7334

TARACTES RUBESCENS AND *TARACTICHTHYS STEINDACHNERI* FROM HAWAIIAN WATERS

The various species of the family Bramidae are mostly high-seas fishes with the possible exception of *Eumegistus*. Although capture records of adult *Taractes rubescens* (Jordan and Evermann, 1887) and *Taractichthys steindachneri* (Döderlein, 1883) are few, Mead (1972) surmises that they are probably widespread in the tropical oceanic Pacific. Most of the documented accounts of the occurrence of these two species in the Pacific Ocean are of juvenile stages taken from stomachs of large predators. In the Pacific, *Taractes rubescens* has been recorded from a few widely separated localities between lat. 05°48′N and 02°26′S and long. 88°46′ and 155°W. All except one of the documented captures are of juveniles smaller than 120 mm. The only adult specimen was taken by a Japanese longliner at lat. 05°48′N, long. 126°00′W. *Taractichthys steindachneri* is also known mostly from juveniles. They have been captured at widely separated localities between lat. 40°48′N and 04°46′S and long. 165°35′W and 98°28′E. Although adult specimens of this species are also taken incidentally by Japanese longliners, documented capture localities are available in the Pacific for only four specimens. This note records the capture of the adults of 10 *Taractes rubescens* and 2 *Taractichthys steindachneri* from Hawaii and also provides some observations on the ecology of the two species.

Within the area around the Hawaiian Islands bounded by lat. 10°-30°N and long. 150°-170°W, *Taractes rubescens* was previously known from one juvenile measuring 27.5 mm in standard length (SL) and *Taractichthys steindachneri* was known from three juveniles measuring 17.0, 42.5, and 130.0 mm SL (Mead, 1972). The latter species was also known from an adult specimen (*Taractes longipinnis* = *Taractichthys steindachneri*) "about 2 feet long" (Gosline and Brock, 1960). However, *T. steindachneri* is probably more common than indicated: Mead (1972) cites a personal communication from W. A. Gosline (December 1963) in which it is indicated that fishermen in Hawaii are familiar with this species. The 12 bramids reported here were captured on longline gear at nine fishing stations during cruise 101 of the NOAA vessel *Charles H. Gilbert* between 17 May and 6 June 1967 (Table 1). The fishing stations were from 14 to 30 km off the coast of Waianae, Oahu, over depths of 1,800-3,000 m. The surface water temperature ranged from 25.5° to 27.4°C and the salinity from 34.5‰ to 34.9‰ at the fishing stations. Other fishes caught together with the bramids, in order of abundance, were *Alepisaurus* sp., *Prionace glauca*, *Thunnus obesus*, *Tetrapturus audax*, *Xiphias gladius*, *Alopias* sp., *Gempylus serpens*, *Katsuwonus pelamis*, *Acanthocybium solandri*, *Thunnus albacares*, *Tetrapturus angustirostris*, and *Isurus* sp.

Three of the *Taractes rubescens* and both of the *Taractichthys steindachneri* were frozen after capture. Approximately 5 yr later, body measurements and counts on two *Taractes rubescens* and two *Taractichthys steindachneri* were made in the laboratory after the specimens thawed out (Table 2). The five preserved specimens are presently in the Southwest Fisheries Center, Honolulu Laboratory's fish collection.

TABLE 1.—Capture locality of *Taractes rubescens* and *Taractichthys steindachneri.*

Date 1967	Position		*Taractes rubescens*			*Taractichthys steindachneri*		
	Lat. N	Long. W	Number	Length	Sex[1]	Number	Length	Sex[1]
				mm			*mm*	
18 May	21°26′	158°22′	1	729	M	—	—	—
19 May	21°34′	158°34′	1	749	M	—	—	—
20 May	21°19′	158°22′	2	781 635	M F	1	611	F
21 May	21°23′	158°24′	2	522 662	F F	—	—	—
22 May	21°16′	158°15′	1	713	M	—	—	—
26 May	21°17′	158°17′	1	730	M	—	—	—
28 May	21°16′	158°16′	1	[2]—	[2]—	—	—	—
3 June	21°21′	158°18′	—	—	—	1	644	F
6 June	21°20′	158°26′	1	760	M	—	—	—

[1] M = male, F = female.

[2] Not determined.

The primary purpose of cruise 101 of the *Charles H. Gilbert* was to determine if longline catch rates for *X. gladius* around Hawaii could be improved by fishing at night. Also included in the fishing experiment was a comparison of Pacific saury, *Cololabis saira*, and squid, *Loligo opalescens*, as bait, and a comparison of the effect of 9.1-, 18.3-, and 36.6-m float lines on the catch rates. Although the number of specimens taken was small, it was interesting to examine the fishing results as they pertain to the bramids.

During cruise 101 longline fishing operations were conducted in two general areas: one off the coast of Hilo, Hawaii, and the other, as noted earlier, off the coast of Waianae, Oahu. The 3 days of fishing off Hilo did not produce any bramids. Off Waianae, bramids were taken on 9 of the 19 days fished in that area. Although the data are too few to make definitive conclusions, it is of interest that slight environmental differences existed in the two areas, which may in part account for the fact that no bramids were taken off Hilo. The surface water temperature was slightly cooler off Hilo, ranging from 24.7° to 25°C as compared with 25.5° to 27.4°C off Waianae. The salinity of the water at the surface ranged from 34.4‰ to 34.6‰ off Hilo and 34.4‰ to 34.9‰ off Waianae.

As far as I know, *Taractichthys steindachneri* and *Taractes rubescens* are not commonly caught by the Hawaiian longline fishermen. This may be because longlines are usually set and retreived during daylight hours. The fact that they were taken on cruise 101 of the *Charles H. Gilbert* when the longlines were fished at night suggests that they may be nocturnal feeders. The results of the experimental use of the float lines of different lengths suggest that they may also be subsurface feeders: More were taken when the longline gear fished deeper, i.e., had longer float lines. Considering only the stations off the Waianae coast, 2,340

TABLE 2.—Measurements and counts on two specimens of *Taractes rubescens* and two specimens of *Taractichthys steindachneri.*

Measurements and counts	*Taractes rubescens*		*Taractichthys steindachneri*	
Standard length (mm)	660	663	538	568
Measurements (in percent of standard length)				
Head length	31.8	32.3	29.2	30.8
Depth of body at origin of dorsal fin	40.0	40.3	45.7	48.9
Least depth of caudal peduncle	7.7	7.5	6.5	7.2
Horizontal diameter of eye	6.4	6.6	6.3	6.5
Snout to origin of dorsal fin	38.6	39.5	36.0	41.9
Snout to origin of anal fin	62.7	60.5	51.1	51.6
Snout to origin of pectoral fin	32.6	31.7	29.4	31.7
Length of pectoral fin	42.7	43.4	42.4	42.1
Length of ventral fin	[1]—	15.2	7.4	8.4
Length of longest dorsal ray	34.1	32.1	38.8	[1]—
Length of longest anal ray	28.8	27.3	30.5	37.8
Counts:				
Dorsal fin	30	30	35	35
Anal fin	20	20	29	28
Pectoral fin	21	20	20	20
Gill rakers	2+8	2+8	4+7	2+8
Scales in horizontal series	[2]45	[2]47	37	37

[1] Damaged.

[2] Excluding the enlarged keel scales.

hooks were fished on longline baskets with 9.1-m float lines, 2,160 hooks on baskets with 18.3-m float lines, and 2,340 hooks on baskets with 36.6-m float lines. No specimens were taken on longline gear with 9.1-m float lines. One *Taractichthys steindachneri* and seven *Taractes rubescens* were taken on longline gear with 18.3-m float lines. One *Taractichthys steindachneri* and three *Taractes rubescens* were taken on longline gear with 36.6-m float lines.

Saury and squid were used as bait on alternate baskets on each fishing station. More bramids were taken on hooks baited with saury than with squid. Nine *Taractes rubescens* were caught on hooks baited with saury, and two on hooks baited with squid. Both of the *Taractichthys steindachneri* were caught on hooks baited with saury. These results would indicate that fish constitute an important part of the diet of these bramids. However, only one of five stomachs (4 *Taractes rubescens* and 1 *Taractichthys steindachneri*) had fish remains. Squid and shrimp remains were more frequent in the stomachs.

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7335

A NON-PARAMETRIC APPROACH TO THE ESTIMATION OF RELATIVE CHANGE IN FISH POPULATION SIZE FROM EGG AND LARVAL SURVEYS

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INTRODUCTION

Biological surveys in the ocean are, most often, carried out for two purposes; to locate and estimate the abundance of organisms. This requires sampling and the subsequent processing of the data. Classical theory prescribes how both should be done to insure accuracy and reliability, but rarely, if ever, can these rules be strictly adhered to in surveys at sea. Such surveys are expensive in terms of money and manpower, and one is seldom granted the luxury of tailoring a survey to one's own interests. Compromises are made and what results is a mélange of good and bad, of acceptable and unacceptable procedures in the collection of the samples and in the data analysis and one can hope for little more without massive increases in expenditures for survey work. The analysis of data from such surveys is subjective and often open to question, and their value can be determined only when independent data are available for confirmation. In this paper, estimates of trend in the size of the spawning population of the Pacific sardine (*Sardinops caerulea*) based only on the number of eggs per station collected on the extensive surveys of the California Cooperative Oceanic Fisheries Investigations (CalCOFI) conducted from 1951 through 1960 are compared to similar estimates from both catch data and the much more complete analysis of Murphy (1966).

ANALYSIS OF SURVEY DATA

Whenever it is necessary to utilize sampling techniques to draw conclusions about some larger population, several fundamental decisions must be made. These decisions range from the determination of a basic sampling scheme to the analysis or summarization to be carried out on the data. Perhaps the most basic question to be asked is whether the process can incorporate theoretical sampling designs and statistical techniques or whether it is a process of data collection and analysis based largely upon intuition, judgement, and ingenuity. The present trend in the scientific community is to overrate the theoretical and underrate the practical techniques of data reduction and evaluation. As stated by Tukey (1963), "We have used our growing ability to mathematize and statisticate the simple to help us to err by denying the reality or relevance of the complex." On the other hand, quantitative ecologists and statisticians dealing with natural and transient populations have long recognized the inherent limitations of classical statistical techniques and have relied most heavily on methods requiring only limited theoretical assumptions.

Two issues lie at the heart of the discussion: 1) probability sampling and 2) the normal or Gaussian distribution. In a probability sample all units have a finite and known chance of inclusion in the sample. Thus the frequency distribution of any estimate or function of estimates can readily be derived mathematically or generated by repeated sampling. Nonprobability sampling schemes such as judgement, haphazard, accessibility or systematic sampling present no such opportunity for development of a full underlying theory. Their usefulness can usually be examined only when results are available from a complete census or from other sampling schemes.

Many investigators have long realized that assumptions of normality have little validity in the treatment of survey data except for the means of large numbers of observations and that the assumption of this distribution has a marked effect on the associated variances of the estimated parameters. This realization is, in fact, responsible for the scarcity of estimation techniques available in survey work. Alternatively, numerous attempts have been made to describe the distribution of organisms in time and space. The degree of success has, in general, been inversely related to the magnitude of the space-time continuum. Characteristically the zero-class (no organisms per measurement unit) estimated from a specific theoretical distribution is either seriously over- or underestimated. Since a zero sample may either delimit the spatial range or may be due to sampling variability alone, the use of these samples to choose among alternative models is questionable as is the process of combining data where outcomes are rare. Large scale phen

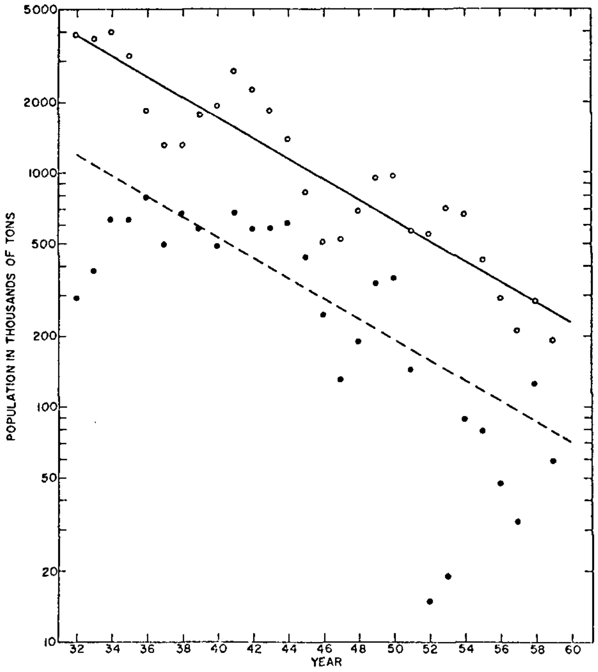

Figure 177. Spawning biomass. • – Murphy's estimates; ○ – total catch. Lines are the least squares fit for the years 1936–1950.

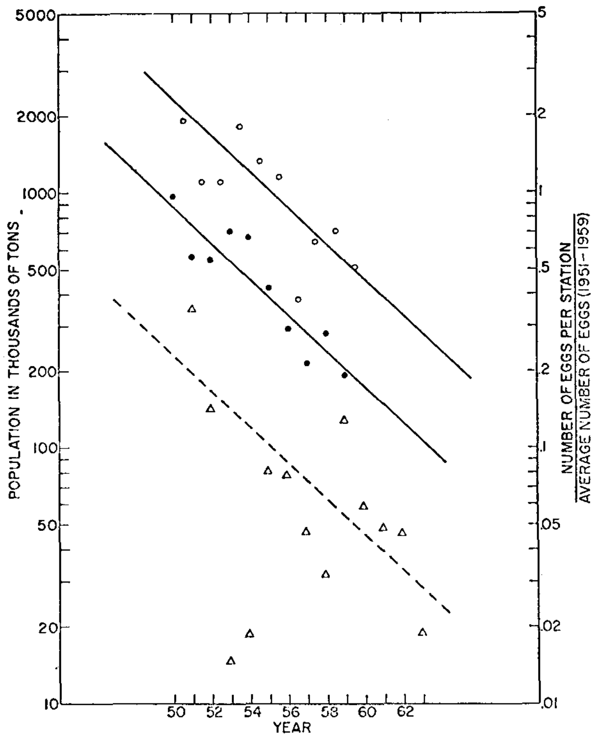

Figure 178. Spawning biomass (1951-1960). • – Murphy's estimates; △ – total catch; ○ – number of eggs per station estimated for survey data.

menon, or at least sparsely sampled large scale phenomena seem little attuned to the strictures of mathematical or statistical theory.

The general tendency in survey work is 1) to decide upon a sampling unit, 2) to determine a sampling plan and 3) attempt to relate these results to those from similar surveys or to other information available about the population under study. In oceanic survey work the difficulties involved in carrying out the first two steps are enormous. The last seems almost insurmountable. It is the purpose of this paper to show evidence that simple, admittedly subjective and intuitive, ocean-survey procedures are effective in monitoring relative changes in the spawning population and thus to offer a ray of hope for the effectiveness of similar efforts.

METHODS

A detailed account of the scientific investigation of the Pacific sardine by CalCOFI has been given by Murphy (1966). In particular, his estimates of the total spawning population were calculated for the years 1932—1959. The estimates were based on the records of aged catches and fishing effort and independent estimates of natural mortality, fishing rates and population size. Since the age structure of a population changes constantly, numbers of spawners have little meaning. MacGregor (1957) showed that fecundity is nearly proportional to biomass; hence variations in total biomass will be used here as a basis for comparison.

Murphy's estimates of biomass, plotted in Figure 177, show a logarithmic decline in the spawning population over the period 1932—1959 with quite systematic variations above and below the general trend. The total catch figures, also plotted in the Figure, show a similar decline and in fact the calculated trend lines are nearly identical. Because of the rapid increase in effort prior to 1936 and the rapid decline of vessels due to bankruptcy and diversion to other fisheries after 1950, only data for the period 1936—1950 were used in the calculation of the regression lines. It is evident that the two sets of data depict the same overall trend and quite similar year-to-year variations. Also suggested is a change in the rate of decline about 1950. This corresponds to a doubling of the natural mortality rate assumed by Murphy in his calculations after the 1949 year class. In Figure 178, Murphy's line is recalculated for the period 1951—1959 and extrapolated to the catch data. Again the agreement is good in spite of the apparently great variability of effort encountered during this period.

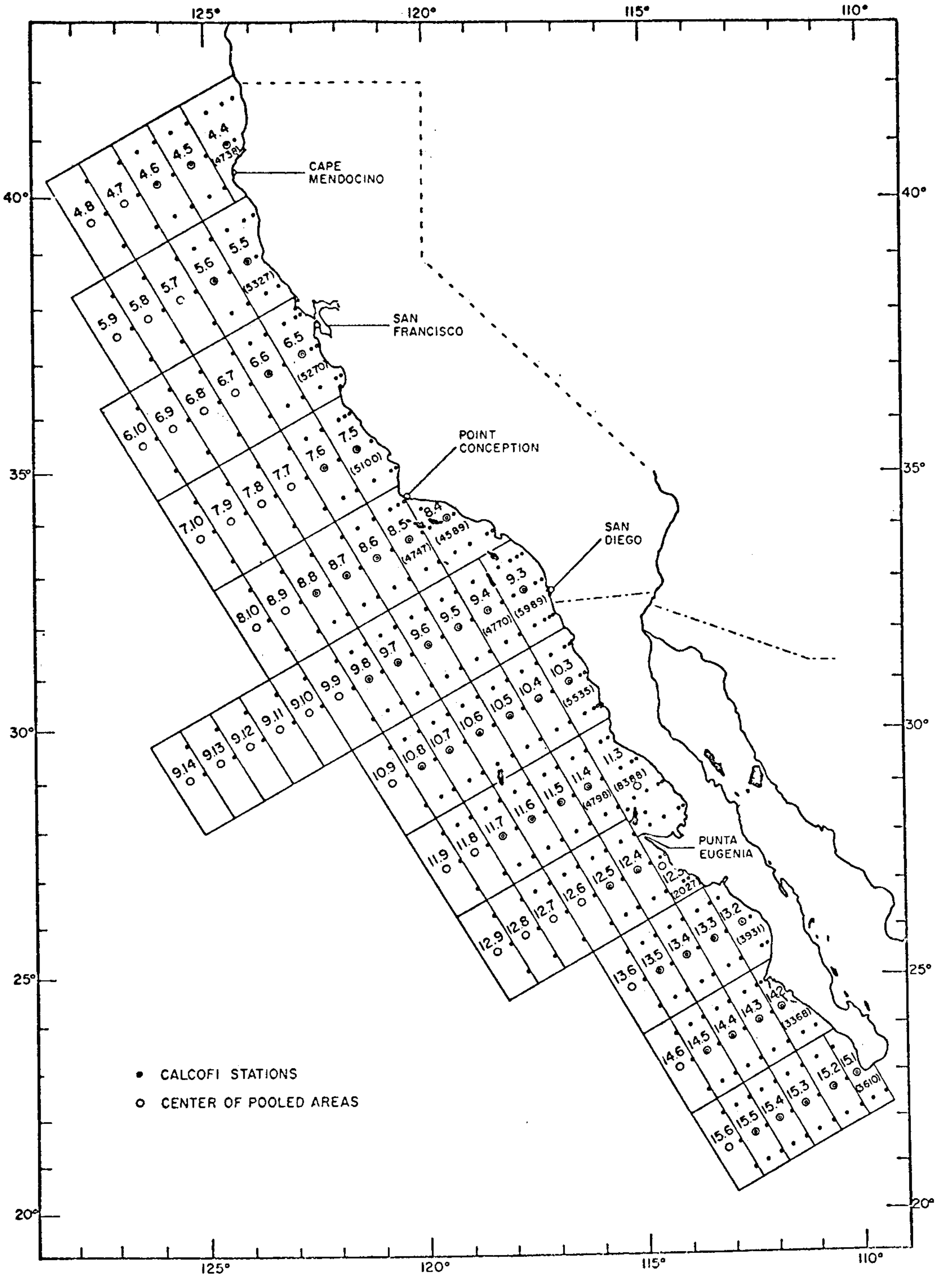

Figure 179. Pooled areas of the CalCOFI survey region.

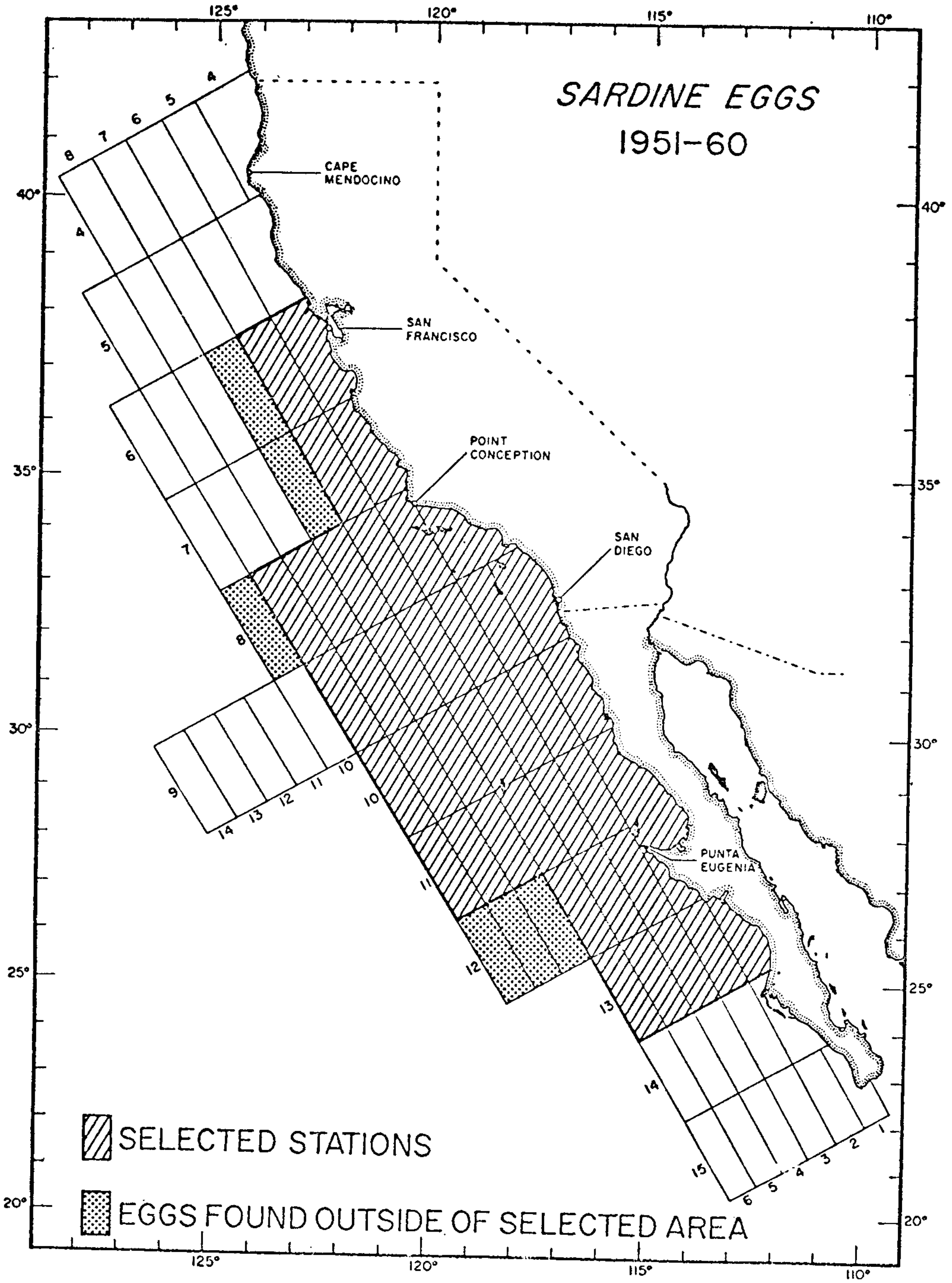

Figure 180. Outlined region shows total area occupied at some time during the period 1950–1960; crosshatched areas were regularly occupied and included in the analysis; dotted areas contained some spawning but were not regularly occupied.

Table 96. Average number of sardine eggs ($\log_{10}$) of positive hauls

Pooled areas[1]	Year									
	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960
8–9	1·472	1·100	1·421	1·600	1·543	1·526	2·101	1·678	1·647	1·428
10–11	1·736	1·787	2·088	1·669	1·649	1·768	1·599	1·548	1·675	1·554
12–13	2·414	1·809	1·708	1·805	1·986	1·967	1·372	·914	·956	2·250

[1] Includes only selected stations, see Figure 180.

Table 97. Percent positive stations

Pooled areas[1]	Year									
	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960
8–9	15·1	9·0	3·0	20·7	16·0	10·0	6·0	24·7	24·6	14·5
10–11	29·1	20·0	19·4	44·7	27·1	21·3	8·8	8·2	9·8	10·8
12–13	25·5	24·0	23·3	17·4	9·4	12·5	9·2	2·9	4·0	3·6

[1] Includes only selected stations, see Figure 180.

For purposes of this study, Murphy's estimates were assumed to be the best representation of the overall trend as well as year-to-year variations. The question to be answered is whether any reasonable manipulation of the data from egg surveys might substantiate these estimates for the period 1951—1959. Intuitively one would think that changes in the level of spawning would be reflected in either the number of eggs per positive haul (density) shown in Table 96 or in the proportion of positive hauls (coverage) shown in Table 97 or perhaps both. Egg numbers, however, would be expected to vary geometrically for several reasons: 1) the spawning population is undergoing logarithmic changes, 2) favourable or unfavourable environmental factors would be expected to affect the spawned eggs proportionally and 3) the almost universal prevalence in population numbers of geometric or logarithmic changes in abundance (Williams, 1964).

Although spawning occurred over the complete survey pattern of the CalCOFI in the first 7 months of most years, 1951 through 1960, the major centers of spawning activity shifted from south to north in the latter years, 1958 through 1959. Accordingly, in order to include all possible spawning areas, averages were calculated for the entire survey area within each calendar month. The sampling unit used here (Fig. 179) is a pooled area 40 by 120 miles containing from 1 to 6 stations of the CalCOFI pattern with an overall average of four stations per unit. Since some stations or part of the survey region were infrequently occupied over the 10-year period, only regularly occupied stations were included in the analysis (Fig. 180). The sampling procedure for the data used is the standard CalCOFI oblique tow standardized to a unit of 10 square meters of sea surface (Ahlstrom, 1953). Only data for the first 7 months of each year were used because surveys were not consistent in the last five.

RESULTS

Table 98 shows that the mean per positive haul, while showing some trend, remained quite stable during periods of apparent decline and Table 99 reveals that the proportion of positive hauls, in general, varied directly with the mean per haul. In Table 100, the anti-logarithm of the mean per positive haul is multiplied by the proportion of positive hauls to obtain an estimate of the mean per station. These values, expressed as a fraction of the average for the period, are shown in Figure 178 for comparison with Murphy's estimates. The general trend is clearly similar and the year-to-year variation agrees very well if the survey values, reflecting a population in existence from January through July, are considered intermediate between two yearly estimates at about 1. September.

The estimates of the mean per station for each year are the simple averages of the monthly means which are based on a selected group of stations regularly occupied over the period 1951—1960. No attempt was made to correct for variations in sampling pattern within the selected area nor were adjustments made for difference in environmental conditions. The close agreement with other indicators of population trend

Table 98. Average number of sardine eggs $(\log_{10})$ of hauls

Year	Month							Average
	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	
1951........	1·864	2·541	1·744	1·705	1·807	1·565	1·862	1·870
1952........	1·530	1·674	1·755	1·925	1·708	1·760	1·629	1·712
1953........	1·462	1·619	1·646	2·241	1·421	1·271	3·218	1·840
1954........	1·303	1·644	1·828	1·602	1·659	1·737	2·030	1·686
1955........	1·989	1·976	1·566	1·383	1·892	1·684	1·565	1·722
1956........	1·643	1·461	1·483	1·538	1·900	1·836	2·584	1·778
1957........	·979	1·830	1·183	2·021	1·926	1·015	2·415	1·610
1958........	1·683	1·937	1·648	1·823	1·484	1·288	1·471	1·619
1959........	1·421	1·536	1·411	1·928	1·985	1·569	1·727	1·654
1960........	1·575	1·962	1·576	1·860	1·449	1·444	1·760	1·661

Table 99. Percent positive stations

Year	Month							Average
	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	
1951	14	12	25	26	28	26	21	21·7
1952	23	16	21	21	19	14	8	17·4
1953	3	21	19	12	16	13	8	13·1
1954	19	27	36	42	35	39	22	31·4
1955	16	20	25	29	23	22	10	20·7
1956	3	18	31	16	19	17	7	15·8
1957	7	6	11	5	10	5	9	7·6
1958	17	13	22	7	12	5	13	12·7
1959	12	23	11	11	8	12	11	12·6
1960	13	11	10	4	4	11	11	9·1

Table 100. Estimated average number $(N\bar{P})$ of sardine eggs per haul

Year	$\overline{\log N}$	N	$\bar{P}$	$N\bar{P}$	$N\bar{P}/\overline{N\bar{P}}$
1951........	1·870	74·1	0·217	16·1	1·96
1952........	1·712	51·5	0·174	9·0	1·10
1953........	1·840	69·2	0·131	9·1	1·11
1954........	1·686	48·5	0·314	15·2	1·85
1955........	1·722	52·7	0·207	10·9	1·33
1956........	1·778	60·0	0·158	9·5	1·16
1957........	1·610	40·7	0·076	3·1	·38
1958........	1·619	41·6	0·127	5·3	·65
1959........	1·654	45·1	0·126	5·7	·70
1960........	1·661	45·8	0·091	4·2	·51

obtained from these estimates shows that such refinements might be used to reduce the inherent variability. In any case, there is convincing evidence that routine sampling (at about 75 to 100 stations per month) over a large spawning area (175 000 square miles) can provide information on relative size of a spawning populations.

SUMMARY

The usefulness of egg and larva surveys for monitoring dynamic fish populations has often been questioned. For many species, the areal coverage required is extensive and thus the sampling density is small. In addition little is known about day to day or area to area sampling variability and standard techniques such as random sampling are rarely feasible. As a result the proper numerical analysis, both of type and extent, of the data is open to question. Some phenomena, however, appear almost universally, such as the inclination to proportional or logarithmic changes in measures of central tendency and variability. By admitting only that spawning levels are basically logarithmic and that these levels will be proportional to some unknown environmental conditions, it was found that for an extensive period (10 years), the average number of eggs per station computed as the anti-logarithm of the mean logarithm per positive haul multiplied by the proportion of positive hauls, when averaged over the total spawning area, reflected the same rate of population decline as evidenced by both the catch data and the estimates obtained by Murphy (1966). Since no distributional assumptions were made, little is known about the associated variability of this estimate. It should be noted that this estimate differs algebraically only slightly from log $(x + 1)$ where the number per positive haul is large.

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