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SEXUAL MATURITY AND SPAWNING OF THE ALBACORE IN THE CENTRAL SOUTH PACIFIC OCEAN

By TAMIO OTSU, *Fishery Research Biologist,* and RICHARD J. HANSEN

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CONTENTS

ABSTRACT

Developmental stages of gonads of the albacore, *Thunnus germo* (Lacépède), taken in the central South Pacific Ocean by Japanese and South Korean longline vessels based in American Samoa were studied. The samples comprised 782 pairs of ovaries and 990 pairs of testes collected between August 1957 and September 1958 from 256 landings.

Occurrence of ova in late stages of development indicates that the South Pacific albacore spawn during the southern summer months, between September and March, as opposed to the northern summer spawning of the North Pacific albacore. This difference in spawning periods is believed to constitute evidence that the stocks of albacore in the South Pacific and the North Pacific are independent of each other. The data suggest that the bulk of the spawning activity of South Pacific albacore is confined to the area between the Equator and 20°S. latitude. No east-west differences in occurrence of developing ovaries were discernible.

SEXUAL MATURITY AND SPAWNING OF ALBACORE IN THE CENTRAL SOUTH PACIFIC OCEAN

By Tamio Otsu, *Fishery Research Biologist,* and Richard J. Hansen, Bureau of Commercial Fisheries Biological Laboratory, Honolulu, Hawaii

The albacore tuna, *Thunnus germo* (Lacépède), is found generally throughout temperate and tropical waters of the Pacific Ocean, where it is the basis of important fisheries for Americans and Japanese. The demand in America for canned albacore has steadily increased, and today this demand is met only by a considerable importation of frozen and canned fish. The Japanese, at present the principal suppliers of albacore, fish for this species along with other tunas in the tropical Indian and Atlantic Oceans as well as in the Pacific (Otsu, 1959).

As part of the research of the staff of the Bureau of Commercial Fisheries Biological Laboratory (Honolulu) a study was initiated in August 1957 of the gonadal development and spawning of albacore in the South Pacific Ocean. Such a study had previously been conducted on North Pacific albacore (Otsu and Uchida, 1959b). Presently it is not known whether the albacore fished by Americans and Japanese in the temperate North Pacific Ocean belong to the same population as those of the South Pacific. This study was undertaken to obtain (1) a broader understanding of the biology of the albacore and (2) a possible clue to the relation between fish occurring in the North and South Pacific Oceans.

Tag recoveries have shown that the albacore of the temperate North Pacific make oceanwide migrations and probably constitute a single intermingling population exploited by both Americans and Japanese (Ganssle and Clemens, 1953; Blunt, 1954; Otsu and Uchida, 1959a; Otsu, 1960). It is also known from previous studies that albacore do not spawn in temperate waters of the North Pacific (Otsu and Uchida, 1959b). There are indications that adult fish move south from temperate waters to spawn in subtropical waters, possibly to the west of, and in the general latitudes of, the Hawaiian Islands (Ueyanagi, 1957; Otsu and Uchida, 1959b). It is necessary to obtain similar information for albacore in the South Pacific before any study can be made of the total population structure of this important tuna resource.

The authors wish to acknowledge the excellent cooperation extended by the management and staff of the Van Camp Sea Food Co., in making this study possible. Donald Doran, former general manager, and his staff at the Van Camp Tuna Company cannery in American Samoa were instrumental in getting the gonad sampling accomplished. Mort Miles and Francis Yuhashi helped in many ways with the collecting, preserving, and shipping of samples. Poulima Tumanuvao and John Williams, Samoan cannery employees, faithfully sampled daily landings, made accurate length and weight measurements on the sampled fish, and kept excellent records which formed the basis of this study.

SOURCE OF MATERIALS

The tuna fishery based in American Samoa offers an excellent source of materials for the study of albacore spawning in the South Pacific Ocean. Albacore are landed throughout the year, making it possible to obtain samples continuously for the study of seasonal variation in gonad development. Furthermore, the great extent of the area fished makes possible the study of areal variations in spawning activity.

An account of the beginning of this tuna fishery is given by Van Campen (1954). At present (1960), the cannery in Pago Pago, American Samoa, is being served by a fleet of about 35 Japanese and 3 Korean longline fishing vessels. From its beginning in 1954, with a fleet of 7 boats and an albacore production of 270 tons, the fishery has continued to expand, until landings of albacore today exceed 12,000 short tons (fig. 1).

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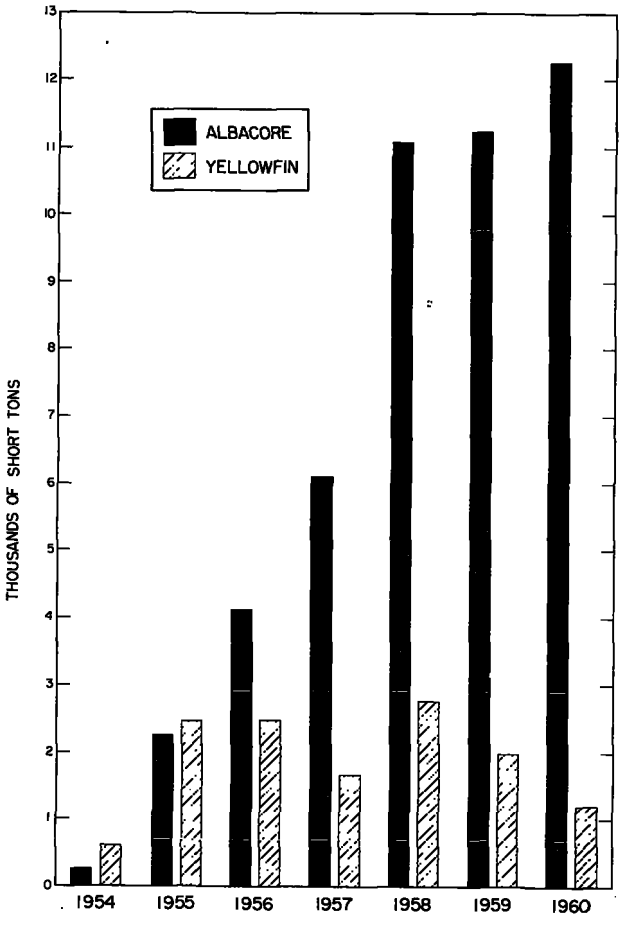

FIGURE 1.—Total annual albacore and yellowfin landings (tons) at the cannery in Samoa: 1954–60.

The fishing grounds, which in 1954 and early 1955 were chiefly in the vicinity of Samoa and to the north, have expanded to more distant and southerly waters. This shift in fishing grounds has been accompanied by a shift in species composition of the catch from predominantly yellowfin, *Neothunnus macropterus* (Temminck and Schlegel), to albacore (fig. 1). The boats range great distances in all directions from Samoa (fig. 2).

In August 1957, arrangements were concluded with the management and staff of the Van Camp Tuna Company to obtain gonad samples at the cannery from 7 randomly selected albacore from each landing. The fork length of each sampled fish was measured to the nearest millimeter, using a standard 1½-meter fish caliper, and the fish was weighed to the nearest ½ pound. The gonads were removed and placed in plastic bags, appropriately labeled, then kept frozen until received by our Honolulu laboratory. Additional information accompanying each gonad sample included the date of sampling, the fishing period (from which it was possible to tell the probable month of capture), and the locality of capture.

Although emphasis in this study was placed on the examination of ovaries, since previous studies had indicated that testes are generally unsatisfactory for the determination of developmental stages (June, 1953; Otsu and Uchida, 1959b), gonads of both sexes were collected in order to insure complete randomness in sampling.

The samples of gonads collected and shipped to Hawaii comprised 1,772 pairs; the approximate capture dates of the fish covered the period July 1957 to September 1958 (table 1). The sampled albacore ranged in size from 72 to 110 cm. (15 to 64 lbs.) (fig. 3).

TABLE 1.—*Gonads collected at the cannery in Samoa, July 1957 to September 1958*

Date	Number of landings sampled	Number of ovaries	Number of testes
1957			
July	2	7	7
August	19	51	75
September	17	42	74
October	9	24	37
November	7	22	27
December	16	62	50
1958			
January	26	60	118
February	20	55	77
March	21	65	81
April	21	74	73
May	15	47	58
June	26	89	91
July	28	101	95
August	27	76	120
September	2	7	7
Total	256	782	990

LABORATORY PROCEDURE

Upon arrival of the frozen samples from Samoa, they were thawed and preserved in 10-percent formalin. Laboratory examination of the formalin-preserved samples followed much the same procedure used and described in detail by Otsu and Uchida (1959b) in their study of North Pacific albacore spawning. Each pair of gonads was trimmed of extraneous tissue and weighed to the nearest 0.5 gram. No further work was done on testes. The ovaries were sectioned and examined under a microscope. The results of the previous study of ova sizes and characteristics of the albacore by Otsu and Uchida (1959b) indicated that

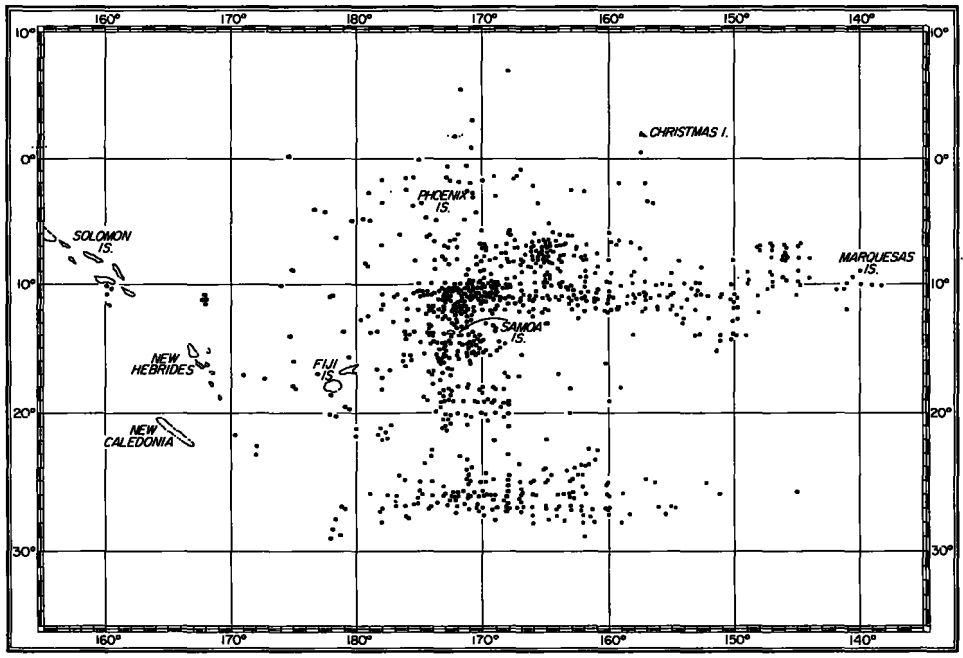

FIGURE 2.—Areas fished by the Samoa-based vessels. Each dot represents the approximate central position of one trip's fishing.

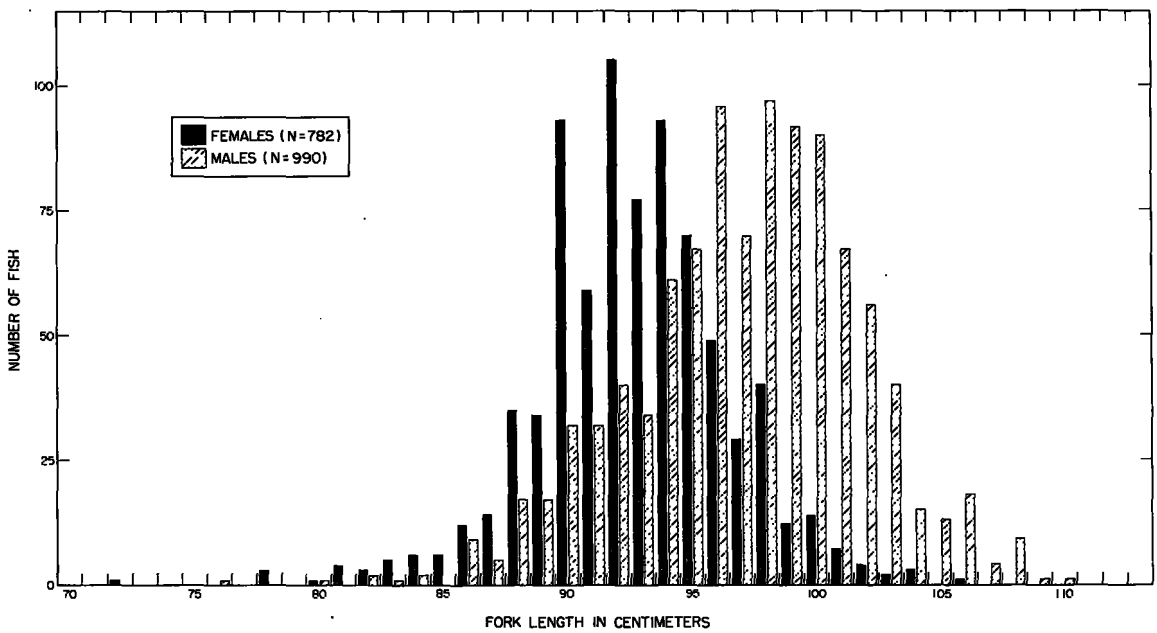

FIGURE 3.—Size of albacore sampled at the tuna cannery in Samoa, August 1957 to September 1958.

a gross examination of the ovaries would suffice. This consisted of recording the stage of development of the ovary by noting the general appearance and characteristics of the largest ova present. Additionally, 25 of the largest ova were measured to give an indication of the maximum sizes comprised in each ovary sample. For early developing ovaries, with ova in the primitive and early developing stages, no measurements were made; only the stage of development was noted.

DEVELOPMENTAL STAGES

Ovaries were classified as "early developing", "late developing", or "advanced", according to the stage of development of the largest ova present. The characteristics of ova in these stages have been described by Otsu and Uchida (1959b). Briefly they are:

Early developing.—In this stage the ovaries contain only the transparent primitive ova, or ova that are in the beginning stages of development and are semi-opaque from deposition of yolk granules.

Late developing.—This is a broad category in which the ova are completely opaque from the heavy accumulation of yolk granules; their diameters range from about 0.4 to 0.8 mm.

Advanced.—In this stage the ovaries are approaching ripeness. The largest ova are semitransparent and contain a conspicuous golden-yellow oil globule. These advanced ova, not fully ripe, range from about 0.7 to 1.0 mm. in diameter.

RESULTS

Seasonal variation in gonad development

Table 2 shows the number of ovaries of each developmental stage found each month. The six ovaries classified as advanced (2 each in Sept. and Oct. 1957 and Jan. 1958) contained ova in the transitional stage between late developing and advanced, just beginning to take on the characteristic semitransparent appearance. The ova diameters (0.60 to 0.64 mm.) resembled more closely the late developing than the advanced stages of Hawaiian albacore ovaries (Otsu and Uchida, 1959b). In comparison, the most highly developed albacore sampled in Hawaiian waters possessed ova with a modal diameter of 0.85 mm.

The percentage of ovaries in the late developing and advanced stages is shown for each month beginning with July 1957 (fig. 4). There is a gradual increase in development, with the peak appearing in December. In May, practically all of the ovaries are in the early developing stage. The increasing trend appears again after May. The 100-percent occurrence of the late developing

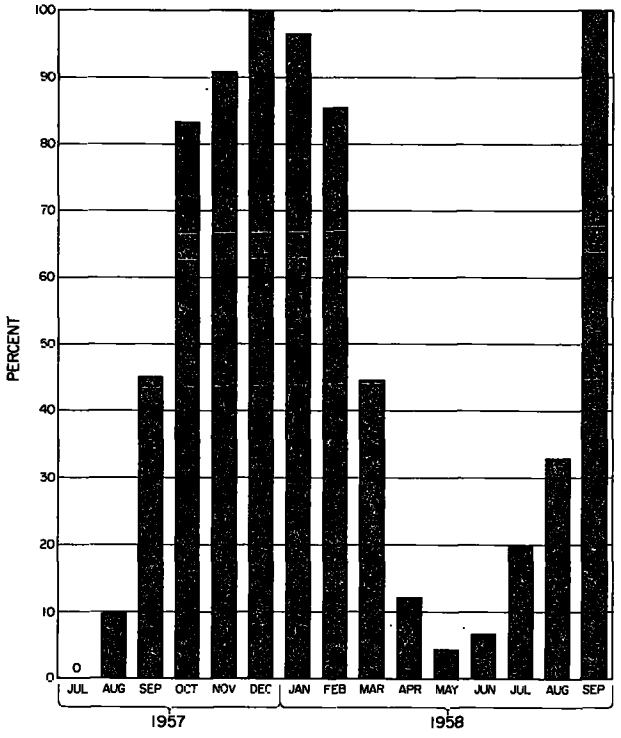

FIGURE 4.—Percentage of ovaries in the late developing and advanced stages, by month.

TABLE 2.—*Developmental stages of ovaries shown by month of capture*

Date	Number in each stage			Total
	Early developing	Late developing	Advanced	
1957				
July	7	0	0	7
August	46	5	0	51
September	23	17	2	42
October	4	18	2	24
November	2	20	0	22
December	0	62	0	62
1958				
January	2	56	2	60
February	8	47	0	55
March	36	29	0	65
April	65	9	0	74
May	45	2	0	47
June	83	6	0	89
July	81	20	0	101
August	51	25	0	76
September	0	7	0	7
Total				782

stage in September 1958 is probably due to the very small sample (7) collected during the month.

It seems clear from figure 4 that the peak of spawning activity in the central South Pacific occurs at some time during the southern summer months, between September and March. It seems logical to assume that the peak spawning period begins around December and extends into January or February, when the percentage of the late developing stage gradually decreases. This interpretation is based on the assumption that this decrease reflects a gradual development of the ovaries through the advanced, ripe, and spawning stages.

This southern summer spawning is in contrast to the albacore of the North Pacific, which appear to spawn during the northern summer months (Ueyanagi, 1957; Otsu and Uchida, 1959b).

Areal variation in gonad development

Since ovaries in the advanced stage were so few, and those in the ripe stage were entirely missing from the samples, we have considered late developing ovaries to be indicative of spawning fish. It has been postulated by Otsu and Uchida (1959b) that when albacore are close to spawning, they become unavailable to the hook and line fishery. There is also a distinct possibility that the ovaries develop very rapidly after passing the late developing stage (Ueyanagi, 1957) and that they are in the advanced stage for but a very brief interval before spawning takes place. This would then make sampling of the later stages a matter of slight chance and may well account for the small numbers of such stages found. Although the more advanced stages are missing from our collection, we believe that reasonable inferences as to spawning can be drawn from the occurrence of ovaries in the late developing stage.

In figures 5 and 6 and tables 3 and 4 are shown, by area and by time, the percentage of occurrence of late developing and advanced ovaries in the samples. Since the data revealed no clear longitudinal differences in the seasonal development of the ovaries (fig. 5), only the latitudinal differences are discussed here. The areas were arbitrarily divided latitudinally as follows: 0°–10° S., 10° S.–20° S., and 20° S.–30° S.

Some differences are apparent. In the area south of latitude 20° S. nearly all of the ovaries sampled were in the early developing stage, indicating that there is very little, if any, spawning in that area. On the other hand, in the area between 10° S. and 20° S., 287 out of 387 pairs of ovaries were found to be in the late developing stage, indicating that most of the albacore spawning south of the Equator takes place in these latitudes. Sampling was inadequate between the Equator and 10° S., but this area may probably be considered an extension of the middle area.

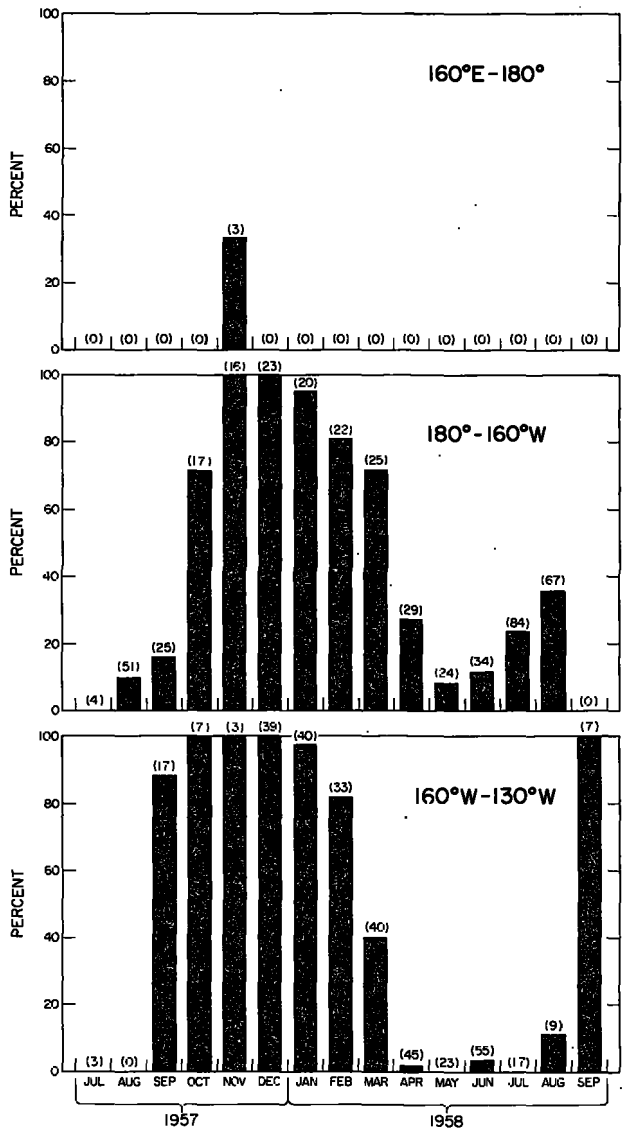

FIGURE 5.—Seasonal and longitudinal variation in ovary development, central South Pacific Ocean (0°–30° S.). (The percentage of late developing and advanced ovaries and the sample number are shown for each month.)

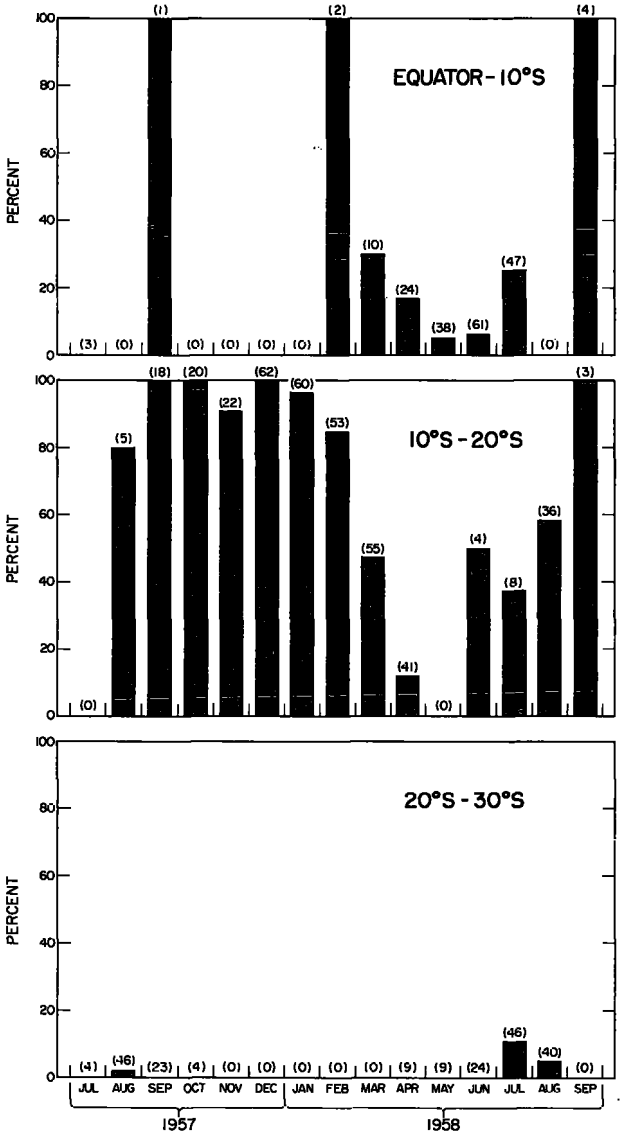

FIGURE 6.—Seasonal and latitudinal variation in ovary development, central South Pacific Ocean (130° W.–160° E.). (The percentage of late developing and advanced ovaries and the sample number are shown for each month.)

Unfortunately, the data are not as complete as desired. For example, no samples were obtained from the southernmost area during the period between November and March, which includes the apparent peak spawning season in the South Pacific. During these months the vessels seem to have confined their activities to the waters north of 20° S. latitude, either because inclement weather precluded their fishing farther south, or because fish were readily available in waters closer to their operating base. Catch records indicate that the latter has been the case, since landings continued high during this period.

TABLE 3.—*Seasonal and longitudinal variation in ovary development, central South Pacific Ocean (0°–30° S. latitude)*

Date	Longitude								
	160° E.–180°			180°–160° W.			160° W.–130° W.		
	Stage of development								
	Early	Late	Advanced	Early	Late	Advanced	Early	Late	Advanced
1957									
July	0	0	0	4	0	0	3	0	0
August	0	0	0	46	5	0	0	0	0
September	0	0	0	21	4	0	2	13	2
October	0	0	0	4	11	2	0	7	0
November	2	1	0	0	16	0	0	3	0
December	0	0	0	0	23	0	0	39	0
1958									
January	0	0	0	1	19	0	1	37	2
February	0	0	0	2	20	0	6	27	0
March	0	0	0	7	18	0	28	12	0
April	0	0	0	21	8	0	44	1	0
May	0	0	0	22	2	0	23	0	0
June	0	0	0	30	4	0	53	2	0
July	0	0	0	64	20	0	17	0	0
August	0	0	0	43	24	0	8	1	0
September	0	0	0	0	0	0	0	7	0
Total	2	1	0	265	174	2	185	149	4

TABLE 4.—*Seasonal and latitudinal variation in ovary development, central South Pacific Ocean (130° W.–160° E. longitude)*

Date	Latitude								
	0°–10° S.			10° S.–20° S.			20° S.–30° S.		
	Stage of development								
	Early	Late	Advanced	Early	Late	Advanced	Early	Late	Advanced
1957									
July	3	0	0	0	0	0	4	0	0
August	0	0	0	1	4	0	45	1	0
September	0	1	0	0	16	2	23	0	0
October	0	0	0	0	18	2	4	0	0
November	0	0	0	2	20	0	0	0	0
December	0	0	0	0	62	0	0	0	0
1958									
January	0	0	0	2	56	2	0	0	0
February	0	2	0	8	45	0	0	0	0
March	7	3	0	29	26	3	0	0	0
April	20	4	0	36	5	0	9	0	0
May	36	2	0	0	0	0	9	0	0
June	57	4	0	2	2	0	24	0	0
July	35	12	0	5	3	0	41	5	0
August	0	0	0	15	21	0	38	2	0
September	0	4	0	0	3	0	0	0	0
Total	158	32	0	100	281	6	197	8	0

The seasonal shift in fishing grounds, as indicated by the areas fished by Samoa-based vessels, may therefore reflect movements of the fish related to their spawning in the more northern waters during the southern summer months.

Minimum size of spawning fish

It was first reported by Ueyanagi (1955) and later supported by the findings of Otsu and Uchida (1959b) that female albacore attain sexual maturity and thus may first spawn at about 90 cm. in length. Because of the larger sample now available a further examination was made of this point.

Figure 7 shows the developmental stage of each ovary plotted by fish length and by ovary weight. The data show that some fish are already mature at 86 cm. This is not far different from previous results. The smallest fish found to be mature in the central equatorial Pacific measured 89.1 cm. (Otsu and Uchida, 1959b), and the smallest from the western Pacific (Ueyanagi, 1957) was 87 cm. long. Some albacore may therefore become sexually mature and spawn for the first time at a size of about 86 cm.

As for the males, Ueyanagi (1957) judged from their general appearance and oozing of milt that testes weighing more than 150 grams were probably ripe. By plotting testis weight against fish length, he showed that the smallest fish having testes weighing more than 150 grams measured 97 cm., and he postulated that length to be the minimum size of sexual maturity in males as

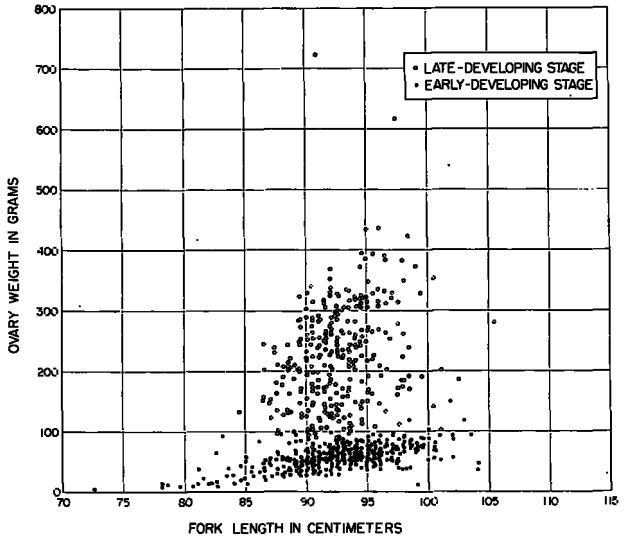

FIGURE 7.—Ovary weight plotted by fish size.

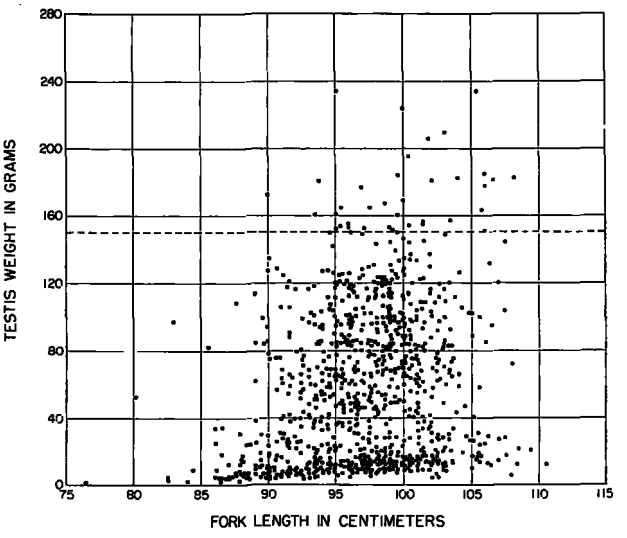

FIGURE 8.—Testis weight plotted by fish size. Dashed line is at 150 grams, the weight used by Ueyanagi (1957) as a criterion of ripeness.

contrasted with 87 cm. for females. Following Ueyanagi's lead, we have plotted testis weight against fish length (fig. 8). It can be surmised from this figure that some male albacore are probably sexually mature when they attain a length of about 90 cm., since testes weighing more than 150 grams already appear at this size. However, lacking more objective means of determining maturity of the males, it cannot be said with certainty that this is the size at which male albacore are first capable of spawning.

Size of the albacore

As shown in figure 3, the sampled fish ranged between 72 and 110 cm. (15 and 64 lbs.). It is interesting to compare the sizes of these fish with those taken in Hawaiian waters, which are believed to be part of the reproductive segment of the North Pacific population. Although very few albacore are landed in the Hawaiian fishery, they are generally very large (see fig. 9, which is based on fig. 7 in Otsu and Uchida, 1959b). Albacore landed in Hawaii in 1955 and 1956 ranged in size between 93 and 128 cm. (33 and 93 lbs.), but females appeared to reach their maximum size at 112 cm. In the South Pacific samples, the largest female measured 106 cm. (fig. 3).

Perhaps most significant is that while the female fish in the two areas were thus of comparable sizes, there was a virtual absence of males larger

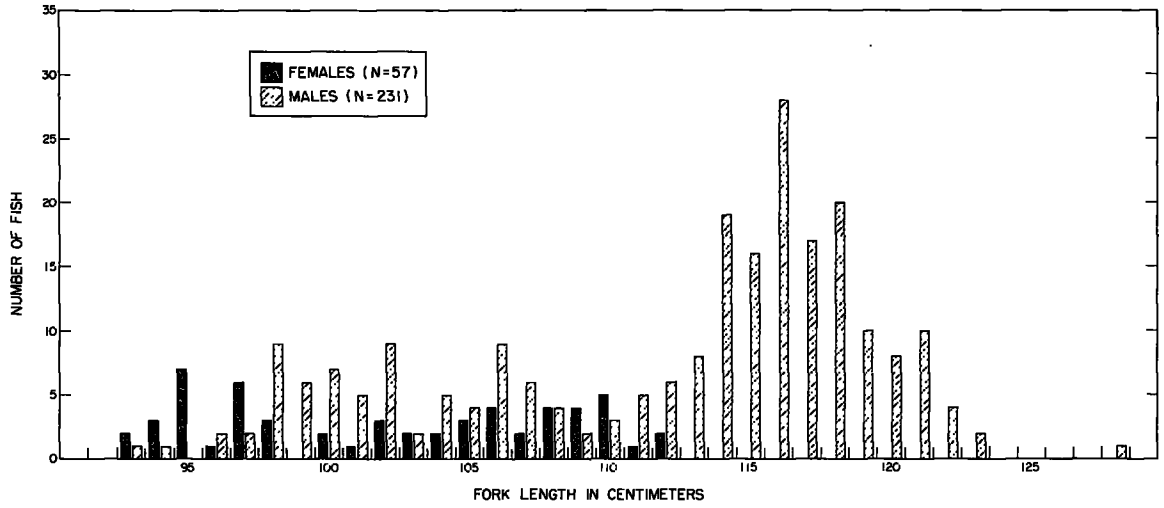

FIGURE 9.—Size of albacore taken in the Hawaiian longline fishery, 1955–56.

than 110 cm. in the South Pacific. A similar lack of large males was found in samples from the central equatorial Pacific (Otsu and Uchida, 1959b); the significance of this difference in size composition between Hawaiian waters and more southern areas is not known. Further study is needed concerning the distribution of these large males.

The most highly developed ovaries reported to date have come from waters around the Hawaiian Islands in the North Pacific (Otsu and Uchida, 1959b) and from the area of the Sunda Islands in the Indian Ocean (Ueyanagi, 1955). None as advanced in development has yet been collected from the central equatorial Pacific or the South Pacific Ocean. The fish taken in the Indian Ocean are also large, falling intermediate between the Hawaiian and the central South Pacific albacore. Despite the apparent absence of the group of largest males in the central South Pacific, it appears certain that the males available to the longline fishery there are generally all adults which are already capable of spawning.

DISCUSSION

Our data suggest that albacore in the central South Pacific Ocean spawn during the southern summer months. This finding is based on the percentage occurrence of ovaries in the late developing stage for each month in which samples were obtained. Since only six pairs of ovaries were found in which development of the ova was beyond the late developing stage, the occurrence of ovaries in the late developing stage was used as an index of spawning fish. The inherent weakness in our assumption, particularly in assessing exact spawning grounds and spawning seasons, is that the time of spawning cannot be determined precisely from the occurrence of fish in this stage of ovary development, in the absence of any knowledge of the rate of ova development. The gradual increase in the proportion of late developing ovaries in the monthly samples from the low point in May to a peak in December, with a gradual decrease thereafter, suggests that spawning must take place during the southern summer months. Depending upon the rate of ova development, albacore may be spawning during only a portion of that period, and that portion may be towards the end, when the percentage of developing ovaries is decreasing.

The weakness in the data is also evident in attempting to determine the spawning grounds. Our data suggest that the bulk of the spawning activity is confined to the north of 20° S. latitude. The data also indicate no east-west differences in spawning activity within the extent of our sampling (fig. 5). In the absence of ovaries of more advanced development, these results may be questionable. There may be sufficient time between the late developing and ripe stages to permit considerable migration. No purposeful spawning migration can be detected from the data at hand. Until more definite findings are made by the cap-

ture of fish near spawning condition or by the collection and identification of fertilized ova or larvae, we can only conjecture that albacore in the South Pacific spawn over an extended area north of 20° S. latitude. The data indicated no apparent differences in size between albacore found in the area north of 20° S. latitude and those found south of 20° S. latitude (fig. 10). Fish smaller than 86 cm., and presumably sexually immature, were sampled in both areas, although they were very few. It appears that adult fish are distributed over the entire range of our sampling, but that their seasonal movements are such that spawning occurs largely in the more northern area.

Perhaps most significant in our findings is that the albacore in the South Pacific Ocean spawn during the southern summer months, in contrast to the northern summer-spawning of the North Pacific albacore (Ueyanagi, 1957; Otsu and Uchida, 1959b). This difference in spawning seasons constitutes some evidence that the South Pacific and North Pacific albacore stocks are independent of each other. Tag recoveries have indicated that the three albacore fisheries in the temperate North Pacific Ocean, conducted by the Japanese off their coastal waters in spring, by Americans off the Pacific coast of the United States in summer, and by the Japanese in midocean during the winter months, are exploiting a single population (Otsu, 1960). There is some evidence that fish occurring within the North Equatorial Current are the reproductive segment of the same North Pacific population (Ueyanagi, 1957). What is not known at present is the relation of these fish to those occurring in the Southern Hemisphere, and presently being fished by Japanese and South Korean longliners in midocean and by Chilean fishermen in their coastal fishery. Pending more definitive results from further tagging, our data suggest that an independent population exists on each side of the Equator, and that

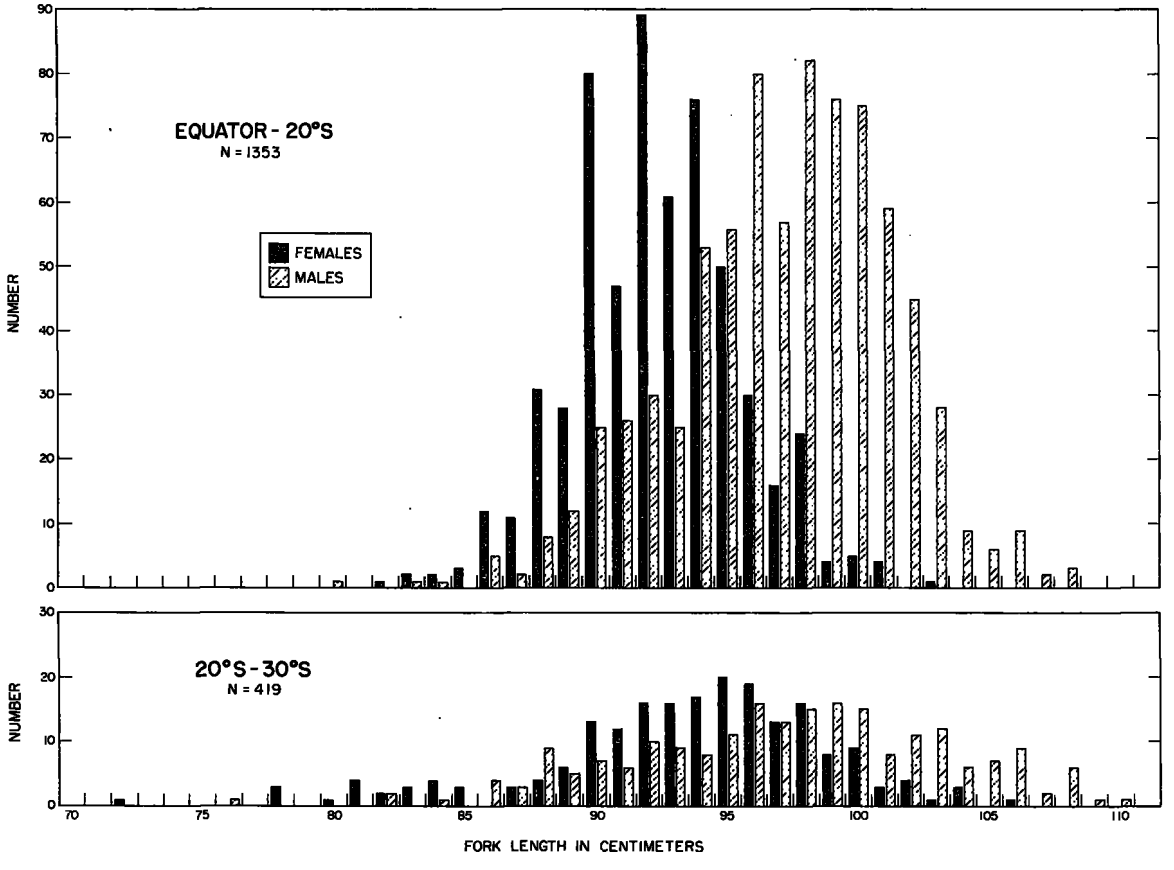

FIGURE 10.—A comparison of the sizes of albacore taken between the Equator and 20° S. and those between 20° S. and 30° S. latitude (by sex).

each is distributed in an approximate mirror image of the other. In the North Pacific, only the albacore in temperate waters are being exploited commercially. Albacore are taken incidentally to other species and in small numbers in subtropical and tropical waters, i.e., between 25° N. and the Equator.

Spawning is believed to occur in subtropical waters, roughly between 10° N. and 25° N. latitude in the western Pacific during the northern summer months. The situation is somewhat different in the South Pacific. The major exploitation in the South Pacific at present is of the subtropical resource of albacore in the area between 10° and 30° S. latitude. Furthermore, the only fishery equivalent to the North Pacific temperate water fisheries is the relatively small coastal fishery of Chile. However, data published by Japan's Nankai Regional Fisheries Research Laboratory (1959), reproduced here as figure 11, indicate the presence of smaller albacore south of the present central South Pacific fishing grounds (south of 30° S. lat.). These albacore appear to be the counterpart of the northern temperate-zone albacore. While there is no extensive fishery for albacore in these southern temperate waters today, there is a likelihood that a large resource is present (Suda, 1956).

While not exactly alike, the distributions follow a similar pattern on both sides of the Equator, with the smaller nonspawning fish occurring in the higher latitudes, and the larger spawning fish in the lower latitudes. Because of the general scarcity of albacore in equatorial waters, there appears little likelihood of any great interchange of fish between the two groups.

SUMMARY

This study is based on the examination of 1,772 pairs of albacore gonads collected at the tuna cannery in American Samoa between August 1957 and September 1958. The 782 female and 990 male gonads were collected randomly from 256 landings made by Japanese longline vessels.

Upon receipt of the frozen gonads from Samoa, they were thawed and preserved in 10-percent formalin. Each pair was weighed, and ovary sections were examined microscopically. The stage of development was determined on the basis of the general appearance and characteristics of the largest ova present. No detailed examination was made of the testes.

Only six ovaries were found to be in the advanced stage of development; these contained ova which were just beginning to take on the semitransparent appearance characteristic of this stage. The remainder of the ovaries were in all degrees of development preceding this stage.

From the monthly occurrence of the more mature stages (late developing and advanced), it was found that the peak of spawning activity in the central South Pacific is during the southern summer months at some time between September and March. This is in contrast to the albacore of the North Pacific, which appear to spawn during the northern summer months.

The examination of the data for areal variations in ovary development revealed no clear longitudinal differences. Latitudinally, nearly all of the more highly developed ovaries were obtained from fish captured north of 20° S., with the bulk between 10° S. and 20° S. latitude. The data indicated that there is little, if any, spawning in areas south of 20° S. latitude.

Plotting the developmental stage of each ovary against fish size revealed that female albacore become sexually mature and spawn for the first time at a size of about 86 cm. This is a slightly lower estimate of the minimum size of first spawning than previously reported (90 cm.).

The sampled fish ranged between 72 and 110 cm. (15 and 64 lbs.). In comparison, the Hawaiian albacore which are believed to be a part of the reproductive segment in the North Pacific are larger, ranging between 93 and 128 cm. (33 and 93 lbs.). A closer examination of the data shows that females are of comparable sizes in both areas, but that the very large males are missing from the South Pacific samples. It appears certain, however, that the males available to the longline fishery in the central South Pacific are nearly all adults which are already capable of spawning. The significance of this size difference in the males between the two areas is not clear.

Although the data are such that the precise spawning area or season could not be determined, the fact that the peak of spawning in the South Pacific occurs during the southern summer months, as contrasted with the northern summer spawn-

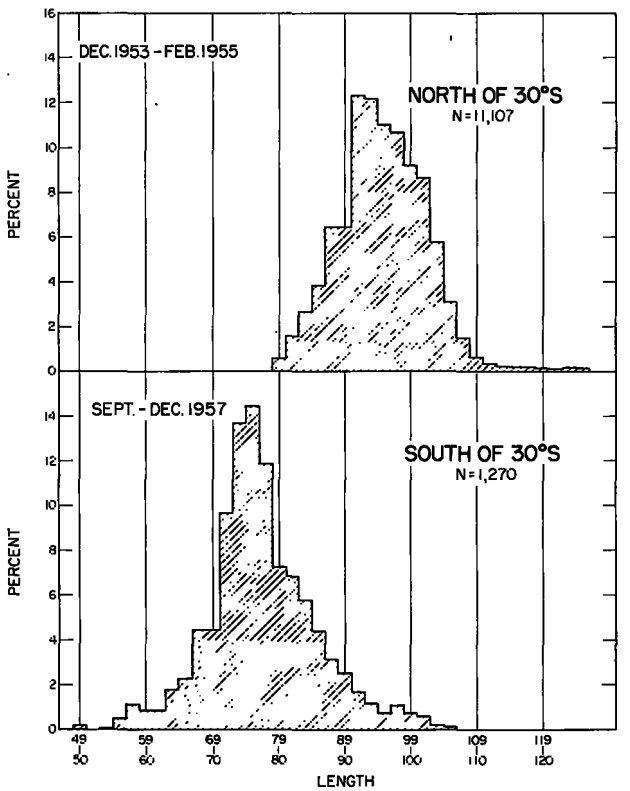

FIGURE 11.—Length frequencies of albacore in the South Pacific Ocean. (Japanese data reproduced from the report for 1959, figure 7, page 319, of the Nankai Regional Fisheries Research Laboratory.)

ing of the North Pacific albacore, constitutes evidence that the stocks in the South Pacific and the North Pacific are independent of each other.

The major exploitation in the South Pacific at present is of the subtropical resource of albacore in the area between 10° S. and 30° S. latitude. Japanese data indicate the presence of smaller albacore south of the present fishing grounds (south of 30° S.). These smaller fish may be part of a large resource not presently exploited, the counterpart of the North Pacific temperate water albacore.

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