and Recoveries

Release				Recovery							
	Date			Total Re-cover-ies	Date		No. of fish		Moved		Days at Lib-erty
Location	Yr.	Mo.	No.		Yr.	Mo.		Location	Mi.	Dir.	
Santa Catalina Is.	54	09	72	17	54	09	1	Santa Catalina Is.	11	N	2
					54	09	1	“ “	0		9
					54	09	1	“ “	0		16
					54	09	1	“ “	0		17
					54	09	1	“ “	3	N	18
					54	09	1	“ “	9	N	22
					54	09	1	“ “	8	N	27
					54	10	1	“ “	2	N	33
					54	10	1	“ “	2	N	36
					54	10	1	Los Coronados	74	S	38
					54	11	1	Santa Catalina Is.	0		79
					55	04	1	Los Coronados	75	S	234
					55	05	1	Santa Catalina Is.	14	N	259
					55	06	1	“ “	9	N	273
					55	06	1	“ “	7	N	284
					55	10	1	Guadalupe Is.	250	S	406
					56	09	1	“ “	250	S	744
San Clemente Is.__	55	06	8	4	55	09	1	SanClemente Is.	11	N	71
					56	04	1	“ “ “	0		292
					56	04	1	“ “ “	0		305
					56	07	1	“ “ “	0		394
Point Vicente____	57	09	1	0							
La Jolla_________	51	07	1	0							
	57	08	1	1	58	04	1	San Onofre	42	N	255
Los Coronados Is.	51	06	3	0							
	51	09	1	1	51	10	1	Los Coronados	0		38
	52	04	2	0							
	52	07	12	7	52	07	1	“ “	0		2
					52	07	1	“ “	0		5
					52	07	1	Ensenada	40	S	7
					52	08	1	Los Coronados	0		9
					52	08	1	“ “	0		14
					52	09	1	“ “	0		38
					U	NK	1	UNK	UNK		UNK
	52	08	4	0							
	53	04	7	4	53	05	1	Los Coronados	0		26
					53	06	1	Ensenada	44	S	49
					53	06	1	Los Coronados	0		60
					53	07	1	Santa Catalina Is.	71	N	81
	53	06	1	1	54	07	1	Los Coronados	0		385
	53	07	1	1	55	09	1	San Martin Is.	130	S	760+
	54	05	7	2	54	05	1	Los Coronados	0		6
					55	05	1	“ “	0		369
	54	06	2	2	54	06	1	“ “	0		2
					54	08	1	Ensenada	39	S	57
	54	08	1	0							
	55	06	4	0							
	56	06	5	3	56	07	1	La Jolla	26	N	12
					56	06	1	Ensenada	42	S	15
					56	08	1	La Jolla	26	N	45
	56	07	3	0							
	57	03	12	3	57	04	1	Los Coronados	0		19
					57	04	1	“ “	0		22
					57	09	1	“ “	0		157
	57	04	4	3	57	06	1	“ “	0		59
					58	06	1	Santa Catalina Is.	74	N	410

APPENDIX—Continued

Tagged Yellowtail Releases and Recoveries

Release				Recovery							
Location	Date Yr.	Date Mo.	No.	Total Re-cover-ies	Date Yr.	Date Mo.	No. of fish	Location	Moved Mi.	Moved Dir.	Days at Lib-erty
Los Coronados Is.					58	07	1	Los Coronados	0		436
—continued	57	05	7	5	57	05	1	Ensenada	42	S	21
					57	05	1	Los Coronados	0		24
					57	07	1	La Jolla	30	N	82
					57	08	1	San Clemente (town)	53	N	121
					58	05	1	Los Coronados	0		390
	57	06	2	2	57	07	1	" "	0		7
					57	07	1	" "	0		30
	57	07	4	2	57	09	1	San Clemente (town)	50	N	39
					57	09	1	Los Coronados	0		65
	57	10	2	1	57	10	1	" "	0		5
Ensenada	54	10	4	0							
San Martin Is.	54	10	23	1	54	11	1	San Cristobal Bay	220	S	32
San Carlos Pt.	54	09	16	2	55	09	1	S. End Cedros Is.	90	S	360
					57	03	1	Los Coronados	220	N	892
Guadalupe Is.	52	08	16	0							
	52	09	6	1	52	09	1	Guadalupe Is. S. End	UNK		8
Guadalupe Is. 45 Mi. NE	54	08	67	4	54	08	1	Ensenada	140	N	8
					54	08	1	San Martin Is.	90	N	12
					55	05	1	San Clemente Is.	227	N	292
					55	06	1	Los Coronados	180	N	318
Guadalupe Is. N. End	52	09	5	0							
	53	09	5	0							
	54	09	87	17	54	09	2	Guadalupe Is.	UNK		4
					54	09	2	" "	"		10
					54	09	5	" "	"		11
					54	09	1	" "	"		15
					54	09	1	" "	"		22
					54	09	1	Guadalupe Is. N. End	0		22
					54	09	3	" " " "	0		23
					54	09	1	Guadalupe Is.	UNK		25
					54	10	1	Guadalupe Is. S. End	16	S	29
	54	10	5	0							
	55	05	5	3	55	07	1	Guadalupe Is. N. End	0		62
					55	09	1	Guadalupe Is.	UNK		106
					56	07	1	San Carlos Point	122	E	402
	55	06	1	0							
	55	07	5	2	55	10	1	Guadalupe Is. E. Side	3	S	75
					56	10	1	Guadalupe Is.	UNK		434
	55	08	10	3	55	10	1	Guadalupe Is. N. End	0		62
					55	10	1	" " " "	0		79
					56	07	1	" " " "	0		339
Guadalupe Is. Mid E. Side	52	06	78	3	52	07	1	Guadalupe-Mid E. Side	0		35
					52	12	1	San Quintin Pt.	152	N	188
					54	07	1	Guadalupe Is.	UNK		767
	53	04	2	0							
	53	08	74	4	53	09	1	Guadalupe Is. N. End	12	N	42
					53	10	1	" " " "	12	N	57
					53	10	1	" " " "	12	N	58
					56	04	1	San Clemente Is.	246	N	982
	54	08	82	13	54	09	1	Guadalupe Is.	UNK		16
					54	09	1	" "	"		18

APPENDIX—Continued

Tagged Yellowtail Releases and Recoveries

Release				Recovery							
Location	Date Yr.	Date Mo.	No.	Total Re-cover-ies	Date Yr.	Date Mo.	No. of fish	Location	Moved Mi.	Moved Dir.	Days at Lib-erty
Guadalupe Is. Mid E. Side —continued					54	09	2	Guadalupe Is.	UNK		19
					54	09	1	Guadalupe Is. Mid E. Side	0		19
					54	09	1	Guadalupe Is.	UNK		20
					54	09	1	" "	"		31
					54	09	1	Guadalupe N. End	15	N	41
					54	10	2	Guadalupe Is.	UNK		56
					55	09	1	" "	"		400
					55	09	1	Guadalupe Mid E. Side	0		408
					55	10	1	" " " "	0		421
	54	10	2	0							
	55	08	1	0							
Guadalupe Is. S. End	51	09	11	0							
	52	06	136	5	52	08	1	Guadalupe Is. S. End	0		83
					52	08	1	" " " "	0		86
					52	08	1	" " " "	0		95
					52	09	1	Guadalupe Is.	UNK		106
					52	11	1	San Martin Is.	157	N	161
	52	08	25	1	52	09	1	Guadalupe Is. S. End	0		20
	52	09	114	2	52	09	1	" " " "	0		14
					52	09	1	" " " "	0		19
	53	04	2	0							
	53	07	6	2	53	08	1	Guadalupe Is. S. End	0		22
					53	09	1	" " " "	0		46
	53	08	159	9	53	09	1	Guadalupe Is.	UNK		36
					53	09	1	Guadalupe Is. S. End	0		44
					53	09	1	Guadalupe Is. N. End	22	N	48
					53	09	1	Guadalupe Is.	UNK		57
					53	10	1	Guadalupe Is. S. End	0		61
					53	10	1	Asuncion Is.	240	S	62
					53	10	1	Guadalupe N. End	22	N	69
					54	10	1	Guadalupe Is. S. End	0		441
					55	05	1	Los Coronados	217	N	645
	53	09	26	3	53	10	1	Guadalupe Is. Mid E. Side	7	N	19
					54	07	1	Guadalupe Is. S. End	0		291
					54	10	1	" " " "	0		385
	53	10	1	0							
	54	08	63	11	54	09	1	Guadalupe Is. Mid E. Side	7	N	19
					54	09	1	Guadalupe Is.	UNK		19
					54	09	1	Guadalupe Is. N. End	15	N	21
					54	09	2	Guadalupe Is.	UNK		30
					54	10	3	" "	"		47
					54	10	1	Guadalupe Is. Mid E. Side	7	N	57
					55	07	1	Guadalupe Is. N. End	15	N	332
					UNK		1	Guadalupe Is.	UNK		UNK
	54	10	27	1	56	10	1	Guadalupe Is. S. End	0		738
	55	05	1	0							
	55	08	9	2	55	09	1	Guadalupe Is.	UNK		47
					55	10	1	Guadalupe Is. Mid E. Side	9	N	84
San Benito Is. 50 Mi. N.W.	54	08	36	0							
	56	08	2	0							
San Benito Is.	52	06	5	1	52	08	1	Hipolito Bank	90	S	86
	54	05	116	9	54	05	1	San Benito	0		20

APPENDIX—Continued

Tagged Yellowtail Releases and Recoveries

Release				Recovery							
	Date			Total Re-cover-ies	Date		No. of fish		Moved		Days at Lib-erty
Location	Yr.	Mo.	No.		Yr.	Mo.		Location	Mi.	Dir.	
San Benito Is. —continued					54	05	1	San Benito	0		21
					54	06	1	" "	0		24
					54	06	2	" "	0		43
					54	06	2	" "	0		44
					55	09	1	Cedros Is., S. End	30	S	501
					57	10	1	San Clemente (town)	314	N	1240
	55	06	42	4	55	10	1	Ensenada	220	N	146
					57	03	1	Los Coronados	260	N	640
					58	04	1	" "	280	N	1061
					58	05	1	Rocky Point	390	N	1064
	55	09	2878	78	56	02	1	Santa Maria Bay	205	S	158
					56	04	1	San Benito	0		214
					56	06	1	Los Coronados	260	N	268
					56	06	2	" "	260	N	269
					56	06	1	" "	260	N	270
					56	06	1	" "	260	N	273
					56	06	1	" "	260	N	289
					56	06	2	Ensenada	215	N	293
					56	06	1	"	215	N	295
					56	06	1	UNK	UNK		UNK
					56	07	1	Ensenada	215	N	294
					56	07	1	"	215	N	307
					56	07	1	Los Coronados	260	N	315
					56	08	1	" "	260	N	346
					56	08	1	" "	260	N	348
					56	09	1	" "	260	N	363
					56	09	2	" "	260	N	365
					56	09	2	" "	260	N	369
					56	09	1	Ensenada	215	N	370
					56	09	1	Los Coronados	260	N	372
					56	09	1	" "	260	N	375
					56	09	1	" "	260	N	377
					56	09	1	Ensenada	215	N	380
					56	09	1	Los Coronados	260	N	381
					56	10	1	" "	260	N	388
					56	10	1	Ensenada	215	N	390
					56	10	1	"	215	N	391
					56	10	1	"	215	N	398
					56	10	1	Los Coronados	260	N	402
					56	10	1	UNK	UNK		408
					56	12	1	Ensenada	215	N	467
					57	03	1	"	215	N	558
					57	03	1	Los Coronados	260	N	565
					57	03	1	" "	260	N	566
					57	04	1	" "	260	N	575
					57	04	1	" "	260	N	582
					57	04	1	" "	260	N	584
					57	04	1	" "	260	N	590
					57	05	1	Ensenada	215	N	601
					57	05	1	Los Coronados	260	N	602
					57	05	1	Ensenada	215	N	602
					57	05	1	Los Coronados	260	N	616
					57	06	1	" "	260	N	656
					57	08	1	Ensenada	215	N	705
					57	08	1	Los Coronados	260	N	710
					57	09	1	" "	260	N	727
					57	09	1	La Jolla	284	N	729
					57	09	1	Los Coronados	260	N	735
					57	09	1	Del Mar	290	N	748
					57	09	2	Los Coronados	260	N	750

APPENDIX—Continued

Tagged Yellowtail Releases and Recoveries

Release				Recovery							
Location	Date Yr.	Date Mo.	No.	Total Re-cover-ies	Date Yr.	Date Mo.	No. of fish	Location	Moved Mi.	Moved Dir.	Days at Lib-erty
San Benito Is. —continued					57	09	1	Los Coronados	260	N	751
					57	09	1	" "	260	N	752
					57	10	1	" "	260	N	758
					57	10	1	" "	260	N	763
					57	10	1	Dana Point	328	N	764
					57	10	1	" "	328	N	765
					57	10	1	San Clemente (town)	320	N	767
					57	10	1	Point Vicente	370	N	775
					57	10	1	Ensenada	215	N	778
					57	11	1	Horseshoe Kelp	350	N	783
					57	11	1	Los Coronados	260	N	792
					57	11	1	" "	260	N	804
					57	11	1	Cape Colnett	167	N	806
					58	03	1	Ensenada	215	N	916
					58	05	1	Horseshoe Kelp	350	N	975
					58	07	1	Los Coronados	260	N	1035
					58	07	1	" "	260	N	1046
					58	07	1	" "	260	N	1048
					58	08	1	" "	260	N	1071
					58	12	1	Ensenada	215	N	1204
					59	01	1	"	215	N	1200+
					59	04	1	La Jolla	286	N	1306
					59	04	1	Los Coronados	260	N	1317
Cedros Is. N. End	52	01	52	5	52	06	1	Kellett Channel	20	S	128
					52	06	1	" "	20	S	150
					52	06	1	" "	20	S	152
					52	08	1	Hipolito Bay	90	S	213
					52	09	1	UNK	UNK		224
	53	09	29	2	53	10	1	San Cristobal Bay	68	S	11
					53	10	1	Cedros Is. N. End	0		15
	54	08	82	1	57	05	1	Los Coronados	270	N	985
	54	09	1	0							
	55	04	5	2	56	08	1	Ensenada	240	N	491
					57	11	1	Horseshoe Kelp	360	N	919
	55	08	5	0							
	55	09	30	2	57	07	1	Los Coronados	260	N	659
					58	08	1	" "	260	N	1054
Cedros Is. S. End	52	01	1	0							
	52	08	14	1	52	08	1	Cedros Is. S. End	0		10
	52	09	6	0							
	53	08	2	0							
	53	09	11	0							
	54	09	14	0							
	55	08	1	0							
	55	09	7117	141	55	10	1	San Cristobal Bay	52	S	32
					55	10	1	Abreojos Pt.	120	S	UNK
					55	11	1	Asuncion Bay	90	S	49
					55	11	1	" "	90	S	52
					55	11	1	San Juanico Pt.	190	S	56
					55	12	1	UNK	UNK		UNK
					56	01	1	Rompiente Pt.	19	S	114
					56	04	1	Los Coronados	280	N	204
					56	05	1	" "	280	N	243
					56	06	2	" "	280	N	256
					56	06	1	" "	280	N	257
					56	06	1	" "	280	N	258
					56	06	1	" "	280	N	259
					56	06	1	Cedros Is. S. End	0		259

APPENDIX—Continued

Tagged Yellowtail Releases and Recoveries

Release				Recovery							
Location	Date Yr.	Date Mo.	No.	Total Re-cover-ies	Date Yr.	Date Mo.	No. of fish	Location	Moved Mi.	Moved Dir.	Days at Lib-erty
Cedros Is. S. End —continued					56	06	1	Cedros Is. S. End	0		263
					56	06	1	Los Coronados	280	N	265
					56	06	1	Ensenada	240	N	272
					56	06	2	Los Coronados	280	N	276
					56	06	1	Ensenada	240	N	276
					56	06	1	Los Coronados	280	N	281
					56	06	1	Cedros Is. S. End	0		283
					56	07	1	Ensenada	240	N	282
					56	07	1	Los Coronados	280	N	285
					56	07	1	San Geronimo Is.	95	N	287
					56	07	1	Los Coronados	280	N	299
					56	08	1	" "	280	N	332
					56	08	1	" "	280	N	337
					56	08	1	Ensenada	240	N	340
					56	08	1	"	240	N	341
					56	09	1	"	240	N	346
					56	09	1	Los Coronados	280	N	348
					56	09	1	" "	280	N	360
					56	09	1	" "	280	N	361
					56	09	1	" "	280	N	362
					56	09	1	Ensenada	240	N	369
					56	09	1	Los Coronados	280	N	376
					56	10	1	Santo Tomas Pt.	226	N	374
					56	10	1	Ensenada	240	N	377
					56	10	1	"	240	N	379
					56	10	1	"	240	N	383
					56	10	1	"	240	N	385
					56	10	1	"	240	N	393
					56	12	1	"	240	N	450
					57	01	1	Hipolito Bay	85	S	476
					57	03	1	Los Coronados	280	N	526
					57	03	1	" "	280	N	527
					57	03	1	" "	280	N	535
					57	03	1	" "	280	N	540
					57	03	1	Magdalena Bay	270	S	547
					57	03	1	Ensenada	240	N	547
					57	03	1	Los Coronados	280	N	548
					57	04	1	" "	280	N	562
					57	04	2	" "	280	N	566
					57	04	1	Ensenada	240	N	572
					57	04	1	Los Coronados	280	N	575
					57	04	2	" "	280	N	579
					57	04	1	" "	280	N	581
					57	04	1	" "	280	N	582
					57	05	1	" "	280	N	589
					57	05	1	Ensenada	240	N	591
					57	05	1	"	240	N	594
					57	05	1	Los Coronados	280	N	597
					57	05	1	" "	280	N	610
					57	05	1	" "	280	N	615
					57	06	1	" "	280	N	634
					57	07	1	La Jolla	315	N	678
					57	09	1	Los Coronados	280	N	713
					57	09	1	Horseshoe Kelp	370	N	714
					57	09	1	" "	370	N	725
					57	09	1	Los Coronados	280	N	726
					57	09	1	" "	280	N	730
					57	09	1	Horseshoe Kelp	370	N	732
					57	09	1	Los Coronados	280	N	734
					57	09	1	Dana Point	348	N	735

APPENDIX—Continued

Tagged Yellowtail Releases and Recoveries

Release				Recovery							
	Date			Total Re-cover-ies	Date		No. of fish		Moved		Days at Lib-erty
Location	Yr.	Mo.	No.		Yr.	Mo.		Location	Mi.	Dir.	
Cedros Is. S. End —continued					57	09	3	Los Coronados	280	N	737
					57	09	1	Ensenada	240	N	737
					57	09	1	Horseshoe Kelp	370	N	740
					57	10	1	Los Cornados	280	N	739
					57	10	1	San Clemente (town)	328	N	742
					57	10	1	Los Coronados	280	N	743
					57	10	1	Horseshoe Kelp	370	N	744
					57	10	1	Los Coronados	280	N	744
					57	10	1	" "	280	N	747
					57	10	1	Point Vicente	390	N	747
					57	10	1	Horseshoe Kelp	370	N	747
					57	10	1	Oceanside	320	N	747
					57	10	1	Los Coronados	280	N	749
					57	10	1	Horseshoe Kelp	370	N	749
					57	10	1	Los Coronados	280	N	751
					57	10	1	Dana Point	348	N	751
					57	10	1	" "	348	N	752
					57	10	1	Los Coronados	280	N	752
					57	10	1	Dana Point	348	N	754
					57	10	1	Los Coronados	280	N	758
					57	10	1	Dana Point	348	N	758
					57	10	1	Los Coronados	280	N	761
					57	10	1	Horseshoe Kelp	370	N	762
					57	10	1	Los Coronados	280	N	765
					57	10	1	Point Vicente	390	N	767
					57	11	1	" "	390	N	773
					57	11	1	Horseshoe Kelp	370	N	775
					57	11	1	Los Coronados	280	N	777
					57	11	1	San Clemente (town)	328	N	778
					57	11	1	Horseshoe Kelp	370	N	785
					57	11	1	Point Vicente	390	N	787
					57	11	1	San Clemente (town)	330	N	789
					57	11	1	Los Coronados	280	N	793
					57	11	1	" "	280	N	797
					57	11	1	San Clemente (town)	330	N	800
					57	12	1	Point Vicente	390	N	816
					58	02	1	Point Dume	410	N	883
					58	03	1	Los Coronados	280	N	898
					58	03	1	Rocky Point	390	N	913
					58	04	1	Ensenada	240	N	932
					58	04	1	Los Coronados	280	N	937
					58	04	1	" "	280	N	942
					58	04	1	" "	280	N	948
					58	05	1	San Benito	30	N	955
					58	05	1	Los Coronados	280	N	961
					58	05	1	San Clemente Is.	340	N	967
					58	05	1	Los Coronados	280	N	969
					58	05	1	Horseshoe Kelp	370	N	971
					58	07	1	La Jolla	315	N	1034
					58	07	1	Ensenada	240	N	1036
					58	07	1	Los Coronados	280	N	1041
					58	08	1	" "	280	N	1062
					58	08	1	Barn-San Clemente	320	N	1071
					58	09	1	Horseshoe Kelp	370	N	1074
					58	10	1	Ensenada	240	N	1124
					58	12	1	"	240	N	1170
					59	06	1	Anacapa Is.	415	N	1367
					59	06	1	Horeshoe Kelp	370	N	1374
					59	08	1	Santa Catalina Is.	360	N	1421
					59	08	1	Los Coronados	280	N	1426
					59	08	1	Oceanside	320	N	1433

APPENDIX—Continued

Tagged Yellowtail Releases and Recoveries

Release				Recovery							
	Date			Total Re-cover-ies	Date		No. of fish		Moved		Days at Lib-erty
Location	Yr.	Mo.	No.		Yr.	Mo.		Location	Mi.	Dir.	
Chester Rocks	54	09	12	0							
Rompiente Point	54	08	1	0							
Turtle Bay	54	08	6	0							
	55	08	1	0							
Turtle Bay 25 Mi. W.	54	08	6	0							
San Cristobal Bay	54	01	5	0							
	55	08	15	0							
San Pablo Bay	52	10	2	0							
	53	09	20	0							
Asuncion Bay	53	09	2	0							
	54	01	46	0							
	54	02	301	5	54	10	1	San Pablo Bay	12	N	247
					54	10	1	Ballenas Bay	60	S	253
					55	09	1	Cedros Is. S. End	90	N	592
					56	09	1	Ensenada	335	N	951
					57	04	1	Los Coronados	370	N	1157
	54	08	7	0							
	55	08	1	0							
Hipolito Bank	52	08	7	1	52	08	1	Hipolito Bank	0		5
	54	02	98	1	54	07	1	Los Coronados	360	N	178
Abreojos Point	56	08	2	0							
Ballenas Bay	53	08	1	0							
	53	09	10	0							
	54	08	3	0							
	55	08	2	0							
Hutchins Bank	54	01	87	2	54	04	1	San Juanico Pt.	39	S	105
					54	10	1	Ballenas Bay	20	N	276
	54	02	11	0							
	54	04	26	0							
	55	02	16	0							
Santo Domingo Pt.	54	02	14	0							
	55	08	4	0							
San Juanico Bay	54	03	1	0							
	55	02	89	0							
	55	08	55	0							
Cape San Lazaro	55	01	1	0							
Santa Maria Bay	53	05	20	0							
	55	01	29	0							
Magdalena Bay	55	01	158	1	55	01	1	Magdalena Bay	0		9
	55	02	6	0							
	55	08	1	0							

APPENDIX—Continued

Tagged Yellowtail Releases and Recoveries

Release				Recovery								
	Date			Total Re-cover-ies	Date		No. of fish		Moved		Days at Lib-erty
Location	Yr.	Mo.	No.		Yr.	Mo.		Location	Mi.	Dir.	
Thetis Bank	53	09	260	33	54	05	1	Thetis Bank	0		237
					54	10	2	Alijos Rocks	129	W	392
					54	10	9	Thetis Bank	0		398
					54	10	1	23-Fathom Bank	29	N	398
					54	10	5	Thetis Bank	0		399
					54	10	12	" "	0		400
					54	10	1	" "	0		402
					54	10	1	" "	0		403
					55	11	1	" "	0		802
	55	04	40	0							
23-Fathom Bank	55	01	44	0							
13-Fathom Bank	53	08	237	27	53	09	3	13-Fathom Bank	0		27
					53	09	8	" "	0		33
					53	09	2	" "	0		34
					53	09	7	" "	0		35
					53	09	6	" "	0		36
					53	09	1	UNK	UNK		UNK
	53	09	1159	39	53	10	1	13-Fathom Bank	0		25
					53	10	2	" "	0		37
					53	10	2	" "	0		39
					53	10	1	" "	0		45
					53	10	1	" "	0		50
					53	11	1	" "	0		59
					53	11	4	" "	0		60
					53	11	1	" "	0		61
					53	11	4	" "	0		62
					53	11	1	" "	0		63
					53	11	2	" "	0		65
					53	11	1	" "	0		67
					53	11	3	" "	0		68
					53	11	1	" "	0		70
					53	11	1	" "	0		71
					53	11	1	" "	0		73
					53	11	1	" "	0		77
					53	11	4	" "	0		UNK
					54	07	1	" "	0		320
					54	08	1	Thetis Bank	55	S	326
					U	NK	5	UNK	UNK		UNK
	54	02	33	0							
	54	07	1	0							
	54	08	221	8	54	10	1	13-Fathom Bank	0		50
					54	10	1	" "	0		63
					54	10	2	" "	0		64
					54	11	2	" "	0		72
					55	09	1	Cedros Is. S. End	170	N	395
					56	08	1	13-Fathom Bank	0		726
	55	01	6	0							
	55	04	5	0							
	55	08	205	0							
Uncle Sam Bank	54	07	1	0							
Pescadero Point	55	04	145	0							
Cape San Lucas	55	04	16	0							
Carmen Island	53	05	14	0							

APPENDIX—Continued

Tagged Yellowtail Releases and Recoveries

Release				Recovery							
	Date			Total Re-cover-ies	Date		No. of fish		Moved		Days at Lib-erty
Location	Yr.	Mo.	No.		Yr.	Mo.		Location	Mi.	Dir.	
Espiritu Santo Is.	55	01	18	0							
Area of Tagging Unknown				23	54	10	1	13-Fathom Bank	UNK		UNK
					54	10	1	Thetis Bank	"		"
					55	05	1	UNK	"		"
					U	NK	1	Guadalupe Is.	"		"
					56	08	1	Los Coronados	"		"
					56	10	1	Ensenada	"		"
					57	04	1	Los Coronados	"		"
					57	09	1	" "	"		"
					57	09	1	" "	"		"
					57	10	1	Horseshoe Kelp	"		"
					57	10	1	" "	"		"
					57	10	1	Los Coronados	"		"
					57	10	1	Horseshoe Kelp	"		"
					58	04	1	Los Coronados	"		"
					58	05	1	Ensenada	"		"
					58	07	1	Los Coronados	"		"
					58	07	1	" "	"		"
					58	08	1	Ensenada	"		"
					58	08	1	Los Coronados	"		"
					58	10	1	San Onofre	"		"
					58	11	1	Ensenada	"		"
					59	03	1	"	"		"
					59	07	1	Los Coronados	"		"