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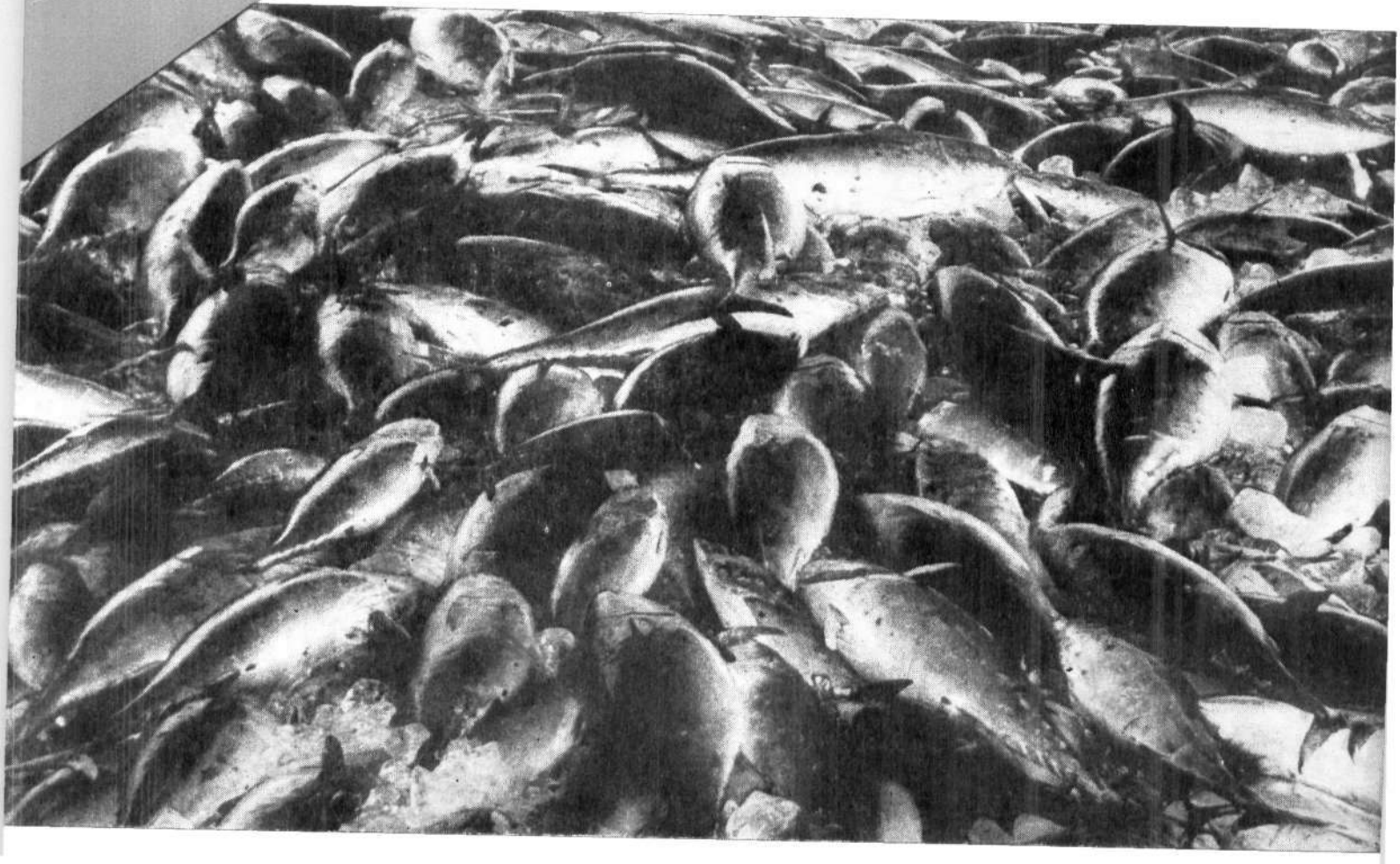

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BIOLOGY OF THE BAIT FISHES *SPRATELLOIDES DELICATULUS* (BENNET) AND *S. JAPONICUS* (HOUTTUYN) FROM MINICOY WATERS

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Spratelloides delicatulus is considered to be an excellent bait fish by Hawaiian fishermen (June 1951, Ikehara 1953, June and Reintjes 1953). This species, however, does not contribute to a good percentage of the bait fish catch in Hawaii but whenever *Stolephorus purpureus* is not available as bait sufficiently, sprats are captured and made use as bait (Welsh 1950). *S. delicatulus* is the widely used sprat in the Indo-Pacific. Its poor survival in captivity is the main handicap (Ikehara 1953, June and Reintjes 1953, Wilson 1971, Lee 1973). Occurrence of this species is very seasonal in the Pacific Ocean and is available more during summer months (Welsh 1950, June 1951 Wilson 1963). Hida (1971) noted that *S. delicatulus* was abundant in lagoons of large atolls in Micronesia.

Matsumoto (1937) observed that *S. delicatulus* is the most important bait fish at Saipan where it is found all the year but is scarce in November, December and January. At the peak of the season, one haul of bait captured is enough bait for a day's fishing. Cleaver and Shimada (1950) reported that *S. delicatulus* is a preferred bait species. This species was reported to be abundant in Western Samoa (Van pel 1960). *S. delicatulus* and *S. gracilis* are considered as possible bait fish resources in New Guinea by Kearney *et al.* (1972). Lewis *et al.* (1974) reported that both species are the most attractive bait fishes for skipjack tuna in Papua New Guinea waters.

Wilson (1971) observed that *S. gracilis* is a good live-bait fish but it is not as hardy as *S. delicatulus*. They are not extensively used at Palau. Lee (1973) reported that *S. delicatulus* is an important bait fish in the Fiji waters. The quantity of round herring comprised of *S. japonicus*, *S. delicatulus* and *S. atrofasciatus* from three major localities in the Ryukyu Islands for 1966 and 1967 was 54.7 and 45 metric tons respectively (Isa, 1972).

Jones (1960, 1964a) reported that *S. japonicus* is used in the Laccadive fishery and stated that it occurs in small schools but is not as abundant as *S. delicatulus*. Thomas (1964) observed that both these bait species are seasonally available and have been observed sometimes in large quantities and are scarce after December.

I. Spartelloides delicatulus

A review of the published literature on bait fishes reveals that there is no information on the biology of *Spratelloides* spp. from Indian waters. The biology the of blue sprat. *S. delicatulus* is presented here based on the material collected from Minicoy lagoon from December 1981 to December 1982. Samples for August, October, November and December were collected from the Minicoy lagoon along with mullets while during other months they were obtained from commercial bait fish catches. Samples were preserved in 5 per cent formalin after collection and were analysed for biological studies. Total length was measured in millimetres and condition of stomach, sex and maturity of individual fish was recorded. The procedures adopted for the analysis of material and data are given in the respective sections.

Distribution and abundance

S. delicatulus (Blue sprat) is found near the inner reef area at Ragandi point on the western side of Minicoy lagoon. They are available in scattered shoals and very rarely occur in large shoals. Blue sprat is

easily found only on the shoal sand near the bodies of moving and clear water in the shallow part of the lagoon.

During 1981-82 tuna fishing season (pole-and-line) *S. delicatulus* dominated the bait fish catches of Minicoy and contributed 64.16 per cent. This species was available during all the months of the season and accounted for the bulk of monthly bait catches. This species starts appearing in the lagoon from September onwards when very young juveniles are available which are very fragile at that stage. The fishery of the species entirely depend on its recruitment ot the shallow moving waters of the lagoon.

Length frequency distribution

These studies are based on 1191 specimens collected from December 1981 to December 1982. The total length of the individual fish ranged between 18 and 59 mm. The percentage frequency in the various size groups are plotted in the form of length frequency, curves in Fig. 1.

It can be seen from the figure that several modal groups occurred, but only some of them could be traced with reasonable assurance of accuracy. While the identity of some of the smaller modal groups is doubtful, in the description given below they are described as such and growth is calculated based on only those modes which could be traced for some months.

There are two modes at 27 mm (Mode A) and 31 mm during December 1981. Samples were not available during January 1982. In February three modes at 25 mm, 31 mm and a small mode at 43 mm appeared. While mode at 31 mm could be traced back as mode A of December 1981 with 4 mm growth, other two modes could not be traced back. Next month four modes appeared at 25 mm (Mode B), 31 mm, 35 mm and one small mode at 41 mm. Only one mode at 35 mm could be traced back as mode A of February with 4 mm growth. Samples were not available during May, June and July. During August only one mode appeared at 51 mm which could be traced back as mode A of March with 16 mm growth in five months. Samples were not available during September. During October four modes could be seen at 29 mm, 37 mm, 41 mm and 45 mm. While mode at 41 mm could be traced back as mode B of March which was evidently not represented in the immediate preceding six months. In December, three modes at 41 mm, 45 mm and 49 mm appeared but only one mode at 49 mm could be traced back as mode B of October with 8 mm growth.

Age and growth

As can be seen from fig. 1; both the modes A and B could be followed upto few months only. Mode A of December 1981 could be followed upto August

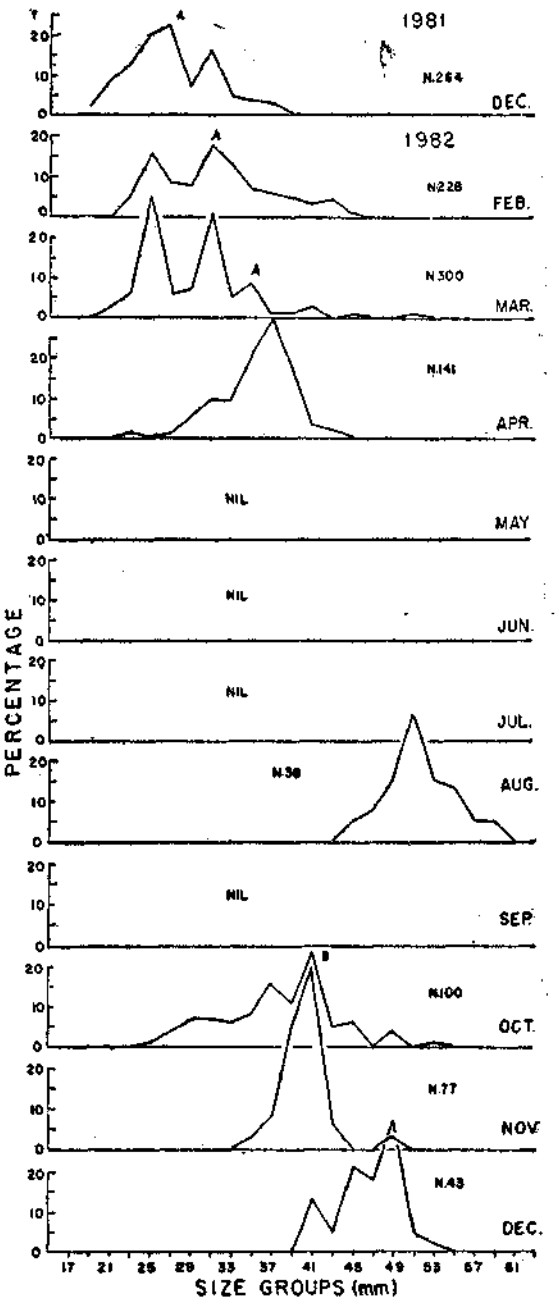

Fig. 1. Length frequency distribution of *S. delicatulus* at Minicoy, 1981-'82.

1982 when it grew from 27 mm to 51 mm *i.e.*, 24 mm in 8 months with monthly growth rate of 3 mm. Mode B of March at 25 mm could be followed upto December 1982 at 49 mm with growth of 24 mm in

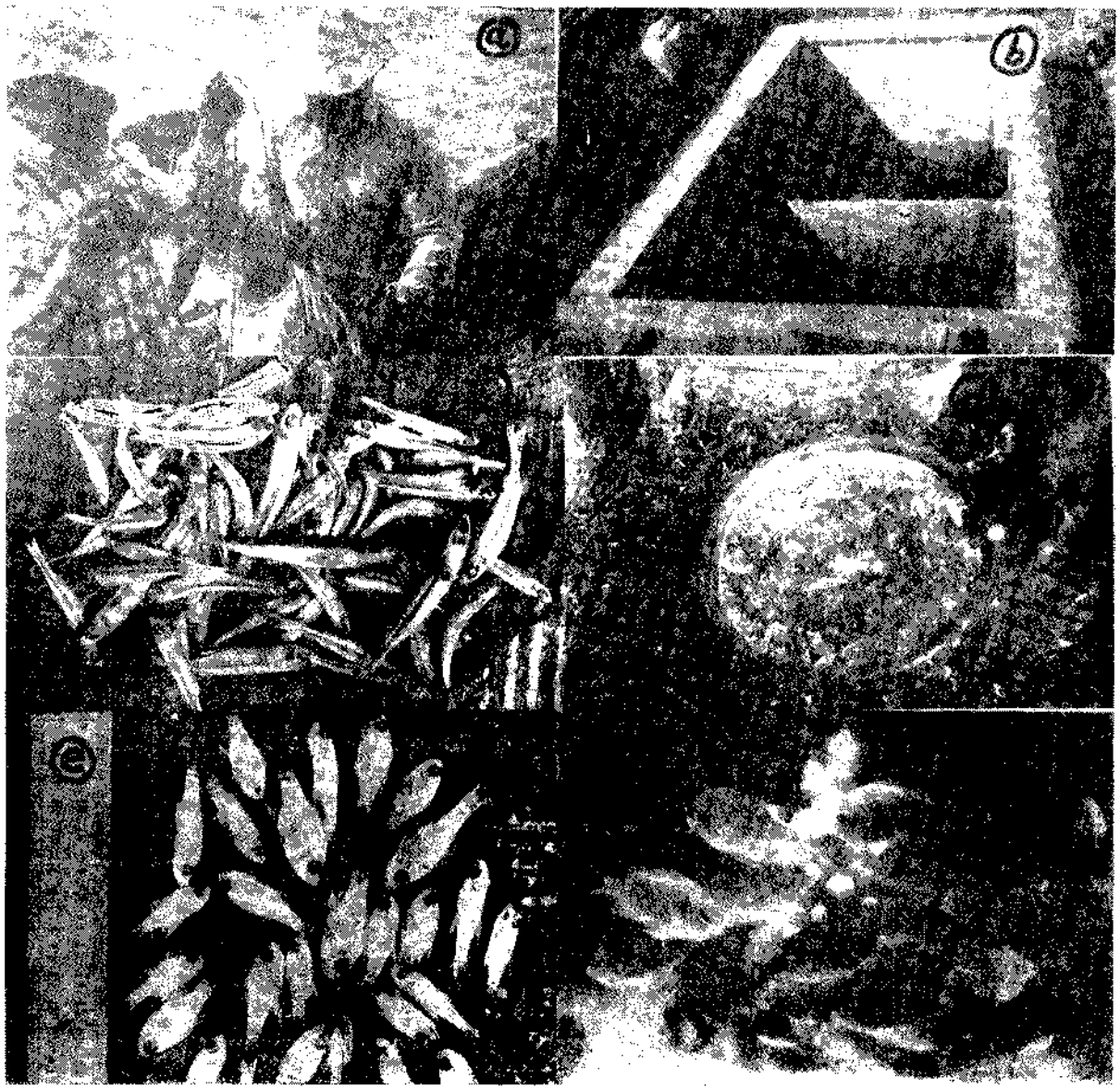

Plate I. (*a*) Live-bait fishes being transferred to tank. (*b*) Bait tank with bait fishes. (*c*) *Pranesus pinguis*. (*d*) *Spratelloides delicatulus*. (*e*) *Apogon* sp. (*f*) *Chromis caeruleus*. (*Photos* 15-18 by *Madan Mohan*)

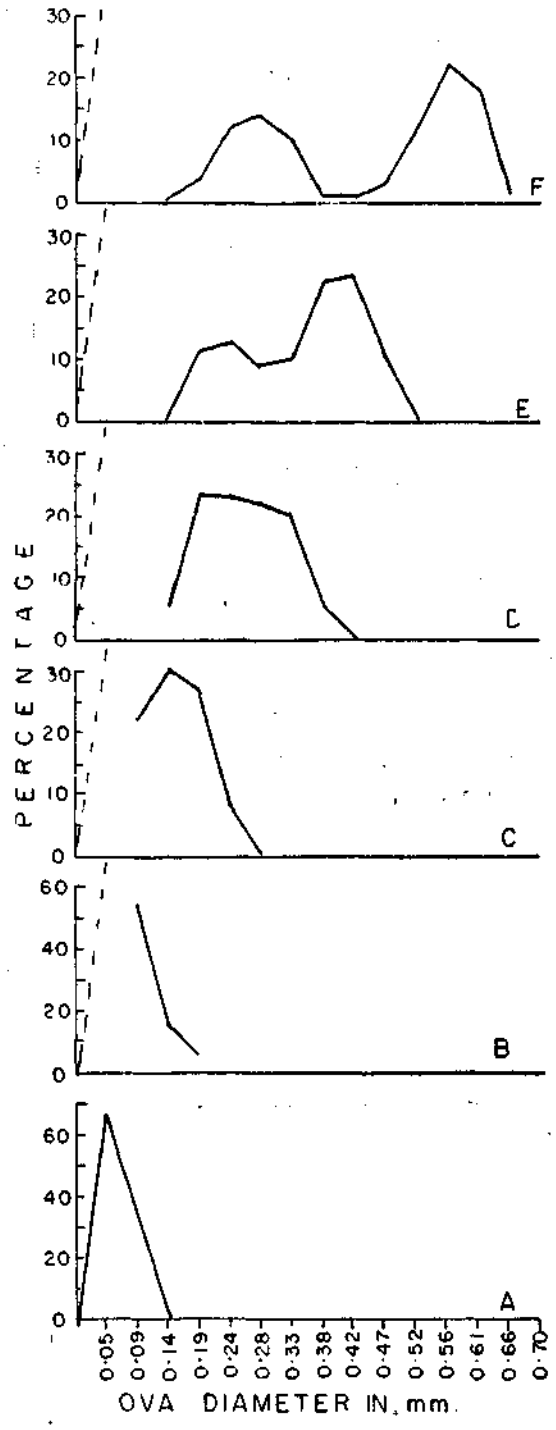

Fig. 2. Ova diameter frequency polygons of *S. delicatulus* at Minicoy, Dec. 1981-Dec. '82.

9 months with monthy growth rate of 2.66 mm. Therefore, both the modes have shown a monthly growth rate of about 3 mm.

Jones (1964) stated that *S. delicatulus* enters the Minicoy lagoon in very large shoals before the monsoon and remains there upto about November. As can be seen from the figure, all the fish collected during August were adults and their gonadial examination revealed that all were mature. Even during October, November and December majority of the fishes collected were mature. Every year the young ones of this species of about 15 mm start appearing from September onwards and during bait fish collections from about November only young fishes are caught and used as bait. During the present investigation samples during August, October, November and December were collected from near the shore and not from Ragandi point from where this species is usually caught.

Maturity and spawning

The maturity stages of individual fish were classified by microscopic examination of ova.

Since ovaries are small in size, ovary as a whole was teased and measurements of 200 ova from immature and maturing ovary and 300 ova from ovary of stage IV and above of maturity stage were taken. Ova were grouped into four ocular micrometer division groups. Ocular micrometer divisions were converted in millimetres and frequency polygons of ovaries, typically seven maturity stages were drawn (Fig. 2). As can be seen from the Figure only immature ova with diameter from 0.01 to 0.14 mm with mode at 0.05 mm are present in stage I of ovary. This group of ova is present in the ovaries of all stages and throughout the year.

In stage II one batch of ova is seen getting separated from the immature ova with mode at 0.09 mm.

In stage III the maturing group of ova progressed in diameter with mode at 0.19 mm. At this stage yolk deposition has started in the big size ova. Some of the ova in which yolk deposition has started are translucent while majority of ova are transparent.

In stage IV three types of ova *i.e.*, immature, maturing and mature can be clearly distinguished. Maturing ova of stage III has shown fast growth with mode of maximum diameter of ova at 0.33 mm.

In stage V mature ova of stage IV has shown further increase in diameter with the mode of ripe ova at 0.42 mm. Ripe ova have become clearly separated from the maturing stock. The mode at 0.42 mm is clearly the group of ova which will be spawned in near future.

In stage VI ripe group of ova ranged in diameter from 0.47 mm to 0.71 mm with mode at 0.56 mm. Ripe ova have shown faster growth than maturing ova. They are yellow in colour and in few of them oil globule is visible. Some of the ova became transparent and are easily separated from the follicles with some loose ova in the lumina of the ovary.

Spent ovary was not available for analysis during these studies.

Spawning season

357 specimens of *S. delicatulus* from December 1981 to December 1982 were examined to study the percentage occurrence of gonads in different stages of maturity. The details are given in Table 1.

In December 1981 stages II to IV were present and stage II dominated over other stages. In February 1982 stages I to stage IV were available stage III being the predominant one followed by stage II. In March stage II to VI were present and stage III dominated followed by stage IV. In April stages I to VI were available and again stage III dominated followed by stage IV. Samples were not available for study during September. In October stages III to VI were available and stage V dominated followed by stage VI. In November stages IV to VI were present and VI dominated followed by stage V. In December stage III to VI were available, stage IV being predominant followed by stage V.

Further fish were divided in three major groups based on maturity stages *i.e.*, immature (Stage I and II), maturing (Stage III) and mature (Stage IV and above). The results are given in Table 2. It can be seen from the Table that maturing fishes dominated over others during December 1981, February and March. But from April onwards mature fishes dominated with very high percentage. From the above it is clear that mature *S. delicatulus* starts appearing in good numbers from April onwards. During August the percentage of mature fish was very high and thence onwards they were available in good quantities. Jones (1964) stated that *S. delicatulus* enters the Minicoy lagoon in very large shoals before the monsoon and

TABLE 1. *Percentage occurrence of gonads of* S. delicatulus *in different stages of maturity* (from December 1981 to December 1982)

Month	No of fish	Sex	Stages of maturity						
			I	II	III	IV	V	VI	VII
1981									
January	22	M	..	54.55	27.27	13.64	4.54	..	..
December	10	F	..	90.00	10.00	..	..	..	..
1982									
January	..	M	..	..	..	..	..	..	..
	..	F	..	..	..	..	..	..	..
February	29	M	6.89	31.03	34.48	27.58	..	..	..
	17	F	5.88	29.41	64.70	..	..	..	..
March	22	M	..	18.18	50.00	22.72	9.09	..	..
	8	F	..	12.50	37.50	37.50	..	12.50	..
April	39	M	2.56	10.26	15.38	43.59	17.95	10.26	..
	22	F	..	9.09	72.73	9.09	..	9.09	..
May	..	M	..	..	..	..	..	..	..
	..	F	..	..	..	..	..	..	..
June	..	M	..	..	..	..	..	..	..
	..	F	..	..	..	..	..	..	..
July	..	M	..	..	..	..	..	..	..
	..	F	..	..	..	..	..	..	..
August	19	M	..	..	10.53	47.37	36.84	5.26	..
	19	F	..	..	..	..	57.89	42.10	..
September	..	M	..	..		..	..	..	..
	..	F	..	..	..	..	..	..	..
October	36	M	..	..	8.33	19.44	30.55	41.67	..
	21	F	..	..	28.57	19.04	47.62	4.76	..
November	10	M	..	..	..	40.00	10.00	50.00	..
	40	F	..	..	..	32.50	50.00	17.50	..
December	22	M	..	..	18.18	36.36	36.36	9.09	..
	21	F	..	..	14.28	52.38	33.33	..	..

M = Male, F = Female

TABLE 2. *Percentage occurrence of* S. delicatulus *in immature, maturing and mature stages from December* 1981 *to December* 1982

Month	Immature	Maturing	Mature
1981			
December		87.50	12.50
1982			
January	..	..	..
February ..	6.52	76.09	17.39
March ..	..	63.33	36.67
April ..	1.64	45.90	52.46
May ..	..	..	..
June ..	..	..	..
July ..	..	..	..
August ..	..	5.26	94.74
September ..	..	..	..
October ..	..	15.79	84.21
November ..	..	..	100.00
December ..	..	16.28	83.72

remains there upto about November. The occurrence of mature specimens from August onwards in near shore area of the lagoon indicates that spawning in this species takes place during the south-west monsoon period and extends upto December. This may be the reason that from October to April only young blue sprat occurs in bait fish catches.

Frequency of spawning

The frequency distribution of ova diameter measurements from the ripe and spawning ovary (Stage V and VI) of *S. delicatulus* reveals that at this stage of maturity the ovary contains three groups of ova *i.e.*, immature, maturing and mature (Fig. 2). From the figure it can be seen that in the ovary of stage VI ripe ova almost get separated from the maturing ova. From stage III onwards mature ova has shown faster growth than maturing ones. Therefore, when ripe ova are spawned out their place is soon taken by maturing ova which have already completed more than half the maturation process. When ripe ova are spawned, maturing ova will grow faster and will be ready to spawn soon. The occurrence of juvenile fishes for a longer period also suggests that *S. delicatulus* may spawn more than once in a spawning season.

Sex ratio

For the period under study the ratio of males to females was found to be 1 : 0.79. The percentage occurrence of sexes in different months are given in Table 3. From the table it can be seen that males dominated over females throughout the period except in November when females dominated. During August, the percentage of both the sexes was equal.

TABLE 3. *Percentage of males and females of* S. delicatulus *from December* 1981 *to December* 1982

Month	Total No. of fish	Males (%)	Females (%)
1981			
December ..	32	68.75	31.25
1982			
January	..	..	..
February ..	46	63.04	36.96
March ..	30	73.33	26.67
April ..	61	63.93	36.07
May ..	..	..	..
June ..	..	..	..
July ..	..	..	..
August ..	38	50.00	50.00
September ..	..	..	..
October ..	57	63.16	36.84
November ..	50	20.00	80.00
December ..	43	51.16	48.84

Fecundity

For fecundity studies ovary as a whole was teased and total number of mature ova were counted. A total of 15 ripe ovaries was examined and as can be seen from the Table 4 that number of mature eggs increased with the length of the fish. However, it may also be seen from the table that the fecundity of fish of the same length showed considerable variations.

TABLE 4. *Fecundity estimates of* S. delicatulus, *during* 1982

Serial No.	Length of fish mm	Total No. of mature ova	Stage of maturity
1 ..	40	286	VI
2 ..	40	317	VI
3 ..	43	407	VI
4 ..	49	638	V
5 ..	49	653	VI
6 ..	50	467	VI
7 ..	50	566	VI
8 ..	50	689	VI
9 ..	51	547	V
10 ..	53	453	V
11 ..	53	624	VI
12 ..	54	760	V
13 ..	56	943	VI
14 ..	58	769	VI
15 ..	58	1005	V

Food and feeding

Preserved stomachs of a total of 367 specimens of *S. delicatulus* were examined for food and feeding habits. The degree of distension of stomachs was recorded depending on their fullness in the following categories (1) Empty, (2) 1/4 full, (3) 1/2 full, (4) 3/4 full, (5) Full and (6) Gorged. Specimens with gorged, full and 3/4 full stomachs were considered to have actively fed, whereas those with half full as moderately fed and with 1/4 full stomachs as poorly fed.

The empty stomachs (189 Nos.) occurred in a high percentage (51.50%) of the 367 stomachs examined. Their percentage was high during April, October, November and December. Actively fed fishes were available in high percentage during December 1981, February, March and August. Moderately fed fishes occurred in good percentage during all months of the observations except in April and September.

The food of the species mainly consisted of crustaceans represented by post larvae of decapods, harpacticoid and calanoid copepods, mysids and gammarids. Fish eggs and algal filaments were also observed rarely.

Behaviour

Blue sprat like other members of the family Dussumieriidae is a schooling species. The size of the school is usually small. They are found in scattered shoals and are observed in the same type of habitat *i.e.*, sandy bottom area of inner reef flat throughout the season of availability.

The analysis of data reveals that during tuna fishing season only young specimens of *S. delicatulus* are caught and used as bait. Samples during August onwards were collected from the shore area of the lagoon along with mullets and *Atherina* spp. Majority of the fishes collected from the shore area were in 'mature stage' while they were not available in bait fish catches at all. Mature specimens collected from shore area would have migrated from the reef area along with strong currents. The absence of spent specimens of this species and mature fishes from bait catches clearly suggests that spawning of this species takes place elsewhere, most probably outside the reef area and not in the lagoon.

Jones (1960) during the third cruise of R. V. *KALAVA* in the Laccadive sea observed that millions of *S. delicatulus* assembled under ship's light when the ship was anchored just outside the reef off Bitra Island (Lat. 11° 38'N, Long. 72° 13'E) and in few numbers next day outside the reef of Agathi Island (Lat. 10° 51' N, Long. 72° 28'E). Wilson (1977) reported that Palauan fishermen occasionally encountered blue sprats some distancea way from the Island. Although *Herklotsichthys punctatus* was used as bait while catching tuna 11 km off Kayangel, the food contents of skipjack caught from the same shoal consisted of large amount of *S. delicatulus*.

II. Spratelloides japonicus

Spratelloides japonicus was originally described as *Atherina japonicus* by Houttuyn in 1782. But Weber and be Beaufort (1951) named this species as *Spratelloides gracillis*. Munro (1955) named it as *Spratelloides japonicus* and this was followed by Jones (1960). Baldwin (1977) in his revirew of the use of live-bait fishes in the Tropical Pacific has mentioned both *Spratelloides gracilis* and *Spratelloides japonicus* seperately while Jones (1960, 1964) has synonimized *S. gracilis* with *S. japonicus*. In the present context *S. gracilis* has been considered a synonym of *S. japonicus*.

Baldwin (1977) presented the distribution of this species in the different world oceans. Jones (1960) has given its distribution as Red Sea, Laccadives and coasts of India and Ceylon to Indonesia, Philippines, Japan, Fiji and Tahiti.

Wilson (1971) noted that *S. japonicus* is a good live bait fish but not as hardy as *S. delicatulus* and not extensively used at Palau, while Lee (1953) noted that it is important in the Fiji fishery, but its survival is very poor.

Isa (1972) reported *S. japonicus* as an important bait fish in the Ryukyu Islands fishery. Kikawa (1977) stated that in Nuguria Islands *S. japonicus* and *S. delicatulus* were represented in the bait fish catches made with the stick held lift nets. *S. japonicus* was more abundant than *S. delicatulus*. Most of them were juveniles, ranging in length from 25 to 40 mm. Wilson (1977) reported that *Spratelloides* spp. are very common in Ponape and they were most frequently taken by the Okinawan fishermen. Smith (1977) stated that in Papua New Guinea, sprats rank second to anchovies in terms of overall abundance and contribution to the bait fish fishery. *Spratelloides gracilis* (= *S. japonicus*) and *S. delicatulus* with their brilliant colouration and rapid swimming action, are very attractive and proved to be excellent bait.

Jones (1960, 1964) noted that *S. japonicus* is used in the Laccadive fishery and that it occurs in small schools but is not as abundant as *S. delicatulus*. Both species are seasonally available and have been observed on

occasion in large quantities, but after December they are scarce (Thomas 1964).

There is no hitherto published information on the biology of *S. japonicus* from Indian waters. A review of the published literature on bait fish biology also reveals that no available information is present in this regard from elsewhere. Therefore, a preliminary Account of the biology of the silver sprat, *S. japonicus* is presented here based on analysis of the collections from Minicoy waters.

Samples for the present investigation were collected from Minicoy bait fish catches during 1981-82 tuna pole-and-line fishing season. Though the species was available as stray catches during all the months of the season, it contributed 20.5 per cent of the total bait catches in February 1982 and 10.5 per cent in January. Samples were preserved in 5 per cent formalin and were analysed later for biological studies.

Length-weight Relationship

54 males ranging from 42 to 62 mm and 34 females ranging from 45 to 60 mm in total length were considered for these studies. $W = aL^b$ could be fitted to the data, where W is the weight of fish, L is the total length of the fish, *a* and *b* are two constants. Logarithmic transformation of the formula gives a straight line relationship to the form

$$\text{Log } W = \text{Log } a + b \text{ Log } L$$

Log *a* and the regression coefficient (*b*) were estimated for the males and females separately by using least square method and the following relationship were obtained.

$$\text{Males Log } W = -1.5743 + 2.0782 \text{ Log } L$$

$$\text{Females Log } W = -1.6707 + 2.0938 \text{ Log } L$$

The coefficient of correlation ('*r*') for the males was 0.878 and for females 0.938.

In the analysis of covariance to test the significance of differences in the regressions of y and x was attempted and it was found that there is no significant difference in the regression coefficient between males and females. Therefore, the data for both males and females were pooled together and a common length weight relationship was fitted as below.

$$\text{Log } W = -1.4380 + 2.0400 \text{ Log } L$$

Regression lines for males and females separately are given in Figs. 3 & 4.

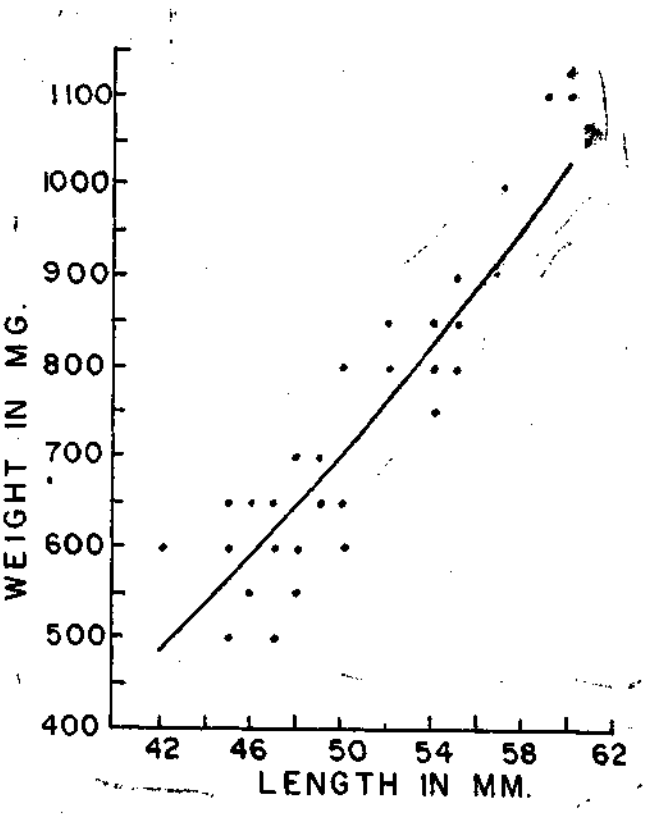

Fig. 3. Length-weight relationship of males of *S. japonicus* at Minicoy.

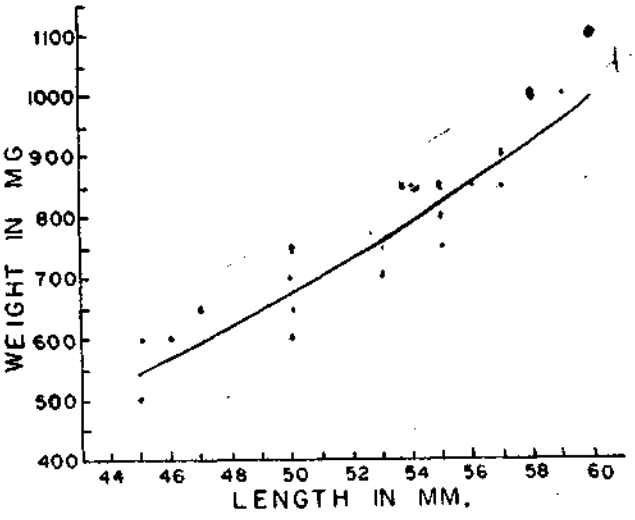

Fig. 4. Length-weight relationship of females of *S. japonicus* at Minicoy.

Distribution and abundance

S. japonicus (Silver sprat) are found in the deeper parts of the Minicoy lagoon north of Ragandi point area. They are found associated with corymbose corals. During high tide period fishes gather on the

top of the coral heads and it is easy to catch them at that time since they will form small schools. During high tide, fish moves in deeper waters little away from the corals.

During 1981-82 pole-and-line tuna fishing season, 263 kg of *S. japonicus* which made 9.40 per cent of the total bait fish catches, were caught at Minicoy and used as bait. It was available in good percentage during January (10.50%) and February (20.50%). This species is caught from December onwards when they start appearing in the western part of Minicoy lagoon. Its availability is very erratic and rarely they are caught in bulk.

Length frequency distribution

During the course of these investigations, the total length of the individual fish ranged between 35 and 60 mm. The percentage frequency in the various size groups are plotted in the form of length frequency curves in Fig. 5.

As can be seen from the figure that there are two modes at 42 mm (A) and 46 mm (B) during December 1981. Samples were not available during January 1982. In February two modes at 50 mm and 56 mm appeared. Mode at 50 mm can be traced back as mode B of December at 46 mm with 4 mm growth. In March, two modes at 50 mm and 54 mm appeared. Mode at 50 mm can be traced back as mode A of December at 42 mm with 8 mm growth.

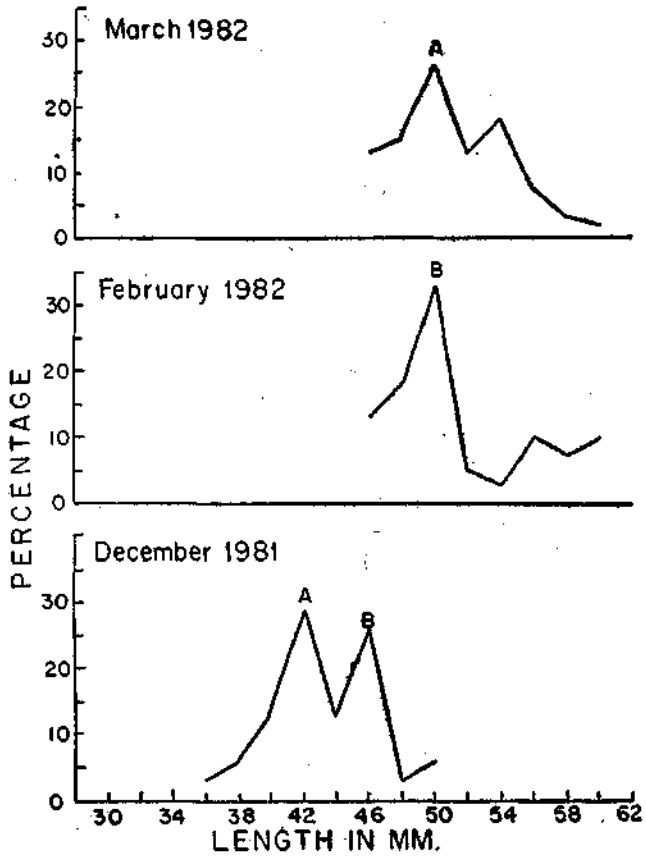

Fig. 5. Monthly length frequency distribution of *S. japonicus* at Minicoy, Dec. 1981-March '82.

Age and growth

Length frequency data of *S. japonicus* are available only for four months due to its seasonal availability. It is interesting to note here that like *S. delicatulus*, its total length ranged from 35 to 60 mm. This species also has shown growth from 42 to 50 mm at the rate of about 3 mm per month.

Maturity and spawning

The maturity stages of individual fish were classified by microscopic examination of the ova of different maturity stages and the procedure is as that followed for *S. delicatulus*.

It can be observed from Fig. 6 that in stage I of the ovary only immature ova which ranged from 0.01 to 0.09 mm with mode at 0.05 mm are present. These immature ova are present in the ovaries of all stages and are shown in figure in broken lines.

In stage II, ova range from 0.01 to 0.19 mm with mode at 0.09 mm.

In stage III, it can be seen that one group of ova is getting seperated from immature stock of ova which ranged from 0.04 to 0.33 mm with mode of maturing ova from 0.19 mm to 0.23 mm. In the bigger size of ova, yolk deposition has started and they look translucent but majority of ova are transparent.

In stage IV maturing ova have shown some progress. Mature ova have their mode from 0.23 to 0.28 mm. Majority of the ova are translucent and can be clearly distinguished from the maturing stock.

In stage V, mature ova have shown faster growth and at this stage of ovary three groups of ova namely immature, maturing and ripe can be clearly distinguished from each other. From the figure it can be seen that ripe ova range from 0.28 to 0.52 mm with clear mode at 0.38 mm while maturing ova have mode from 0.19 to 0.23 mm. Ripe ova with mode at 0.38 mm are the group of ova which will spawn in the near future leaving behind maturing stock.

Spawning season

Sexwise monthly distribution of maturity stages of *S. japonicus* is shown in the Table 5. During December

TABLE 5. *Percentage occurrence of gonads of* S. japonicus *in different stages of maturity during* 1981-82 *season*

Month	No. of fish	Sex	Stages of maturity						
			I	II	III	IV	V	VI	VII
1981									
December	17	M	..	41.18	52.94	5.88	..	..	..
	14	F	7.14	85.72	7.14	..	..	..	..
1982									
February	23	M	..	..	56.52	21.74	13.04	8.70	..
	16	F	..	6.25	37.50	12.50	37.50	16.25	..
March	31	M	..	..	41.93	48.39	3.23	6.45	..
	21	F	..	9.52	47.62	14.29	19.05	9.52	..

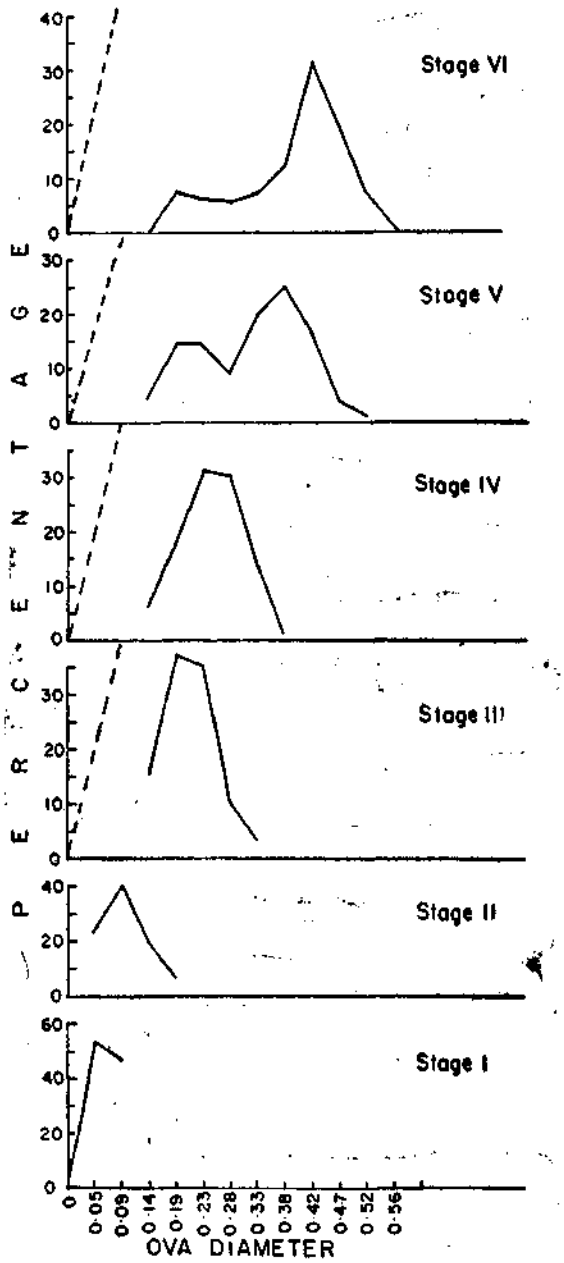

Fig. 6. Ova diameter frequency polygons of *S. japonicus* at Minicoy.

1981 fish from stages I to IV were available. But in February and March 1982 fish from stages II to VI in maturity were available. Even during February and March maturing fishes dominated over mature fishes.

Since this species is usually available for few months every year at Minicoy, it is rather difficult to state anything about its spawning season. But presence of mature fishes from February shows that this species may certainly be spawning from March onwards. Nature of the ovary suggests that fish may spawn more than once in a spawning season. Therefore, because of the occurrence of juveniles of this species from December onwards, it can be stated that *S. japonicus* has an extended spawning season at Minicoy.

Frequency of spawning

As can be seen from Fig. 6 that ovary in the ripe maturity stage contains three types of ova namely immature, maturing and ripe. Immature ova are available in plenty due to continuous proliferation of ova in the ovary. Maturing and mature ova have separate distinct modes. From stage IV onwards mature ova have shown faster rate of growth than the maturing ones and in ripe ovary they are almost ready for spawning. While this batch of ripe ova is spawned out, their place will be soon occupied by maturing ova which have already completed more than half of maturation process. These ova will show faster rate of growth and soon will be ready for spawning. Therefore, it can be stated that like *S. delicatulus* this species also spawns more than once in a spawning season.

Sex ratio

Percentage of males in comparison to females was found to be higher during all the months of observations (Table 6). Even for the season as a whole, males dominated over females. Ratio of males to females was calculated as 1 : 0.72.

TABLE 6. *Sex ratio of* S. japonicus *at Minicoy during* 1981-82 *season*

Month	Total No. of fish	(Males %)	Females (%)
1981			
December ..	31	54.84	45.16
1982			
February ..	39	58.97	41.03
March ..	52	59.62	40.38
Total ..	122	58.20	41.80
Sex ratio ..		1	0.72

Fecundity

Since the ovary of *S. japonicus* is very small in size, ovary as a whole was teased on a slide and mature ova were counted with the aid of a binocular microscope. Fifteen ripe and spawning ovaries were selected for these studies and counts were made. Total length of fish, weight of fish, total number of mature ova and stage of maturity are given in Table 7. It can be seen from the table that the number of mature ova increased with increase in fish length. Even then, fish of the same length showed variations in total number of mature ova.

TABLE 7. *Fecundity estimates of* Spratelloides japonicus

Serial No.	Total length of fish in mm	Weight of fish in mg	Total No. of mature ova	Stage of maturity
1 ..	45	500	381	V
2 ..	45	600	425	V
3 ..	50	750	512	V
4 ..	50	700	538	V
5 ..	50	750	563	V
6 ..	53	750	742	V
7 ..	55	750	637	V
8 ..	55	750	674	VI
9 ..	57	700	934	V
10 ..	57	900	986	V
11 ..	57	900	1,009	V
12 ..	57	850	1,123	V
13 ..	58	1,000	1,011	VI
14 ..	59	1,100	1,133	VI
15 ..	60	1,100	1,181	V

Food and Feeding

A total of 132 specimens of *S. japonicus* were examined for food and feeding studies. The degree of distension of stomachs was recorded depending on the fullness in the following categories (1) Empty, (2) 1/4 Full, (3) 1/2 full, (4) 3/4 Full, (5) Full and (6) Gorged.

The empty stomachs occurred in high percentage (79.51%) of the total stomachs examined (Table 8). Their percentage was high during all the months of observations. Half full contributed 17.21% and full stomachs 3.28 per cent.

S. japonicus mainly subsists on crustaceans. These were represented mostly by harpacticoid and calanoid copepods and post larvae of decapod crustaceans. Gammarids and fish eggs were recorded in very few numbers.

Behaviour

Like other members of the family Dussumiieridae, *S. japonicus* is also a schooling species. It can be seen in small schools swimming over the coral heads in deeper waters.

Usually young ones of the species are used as bait at Minicoy. Whenever they are available in good numbers, they are preferred as bait. During 1981-82 tuna pole-and-line fishing season, 25,134.5 kg of tunas were caught by using 263 kg of *S. japonicus* as bait. When its efficiency in attracting tuna was compared with other bait fishes of the season, it proved to be most efficient with catch per unit bait of 95.57 kg.

This species possesses all desirable qualities which are essential for a bait fish such as small size, silvery on body sides, slender, hardy during transportation and efficient in chumming tunas during tuna fishing operations.

TABLE 8. *Percentage occurrence of stomachs of* Spratelloides japonicus *in various degrees of fullness during* 1981-'82 *season at Minicoy*

Month		Empty	¼th full	½ full	¾th full	Gorged	Sample number
1981 December	..	77.42	..	22.58	..	..	31
1982 February	..	71.79	..	20.51	..	7.70	39
1982 March	..	86.54	..	11.54	..	1.92	52
Total numbers	..	97	..	21	..	4	122
Percentage	..	79.51	..	17.21	..	3.28	

REFERENCES

AIKAWA, H. 1937. Notes on the shoal of bonito (Skipjack *Katsuwonus pelamis*) along the Pacific coast of Japan. (In Jpn., Engl. summ.) *Bull. Jpn. Soc. Sci. Fish.* 61: 13-21. (Engl, transl. by W. G. Van Campen, 1952. In *U. S. Fish Wildl. Serv., Spec. Sci. Rep. Fish.* 83 ; 32-50).

AIKAWA, H., AND M. KATO. 1938. Age determination of fish (Preliminary Report I). (In Jpn., Engl. synop.) *Bull. Jpn. Soc. Sci. Fish.* 7 ; 79-88. (Engl. transl. by W. G. Van Campen, 1950. *In U. S. Fish Wildl. Serv., Spec. Sci. Rep. Fish.* 21, 22 p.

ALAGARAJA, K. 1984. Simple methods for estimation of parameters for assessing exploited fish stocks. *Indian J. Fish.* 31(2) : 177-208.

ALVERSON, F. G. 1963. The food of yellowfin and skipjack tunas in the eastern tropical Pacific Ocean. (In Engl. and Span.) *Inter-Am. Trop. Tuna Comm. Bull.* 7 ; 293-296.

ANON. 1978. General description of marine fisheries—Karnataka, India. Working paper under FAO/UNDP small scale fisheries promotion in South Asia, RAS/77/044—WP No. 22: 1-40.

APPUKUTTAN, K. K., P. N. RADHAKRISHNAN NAIR, AND K. K. KUNHIKOYA. 1977. Studies on the fishery and growth rate of oceanic skipjack, *Katsuwonus pelamis* (Linnaeus), at Minicoy Island from 1966 to 1969. *Indian J. Fish.* 24 (1&2) : 31-47.

BALDWIN, W. J. 1977. A review on the use of live baitfishes to capture Sipjack tuna, *Katsuwonus pelamis*, in the tropical Pacific Ocean with emphasis on their behaviour, survival and availability. *In* R. S. Shomura (Editor), *Collection of tuna baitfish papers*, p. 8-35. U. S. Dep. Commer., NOAA Tech. Rep. NMFS Circ. 408.

BATTS, B. S. 1972a. Age and growth of the skipjack tuna, *Katsuwouns pelamis* (Linnaeus), in North Carolina waters. *Chesapeake science*, 13(4) : 237-244.

BATTS, B. S. 1972b. Sexual maturity, fecundity and sex ratios of the skipjack tuna, *Katsuwonus pelamis* (Linnaeus), in North Carolina waters. *Trans. Am. Fish. Soc.* 101 : 626-637.

BAYLIFF, W. H. 1973. Observations on the growth of yellowfin tuna in the eastern Pacific Ocean derived from tagging experiments. *Inter-Am. Trop. Tuna Comm. Internal Rep.* 7 ; 26p.

BENNET, P. SAM. 1967. Kachal, a tackle for filefish (Family Balistidae : Pisces) *J. Bombay Nat. Hist. Soc.*, 64(2) : 377-380.

BERTALANFFY, L. VON. 1938. A quantitative theory of organic growth (Inquiries on growth laws, I). *Human Biology*, 10(2) : 181-213.

BEVERTON, R. J. H., AND S. J. HOLT. 1957. On the dynamics of exploited fish populations. *Min. Agric. Fish. and Food (U.K. Fish. Investing. Ser.* II, 19 : 1-533.

BLACKBURN, M., AND D. L. SERVENTY. 1971. Observations on distribution and life history of skipjack tuna, *Katsuwonus pelamis*, in Australian waters. *Fish. Bull., U. S.* 79 ; 85-94.

BLUNT, C. E. Jr., AND J. D. MESSERSMITH. 1960. Tuna tagging, in the eastern tropical Pacific, 1952-1959. *Calif. Fish Game* 46 (3) : 310-369.

Bobp. 1983. Marine small scale fisheries of India : A general description. BOBP/INF/3 (GCP/RAS/040/SWE), 69p.

———1985. Tuna fishery in the EEZs of Sri Lanka. UNDP/FAO, Bay of Bengal Programme, BOBP/WP/31, 90 p.

BOY, R. L. AND B. R. SMITH. 1984. Design improvements to Fish Aggregating Devices (FAD) mooring systems in general use in Pacific island countries *SPC Handbook* No. 24, 77p.

BROCK, V. E. 1954. Some aspects of the biology of the aku, *Katsuwonus pelamis*, in the Hawaiian Islands. *Pac. Sci.* 8 ; 94-104.

BRYAN, P. G. 1978. On the efficiency of mollies (*Poecilia mexicana*) as live bait for pole and line Skipjack fishery : Fishing trials in the tropical central Pacific. *Technical report on project No. 4-35-D, American Samoa Baitfish programme, Pago Pago, American Samoa.*

BUNAG, D. M. 1956. Spawning habits of some Philippine tuna based on diameter measurements of the ovarian ova. *Philipp. J. Fish.*, 1958, 4 : 145-177.

CHATWIN, B. M. 1959. The relationships between length and weight of yellowfin tuna (*Neothunnus macropterus*) and skipjack tuna (*Katsuwonus pelamis*) from the eastern tropical Pacific Ocean. (In Engl. and Span.) *Inter-Am. Trop. Tuna. Comm. Bull.* 3 ; 307-352.

CHRISTY, F. T. JR. L. C. CHRISTY, W. P. ALLEN AND R. NAIR. 1981. Maldives—Management of Fisheries in the Exclusive Economic Zone. Rep. FI : GCP/INT/334/NOR, GCP/RAS/087/NOR. *FAO/Norway Co-operative Programme*, 99 p. FAO, Rome.

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

CLEAVER, F. C., AND B. M. SHIMADA. 1950. Japanese Skipjack (*Katsuwonus pelamis*) fishing methods. *Commer. Fish. Rev.* 12 (11) : 1-27.

COLE, J. S. 1980. Synopsis of biological data on the yellowfin tuna, *Thunnus albacares* (Bonnaterre, 1788), in the Pacific Ocean. *Inter-Am. Trop. Tuna Comm., Spec. Rep.* (2) : 71-150.

COLLETTE, B. B., AND L. N. CHAO. 1975. Systematics and morphology of the bonitos (*Sarda*) and their relatives (Scombridae, Sardini). *Fish. Bull., U. S.* 73 ; 516-625.

CMFRI. 1980. Trends in total marine fish production in India, 1979. *Mar. Fish. Infor. Serv. T & E Ser.*, 22 ; 1-19.

———1981. All India census of marine fishermen, crafts and gear, 1980. *Mar. Fish. Infor. Serv. T & E Ser.*, 30 : 33p.

———1981. Trends in total marine fish production in India, 1980. *Mar. Fish. Infor. Serv. T & E Ser.*, 32 : 1-6.

———1982. Trends in total marine fish production in India, 1981. *Mar. Fish. Infor. Serv. T & E Ser.*, 42 : 1-33.

———1983. Trends in marine fish production in India, 1982-83. *Mar. Fish. Infor. Serv. T & E Ser.*, 52 : 21p.

———1983. A code list of common marine living resources of Indian seas. CMFRI Special Publ., 12 : 150p.

DAVIDOFF, E. B. 1963. Size and year class composition of catch, age and growth of yellowfin tuna in the eastern tropical Pacific Ocean, 1951-1961, *Inter-Am. Trop. Tuna Comm. Bull.* 8(4) 201-251.

DE JONG, J. K. 1939. A preliminary investigation on the spawning habits of some fishes of Java Sea. *Treubia*, 17 ; 307-330.

DHULKHED, M. H., C. MUTHIAH, G. SYDA RAO, AND N. S. RADHAKRISHNAN. 1982. The purse seine fishery of Mangalore (Karnataka). *Mar. Fish. Infor. Serv. T & E Ser.*, 37 : 1-7.

DIAZ, E. L. 1963. An increment technique for estimating growth parameters of tropical tunas as applied to yellowfin tuna (*Thunnus albacares*). *Inter. Am. Trop. Tuna Comm. Bull.* 8(7) : 383-416.

DIVAKARAN, O., M. ARUNACHALAM, N. B. NAIR AND K. G. PADMANABAN. 1980. Studies on the zooplankton of the Vizhinjam inshore waters, south-west coast of India. *Mahasagar*, Bull. Nat. Inst. Oceanogr., 13(4) : 335-341.

ELLIS, R. H. 1924. A short account of the Laccadive Island and Minicoy. *Govt. Press, Madras*, 30p.

FISHER, R. A. 1970. Statistical methods for research workers 14th Ed.

GEORGE, P. C., B. T. ANTONY RAJA, AND K. C. GEORGE. 1977, Fishery resources of the Indian Economic Zone. *Silver Jubilee Souvenir, IFP*, Oct. 1977, 79-116.

GEORGE, M. S. 1981. Role of small scale fisheries in Karnataka and its impact on rural economy. *CMFRI Bull.*, 30-B : 22-29.

GODSIL, H. C. 1954. A descriptive study of certain tuna-like fishes. *Calif. Dep. Fish Game, Fish Bull.* 97, 185p.

GOODING, R. M., AND J. J. MAGNUSON. 1967. Ecological Significance of a drifting object to pelagic fishes. *Pac. Sci.* 21(4) : 486-497.

GNANAMUTHU, J. C. 1966. On the occurrence of the oriental bonito, *Sarda orientalis* (Temminck and Schlegel) along the Madras coast. *J. Mar. Biol. Assoc. India.* 8 : 365.

HAMADA, H., M. MORITA, Y. ISHIDA, AND Y. TAKEZAGA. 1973. Investigation of long-corseletted frigate mackerels (*Auxis rochei*). (*In Jpn.*) *Rep. Kochi Pref. Fish. Exp. Stn.* 69 ; 1-12. (Unedited Engl. transl. infiles of Southwest Fish. Cent., Natl. Mar. Fish. Serv.., NOAA, Honolulu, HI 96812.)

HENNEMUTH, R. C. 1959. Additional information on the length-weight relationship of skipjack tuna from the eastern tropical Pacific Ocean. (In Engl. and Span.) *Inter-Am. Trop. Tuna Comm. Bull.* 4 : 25-37.

HENNEMUTH, R. C. 1961. Size and year class composition of catch, age and growth of yellowfin tuna in the eastern tropical Pacific Ocean for the years 1954-1958. *Inter-Am. Trop. Tuna Comm. Bull.* 5(1) : 112.

HICKLING, C. F., AND R. AUTENBERG. 1936. The ovary as an indicator of spawning period in fishes. *J. Mar. Biol. Assoc.* U. K. 21 : 311-317.

HIDA, T. S. 1971. Baitfish scouting in the Trust Territory. *Commer. Fish. Rev.* 33 (11-12) : 31-33.

HIDA, T. S., AND J. A. WETHERALL. 1977. Estimates of the amount of nehu, *Stolephorus purpureus*, per bucket of bait in the Hawaiian fishery for skipjack tuna, *katsuwonus pelamis*. *In* R. S. Shomura (editor), *Collection of tuna baitfish papers*, p. 55-56. U. S. Dep. Commer., NOAA Tech. Rep. NMFC Circ. 408.

HONMA, M., AND Z. SUZUKI. 1978. Japanese tuna purse seine fishery in the Western Pacific. (In Jph., Engl. summ.) *Far Seas Fish. Res. Lab. S Ser.*, 10, 66p.

HORNELL, J. 1910. Report on the results of a fishery cruise along the Malabar Coast and the Laccadive Islands in 1908. *Madras Fish. Bull.*, 4 : 71 126.

HOTTA, H., AND T. OGAWA. 1955. On the stomach contents of the skipjack, *Katsuwonus pelamis*. (In Jpn., Engl. summ.) *Bull. Tohoku Reg. Fish. Res. Lab.* 4 ; 62-82.

HUNTER, J. R., AND C. T. MITCHELL. 1967. Association of fishes with flotsam in the offshore waters of Central America. *U. S. Fish Wildl. Serv., Fish. Bull.* 66(1) : 13-29.

IKEHARA, I. I. 1953. Live-bait fishery for tuna in the central Pacific. *U. S. Fish Wildl. Serv. Spec. Sci.* Rep *Fish.* 107, 20p.

INOUE, M., R. AMANO, AND Y. IWASAKI. 1963. Studies on environments alluring skipjack and other tunas—1. On the oceanographical condition of Japan adjacent waters and the drifting substances accompanied by Skipjack and other tunas. (In Jpn., Engl. summ.) *Rep. Fish. Res. Lab., Tokai Univ.* 1(1) 12-23.

INOUE, M., R. AMANO, Y. IWASAKI, AND M. YAMAUTI. 1968a. Studies on the environments alluring skipjack and other tunas—II. On the driftwoods accompanied by skipjack and tunas. *Bull. Jpn. Soc. Sci. Fish.* 34 ; 283-287.

ISA, J. 1972. The skipjack fishery in the Ryukyu Islands. *In* K. Sugawara (editor), The Kuroshio II. *Proceedings of the second symposium on the results of the cooperative study of the Kuroshio and adjacent regions*, Tokyo, Japan, September 28—October 1, 1970, pp. 385-410. Saikon Publ. Co., Ltd., Tokyo.

JONES, R. 1981. The use of length composition data in fish stock assessment (with notes on VPA and cohort analysis). *FAO Fish. Circ.* 734 FIRM/C 743.

JONES, S. 1958. The tuna live-bait fishery of Minicoy Island. *Indian J. Fish.* 5(2) : 300-307.

JONES, S. 1959. Notes on eggs, larvae and juveniles of fishes from Indian waters. III, *Katsuwonus pelamis* (Linnaeus) and IV. *Neothunnus macropterus* (Temminck and Schlegel). *Indian J. Fish.* 6(2) : 360-373.

JONES, S. 1960a. Notes on eggs, larvae and juveniles of fishes from Indian waters. V. *Euthynnus affinis* (Cantor). *Indian J. Fish.* 7(1) : 101 106.

JONES, S. 1960b. Further notes on *Spratelloides delicatulus* (Bennett) as a tuna live-bait with a record of *S. japonicus* (Houtuyn) from the Laccadive Sea. *J. Mar. Biol. Assoc. India.* 2(2) : 267-268.

JONES, S. 1964. A preliminary survey of the common tuna baitfishes of Minicoy and their distribution in the Laccadive Archipelago. *Proc. Symp. Scombroid Fishes, Mar. Biol. Assoc. India, Symb. Ser.* I, Pt. 2 : 643-680.

JONES, S., M. KUMARAN. 1959. The fishing industry of Minicoy Island with special reference to the tuna fishery. *Indian J. Fish.* 6 (1) : 30-57.

JONES, S., M. KMUARAN. 1963. Distribution of larval tuna collected by the Carlsberg Foundation's *Dana* Expedition (1928-30) from the Indian Ocean. (In Engl., Fr. resume.) *FAO Fish. Rep.* 6 (3) : 1753-1774.

JONES, S., AND E. G. SILAS. 1960. Indian tunas—a preliminary review with a key for their identification. *Indian J. Fish.* 7(2) : 369-393.

JONES, S., AND E. G. SILAS. 1963a. Synopsis of biological data on skipjack, *Katsuwonus pelamis* (Linnaeus) 1758 (Indian Ocean) *FAO Fish. Rep.* 6(2) : 663-694.

JOSEPH, K. M. 1984. Salient observations on the results of fishery resource survey during 1983-'84. FSI/BULL/13/84, p. 1-11.

JOSEPH, J. 1963. Fecundity of yellowfin tuna (*Thunnus albacares*) and skipjack (*Katsuwonus pelamis*) from the Pacific Ocean. (In Engl., and Span.) *Inter-Am. Trop. Tuna Comm. Bull.* 7 ; 257-292.

JOSEPH, J., AND T. P. CALKINS. 1969. Population dynamics of the skipjack tuna (*Katsuwonus pelamis*) of the eastern Pacific Ocean. (In Engl., and Span.) *Inter-Am. Trop. Tuna Comm. Bull.* 13 : 1-273.

JOSSE, E., J. C. LE GUEN, R. KEARNEY, A. LEWIS, A. SMITH, L. MAREC, AND P. K. TOMLINSON. 1979. Growth of skipjack. *South Pac. Comm. Occas. Pap.* 11, 83 p.

JUNE, F. C. 1951. Preliminary fisheries survey of the Hawaiian-Line Islands area. Part II. Notes on the tuna and bait resources of the Hawaiian, Leeward and Line Islands. *Commer. Fish. Rev.* 13(1) : 1-22.

JUNE, F. C. 1953. Spawning of yellowfin tuna in Hawaiian waters. *U. S. Fish Wildl. Serv., Fish. Bull.* 54 : 47-64.

JUNE, F. C., AND J. W. REINTJES. 1953. Common tuna-baitfishes of the central Pacific. *U. S. Fish Wildl. Serv., Res. Rep.* 34, 54p.

KAWAGUCHI, K. 1967. Report to the Government of India on the exploratory tuna longline fishing off the south-west coast of India. *UNDP Rep. No. TA* 2274, *FAO*, 31 p,

KAWASAKI, T. 1955a. On the migration and the growh of the skipjack, *Katsuwonus pelamis* (Linnaeus), in the south-western sea area of Japan. (In Jpn., Engl. summ.) *Bull. Tohoku Reg. Fish. Res. Lab.* 4 : 83-100.

KAWAKAI, T. 1955b. On the migration and the growth of the skipjack, *Katsuwonus pelamis* (Linnaeus), in the Izu and Bonins Sea areas and the north-eastern sea area along the Pacific coast of Japan. (In Jpn., Engl. summ.) *Bull. Tohoku Reg. Fish. Res. Lab.* 4 : 101-119.

KAWAKAI, T. 1963. The growth of skipjack on the north-eastern Sea of Japan. (In Jpn., Eng . summ.) *Bull. Tohoku Res. Fish. Res. Lab.* 23 : 44-60.

KAWAKAI, T. 1964. Population structure and dynamics of skipjack in the North Pacific and its adjacent waters. (In Jpn., Engl. summ.) *Bull. Tohoku Reg. Fish. Res. Lab.* 24 ; 28-47.

KAWASAI, T. 1965. Ecology and dynamics of the skipjack population. II. Resources and fishing conditions. (In Jpn.) *Jpn. Fish. Resour. Prot. Assoc.*, Stud. Ser. 8 ; 49-108. (Engl. transl. 1967, 79 : U. S. Joint Publ. Res. Serv.).

KEARNEY, R. E. 1975. Some hypotheses on skipjack (*Katsuwonus pelamis*) in the Pacific Ocean. *South Pac. Comm.*, Occas. Pap. 7, 23p.

KEARNEY, R. E. 1980. Skipjack survey and assessment programme annual report for the year ending 31st December 1979. *South Pacific Comm.*, 18p.

KEARNEY, R. E., A. D. LEWIS AND B. R. SMITH. 1972. Cruise report *TAGULA* 71-1. Survey of Skipjack tuna and bait resources in Papua New Guinea waters. *Dep. Agric., Stock Fish., Res Bull.* 8, 145 p. Port Moresby.

KIKAWA, S. 1977 Japanese skipjack tuna, *Katsuwonus pelamis*, baitfish surveys in the western and southwestern Pacific Ocean. *in* R. S. Shomura (Editor), *Collection of Tuna Baitfish Papers.* p. 81-88. *U. S. Dep. Commer.* NOAA Tech. Rep. NMFS CIRC. 408.

KIKAWA, S., AND I. WARASHINA. 1972. The catch of the young yellowfin tuna by the skipjack pole-and-line fishery in the southern area of the Western Pacific Ocean. *Far Seas Fish. Res. Lab. Bull.*, 6 : 39-49.

KIKAWA, S., AND STAFF OF THE NANKAI REGIONAL FISHERIES RESEARCH LABORATORY. 1963. Synopsis of biological data on bonito *Sarda orientalis* Temminck and Schlegel 1842. *FAO Fish Rep.* 6, 2 : 147-156.

KIMURA, K. 1954. Analysis of skipjack (*Katsuwonus pelamis*) shoals in the water of " Tohoku Kaiku " by its association with other animals and objects based on the records by fishing boats. (In Jph., Eng . summ.) *Bull. Tohoku Reg. Fish. Res. Lab.* 3, 87 p.

KIMURA, K. 1932. Growth curves of bluefin tuna and yellowfin tuna based on the catches near Sigedera, on the West Coast of Province Izu. *Jap. Soc. Sci. Fish., Bull.*, 1(1) : 1-4.

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

KISHNOUYE, K. 1895. The food of the tunas and skipjack. *Doubtsugaku zasshi*, 7 : 111.

KLAWE, W. L. 1961. Notes on larvae, juveniles, and spawning of bonito (*Sarda*) from the eastern Pacific Ocean. *Pac. Sci.* 15 : 487-493.

KUMARAN, M. 1964. Studies on the food of *Euthynnus affinis* (Cantor), *Auxis thazard* (Lacepede), *Auxis thynnoides* Bleeker and *Sarda orientalis* (Temminck and *Schlegel*). *Proc. Symp. Scombroid Fishes, Part* 2. *Mar. Biol. Assoc. India, Symp. Ser.* 599-606.

LEE, R. 1973. Live-bait research. Skipjack tuna fishing project in Fiji. *South Pac. Isl. Fish Newsl.* 9 : 26-30.

LECREN, E. D. 1951. The length-weight relationship and seasonal cycle in gonad weight and condition in the perch (*Perca fluviatilis*). *J. Anim. Ecol.*, 20 : 201-219.

LEWIS, A. D., B. R. SMITH, AND R. E. KEARNEY. 1974. Studies on tunas and bsitfish in Papua New Guinea waters II. *Dep. Agric. Stock Fish., Res. Bull.* **11**, 112 p.

LUTHER, G., P. N. RADHAKRSHNAN NAIR, G. GOPAKUMAR, AND K. PRABHAKARAN NAIR. 1982. The present status of small-scale traditional fishery at Vizhinjam. *Mar. Fish. Infor. Serv. T & E Ser.*, **38** : 17p.

MC NEELY, R. L. 1961. Purse seine revolution in tuna fishing, *Pac. Fisherman* **59**(7) : 27-58.

MANGUSON, J. J., AND J. G. HEITZ. 1971. Gill raker apparatus and food selectivity among mackerels, tunas, and dolphins. *Fish. Bull., U. S.* **69** ; 361-370.

MARCILE, J. AND B. STEQERT. 1976. Etude preliminaire de la croissance du lisato (*Katsuwonus pelamis*), *dens louert de l'ocean* Indian Tropical. *Cah. O.R.S.T.O.M. Ser. Oceanogr.*, **14**(2) : 139-151.

MATHEW, M. J. AND T. B. RAMACHANDRAN. 1956. Notes on the survey of fishing industry of the Laccadive and Aminidivi islands. *Fisheries Station Reports and Year Book*, Madras, 1954-55 : 125-137.

MATSUMOTO, T. 1937. An investigation of the skipjack fishery in the waters of Woleai, with notes on the bait situation at Lamotrek and Puluwat Is. (In Jap.) *S. Sea Fish. News* (Nanyo Suisan Joho) 3 : 2-6. (Engl. transl. *In* W. G. Van Campen (translator), 1951, Exploratory tuna fishing in the Caroline Islands. *U. S. Fish Wildl. Serv., Spec. Sci. Rep. Fish.* 46 : 35-42.

MATSUMOTO, W. M., R. A. SKILLMAN. 1984. Synopsis of biological data on skipjack tuna, *Katsuwonus pelamis* (Linnaeus). *U. S. Nat. Mar. Fish. Serv. NOAA Tech. Rep. NMFS SSRF*, 451, p 92.

MATSUMOTO, W. M. 1959. Descriptions of *Euthynnus* and *Auxis* larvae from the Pacific and Atlantic Oceans and adjacent seas. *Dana-Rep., Carlsberg Found.* 50, 34 p.

MATSUMOTO, W. M., T. K. KAZAMA AND D. C. AASHAD 1981. Anchored Fish Aggregating devices in Hawaiian waters. *Mar. Fish. Rev.*, **43** (9) : 1—13.

MOORE, H. L. 1951. Estimation of age and growth of yellowfin tuna (*Neothunnus macropterus*) in Hawaiian waters by size frequencies. U. S. Fish & Wildl. Serv., Fish. Bull., 52 : 133-149.

MORROW, J. E. 1954. Data on dolphins, yellowfin tuna and little tuna from East Africa. *Copeia*, 14-16 p.

MUNRO, I. S. R. 1955. *The Marine and Fresh Water Fishes of Ceylon.* Department of External Affairs, Canberra.

MUTHIAH, C. 1982. Drift gillnet fishery of Dakshina Kannada coast. *Mar. Fish. Infor. T. & E Ser.* No. 37 : 8-15.

MURDY, E. O. 1980. The commercial harvesting of tuna attracting Payayos : A possible boon for small scale fishermen. *ICLARM News letter*, 3(1) : 10-13.

NAKAMURA, H. 1936. The food habits of yellowfin tuna *Neothunnus macropterus* (Schlegel), from the Celebes Sea. *U. S. Fish and Wildlife Service, Spec. Sci. Rept. Fisheries*, **23** ; 1-8.

NAKAMURA, E. L., AND J. H. UCHIYAMA. 1966. Length-weight relations of Pacific tunas. *In* T. A. Manar (Editor), *Proceedings of the Governor's Conference on Central Pacific Fishery Resourecs*, pp. 197-201. State of Hawaii, Honolulu.

NAKAMURA, E. L., AND W. M. MATSUMOTO. 1967. Distribution of larval tunas in Marquesan waters. *U. S. Fish Wildl. Serv. Fish. Bull.* **66** : 1-12.

NAYAR, G. 1958. A preliminary account of the fisheries of Vizhinjam. *Indian J. Fish.*, **5** (1) : 32-55.

NOSE, Y., S. TOMOMATSU., K. MIMMARA, AND Y. HIYAMA. 1955. A method to determine the time of ring formation in hard tissues of fishes, especially for the age determination of Pacific tunas. *Rec. of Oceanog. Works, Japan*, n.s., **2**(3) : 9-18.

OMMANNE , F. D. 1953. The pelagic fishes. Note on tow nettings : Distribution of macroplankton, fish eggs and young fish. *In* Report on the Mauritius-Seychelles fisheries survey 1948-49. Part II. *G. B. Colon. Off. Fish. Publ.* **1**(3) : 58-104,

ORANGE, C. J. 1961. Spawning of yellowfin tuna and skipjack in the Eastern Tropical Pacific, as inferred from studies of gonad development. *Inter-Am. Trop. Tuna Comm., Bull* **5**(6) : 459-526.

OTSU, T., AND R. N. UCHIDA. 1959. Sexual maturity and spawning of albacore in the Pacific Ocean. *Fish. Bull.* U. *S.* **59**(148) : 287-305.

PAULY, D., AND N. DAVID. 1981. ELEFAN I. A basic program for the objective extraction of growth parameters from length-frequency data. *Meeres orschun.* **28**(4) : 205-211.

PINKAS, L., M. S. OLIPHANT, AND I. L. KEVARSON. 1971. Food habits of albacore, bluefin tuna and bonito in Colifornia waters.

PINKAS, L., M. S. OLIPHANT, AND I. L. KEVERSON. 1971. Food habits of albacore, bluefin tuna and bonito in California waters. *Calif. Dep. Fish Game, Fish Bull.* 152, 105 p.

PILLAI, P. P. 1981. Report on the analysis and evaluation of the fishery and biological data collected by the scientists from the CMFR Institute, Cochin, on board 'M. V. Prashikshani during Feb.-June, 1981. *News Letter, CIFNET*, I (2) : 6p.

PRESTON, G. 1982. The Fijian experience in the utilisation of fish aggregating devices. *Working Paper* 25, *Fourteen Regional Teehnical Meeting on Fisheries*, 64 p.

PRABHU, M. S. 1956. Maturation of intra-ovarian eggs and spawning periodicities in some fishes, *Indian J. Fish.* 3(1) : 59-90.

PRINDLE, B. 1981. Factors correlated with incidence of fish-bite on deepsea mooring lines. *WHOI*-81--57, Woods Hole, Massachusetts.

PRINDLE, B. AND R. G. WALDEN. 1976. Deep-sea line fishbite manual. *NOAA, National Data Bouy Office, Bay St. Louis, Mississipi.*

PUTHRAN, V. A. AND V. N. PILLAI. 1972. Pole and line fishing for tuna in the Minicoy waters. *Seafood Exp. Jour.*, 4 : 11-18.

RAJU, G. 1964a. Observations on the food and feeding habit of the oceanic skipjack, *Katsuwonus pelamis* (Linnaeus) of the Laccadive Sea during the year 1958-59. *Proc. Symp. Scombroid Fishes*, Part 2. *Mar. Biol. Assoc. India, Symp. Ser.* 1 : 607-625.

RAJU G. 1964b. Studies on the spawning of the oceanic skipjack, *Katsuwonus pelamis* (Linnaeus)in Minicoy waters. *Proc. Symp. Scombroid Fishes*, Part 2. *Mar Biol. Assoc. India. Symp. Ser.* 1 : 744/768.

RANADAE. M. R. 1961. Notes on the tuna and frigate mackerel from Ratnagiri. *J. Bombay Nat. Hist. Soc.*, 58 (2) : 351-354.

RAO, K. V. NARAYANA. 1964. An account of the ripe ovaries of some Indian tunas. *Prof. Symp. Scombroid Fishes*, Part 2. *Mar. Biol. Assoc. India., Symp. Ser.* 1 : 733-743.

RAO. K. V. NARAYANA., G. SYDA RAO., G. LUTHER, M. N. KESAVAN ELAYATHU. 1982. The emerging purse-seine fishery for anchovy (white bait) resources of the west coast of India. *Mar. Fish. Infor. Serv. T & E.* Ser. 36.

REINTJES, J. W., AND J. E. KING. 1953. Food of yellowfin tuna in the Central Pacific. U. *S. Fish Wildl. Serv., Fish. Bull.* 54 : 91/110.

ROBERT, W. H., AND V. E. BROCK. 1948. On the herding of prey and schooling of the black skipjack, *Euthynnus yaito* Kishinouye. *Pacific Science*, 2(4) : 297-298.

RODRIGUEZ-RODA, J. 1966. Estudio de la bacoreta, *Euthynnus alleteratus* (Raf.), bonito, *Sarda sarda* (Bloch) y melva, *Auxis thazard* (Lac.). capturados por las almadrabas espanolas (In Span, Eng. Summ.) *Inves. Pesq.* 30 ; 247/292.

RONQUILLO, I. A 1953. Food habits of tunas and dolphins based upon the examination of their stomach contents. *Philipp. J. Fish.* 2(1) : 71-83.

RONQUILLO I .A. 1963. A contribution to the biology of Philippine tunas *FAO Fish. Rep.* 6 : 1683-1752.

ROTHSCHILD, B. J. 1963. Skipjack ecology. *In* W. G. Van Campen (Editor), Progress in 1961-62. p 13-17. *U. S. Fish Wildl. Serv. Circ.* 163.

ROTHSCHILD B. J. 1967. Estimates of the growth of skipjack tuna (*Katsuwonus pelamis*) in the Hawaiian Islands. *Proc. Indo-Pac. Fish Counc.* 12 (Sect. 2) : 100-111.

SCHAEFER, M. B. 1948. Size composition of catches of yellowfin tuna (*Neothunnus macropterus*) from Central America, and their significance in the determination of growth, age, and schooling habits, *U. S. Fish Wildl. Serv. Fish. Bull.* 51 : 197-200.

SCHAEFER, M. B. 1961. Appendix A. Report on the investigations of the Inter-American Tropical Tuna Commissionn for the year 1960. (In Engl. and Span.) *Inter-Am. Trop. Tuna Comm. Bull Annu. Rep.* 1960 : 40-183.

SCHAEFER, M. B., B. M. CHATWIN, AND G. C. BROADHEAD. 1961. sTagging and recovery of tropical tunas, 1955-1959. *Inter-Am. Trop. Tuna Comm. Bull.* 5(5) : 343-416.

SCHAEFER, M. B., G. C. BROADHEAD, AND C. J. ORANGE. 1963. Synopsis on the biology of yellowfin tuna, *Thunnus albacares* (Bonnaterre), 1788 (Pacific Ocean). *FAO Fish. Rep.* 6(2) : 538-561.

SCHAEFER, M. B., AND J. C. MARR. 1948. Juvenile (*Euthynnus lineatus* and *Auxis thazard* from the Pacific Ocean off Central America. *Pac. Sci.* 2 : 262-271.

SERVENTY, D. L. 1956. Additional observations on the biology on the northern bluefin tuna, *Kishinoella tonggol* (Bleeker) in Australia. *Aust. J. Mar. Freshwat. Res.*, 7(1) : 44-63.

SHABOTINIETS, E. I. 1968. Opredelenie vozrasta tuntsov Indiiskogo okeana (Age determination of Indian Ocean tunas). (In Russ., *Tr. VNIRO* 64, *Tr. Azeher NIRO* 28 : 374-376. (Engl. transl) by W. L. Klawe. 1968. 5 p., *Inter-Am. Trop. Tuna Comm.*, La Jolla. Calif.)

SILAS, E. G. 1963. Synopsis of biological data on oriental bonito *Sarda orientalis* (Temminck and Schlegel) 1842 (Indian Ocean), *FAO Fish. Rep.* 6, 2 : 834-861.

SILAS E. G. 1964. Aspects of the taxonomy and biology of the oriental bonito *Sarda orientalis* (Temminck and Schlegel). *Proc. Symp. Scombroid Fishes*, Part 1. *Mar. Biol. Assoc. India. Symp. Ser.* 1 : 283-308.

SILAS, E. G. 1967. Tuna fishery of the Tinnevelly Coast, Gulf of Mannar. *Proc. Symp. Scombroid Fishes*, Part 3. *Mar. Biol. Assoc. India. Symp. Ser.* 1 : 1083-1118.

SILAS, E. G. 1969. Exploratory fishing by R. V. *Varuna*. *Bull. Cent. Mar. Fish. Res. Inst.* 12, 86 p.

SILAS, E. G. 1982. With rising energy cost, is there a future for deep sea operations in India ? or, would it be more prudent for us to concentrate on Aquaculture ? (Mim. Rep.) Key Note address, *International conference on deep sea fishing*, New Delhi, June 1982, 32 p.

SILAS, E. G., M. S. RAJAGOPALAN, AND P. PARAMESWARAN PILLAI, 1979. Tuna fisheries in India : recent trends. *Mar. Fish. Infor. Ser. T & E Ser.*, 13 ; 12 p.

SILAS, E. G. AND P. P. PILLAI, 1982. Resources of tunas and related species and their fisheries in the Indian Ocean. *CMFRI Bull.*, 32, 174 p.

SILAS, E. G., AND P. P. PILLAI, 1983. Tuna resources of the Indian seas—an overview. *Proc. Sympos. Harvest and Post-harvest Technol. Fish., Fish Technol.*, pp. 20-27 Cochin, India,

SILAS, E. G., AND P. P. PILLAI, 1984. Recent developments in National Tuna Fishery, an update for India. Proc. Ad-hoc Workshop on the *stock assessment of tuna in the Indo-Pacific Region*, IPTP, Jakarta, Aug., 1984, 18 p.

SILAS, E. G., P. PARAMESWARAN PILLAI, A. A. JAYAPRAKASH, AND M. AYYAPPAN PILLAI, 1984. Focus on small scale fisheries : Drift gillnet fishery off Cochin, 1981 and 1982. *Mar. Fish. Infor Ser. T & E Ser.*, 55 : pp. 1-12.

SIMMONS, D. C. 1969. Maturity and spawning of skipjack tuna (*Katsuwonus pelamis*) in the Atlantic Ocean, with comments on nematode infestation of the ovaries. *U. S. Fish Wildl. Serv. Spec. Sci. Rep. Fish.* 580, 17 p.

SIVASUBRAMANIAN, K. 1966. Distribution and length-weight relationship of tunas and tuna-like fishes around Ceylon. *Bull. Fish. Res. Stn. Ceylon* 19(1-2 : 27-46.

SIVASUBRAMANIAN, K. 1969. Occurrence of oriental bonito (*Sarda orientalis* Temminck and Schlegel) in the inshore waters of Ceylon. *Bull. Fish. Res. Stn. Ceylon*, 20(1) : 73-77.

SIVASUBRAMANIAN, K. 1973. Co-occurrence and the relative abundance of narrow and broad corseletted frigate mackerels *Auxis thazard* (Lacepede) and *Auxis rochei* (Risso), around Ceylon. *In Proceedings of the Symposium on Living Resources of the Seas Around India*, p. 537-547. Cent. Mar. Fish. Res. Inst., Cochin.

SIVASUBRAMANIAN, K. 1985. The tuna fishery in the EEZs of India, Maldives and Sri Lanka. BOBP/WP/31, 19-47.

SKILLMAN, R. A. (MS). Estimates of von Bertalanffy growth parameters for skipjack tuna, *Katsuwonus pelamis* from capture-recapture experiments in the Hawaiian Islands. *South-west Fish. Centre, Honolulu Lab.*, NMFS, NOAA, Honolulu.

SMITH, B. R. 1977. Appraisal of the live-bait potential and handling characteristics of the common tuna bait species in Papua New Guinea. *In* R. S. Shomura (Editor), *Collection of Tuna Baitfish Papers*, p. 95-103. *U. S. Dep Commer.* NOAA Tech. Rep. NMFS CIRC. 408.

SRINATH, M. 1986. Handbook of working methods for estimating mortality rates of exploited fish stocks (MS.)

STEQUERT, B. 1976. Estude de la maturite sexuelle, de la ponte et de la fecendite du listao (*Katsuwonus pelamis*) de la cote nord-ouest de Madagascar. (A study of sexual maturity, the fertility and spawning of the skipjack (*Katsuwonus pelamis*) of the north-west coast of Madagascar.) (*In Fr., Engl.*, abstr.) Cah. O.R.S.T.O.M., Ser. Oceanogr. **14** : 227-247.

SUDA, AKIRA, S. KUME, AND T. SHIOHAMA. 1969. An indicative note on the role of thermocline as a factor controlling the long-line fishery ground for bigeye tuna. *Bull. Far seas Fish. Res Lab.*, **1** ; 99-114.

SURESH, K., AND M. P. M. REDDY 1980. Variations in oceanographic factors and the possible relation to fluctuations in oil sardine and mackerel catches off Mangalore. *Indian J. Fish.* **27**(1&2) : 1-9.

SUZUKI, Z. 1971. Comparison of growth parameters estimated for the yellowfin tuna in the Pacific Ocean. *Far. Seas Fish. Res. Lab., Bull.*, **5** : 89-105.

TAN, H., Y. NOES, AND Y. HIYAMA. 1965. Age determination and growth of yellowfin tuna, *Thunnus albacares*, Bonnaterre. *Bull. Jap. Soc. Sci. Fish.*, **31**(6) : 414-422.

TESTER, A. L., AND I. NAKAMURA. 1957. Catch rate, size, sex, and food of tunas and other pelagic fishes taken by trolling off Oahu, Hawaii, 1951-55. *U. S. Fish Wildl Serv., Spec. Sci. Rep. Fish.*, **250**, 25 p .

THOMAS, P. T. 1964a. Food of *Katsuwonus pelamis* (Linnaeus) and *Neothunnus macropterus* (Temminck and Schlegel) from Minicoy waters during the season 1961-62. *Proc. Symp. Scombroid Fishes.*, Part II. *Mar. Biol. Assoc. India, Symp. Ser*, **1** : 626-630.

THOMAS, P. T. 1964b. A study on the fluctuations in the occurrence of major tuna live-bait fishes of Minicoy. *Proc. Symp. Scombroid Fishes.* Part II. *Mar. Biol. Assoc. India.* pp. 681-690.

UCHIDA, R. N., AND R. F. SUMIDA. 1971. Analysis of the operations of seven Hawaiian skipjack tuna fishing vessels, June-August 1967. *U. S. Dep. Commer., Natl. Mar. Fish. Serv. Spec. Sci. Rep. Fish.* 629, 25 p.

UCHIYAMA, J H., AND P. STRUHSAKER. 1981. Age and growth of skipjack tuna, *Katsuwonus pelamis*, and yellowfin tuna *Thunnus albacares*, as indicated by daily growth increments of sagittae. *Fish. Bull.*, U. S. **79** ; 151-162.

UDA, M. 1983. Types of Skipjack schools and their fishing qualities. *Bull. Jap. Soc. Sci. Fish.*, **2** : 107-111.

VAN PEL, H. 1960. Report on the sea fisheries of Western Samoa. *South Pac. Comm.*, Noumea, New Caledonia, 24 p.

VARGHESE, G. 1970. Comparative merits of mechanised boats over non-mechanised boats on oceanic skipjack tuna live-bait fishery. *Seafood Exp. Jour.*, **3** ; 115-121.

VARGHESE, G. 1982. Tuna rich Lakshadweep. *Fishing chimes*, Ann. Number, 1982, 70-72.

VARGHESE, K. K., M. E. JOHN, AND V. SIVAJI, 1984. Some observations on the tuna resources of the Indian Ocean. *Fishery Survey of India, Bull.*, **13** : 30-33.

WADE, C. B. 1950. Juvenile forms of *Neothunnus macropterus*, *Katsuwonus pelamis* and *Euthynnus yaito* from Philippine seas. *U. S. Fish Wildl. Serv., Fish. Bull.* **51** : 398-404.

WALDRON, K. D. 1963. Synopsis of biological data on skipjack *Katsuwonus pelamis* (Linnaeus) 1758 (Pacific Ocean), *FAO Fish. Rep.* 6(2) : 695-748.

WANKOWSKI, J. W. J. 1981. Estimated growth of surface-schooling skipjack tuna, *Katsuwonus pelamis* and yellowfin tuna. *Thunnus albacares*, from the Papua New Guinea region. *Fish. Bull., U. S.* **79**(3) : 517-531.

WATANABE H. 1958. On the difference of stomach contents of the yellowfin and bigeye tunas from the western equatorial Pacific, *Rept. Nankai Rep. Fish. Lab.*, **7** ; 72-81.

WATANABE, H. 1960. Regional differences in food composition of the tunas and marlins from several oceanic areas. *Rept. Nankai Reg. Fish. Lab.*, **12** ; 75-84.

WEBER, M., AND L. F. DE BEAUFORT. 1951. *The Fishes of the Indo-Australian Archipelago*. 9. Leiden, 484. p. 89 figs.

WELSH, J. P. 1949. A preliminary study of food and feeding habits of Hawaiian Kawakawa, mahimahi, ono, aku and ahi, *Hawaii Div. Fish and Game, Fish. Prog. Rept.* 1(2) : 1-26 (*In* Fish and game, Spec. Bull., **2**. 1950.

WELSH J.P. 1950. A preliminary report of the Division of Fish and Game bait program. Part I. Summary of field work with special reference to Hilo Harbor nehu scarcity. *Spec. Bull.* 2 *Hawaii Div. Fish Game, Board Agric. For., Fish. Prop. Rep.* 1(0), November 15th 1949, 25 p.

WHITE, T., AND M. YESAI, 1982. The status of tuna fisheries in Indonesia and Philippines. FAO Indo-Pacific Tuna development and Management Programme. IPTP/82/WP/3. SCS/82/WP/112 : 62 p.

WHITLEY, G. P. 1964. Scombroid fishes of Australia and New Zealand. *Proc. Symp. Scombroid Fishes*, Part I. *Mar. Biol. Assoc. India. Symp. Ser.***1** ; 221-253.

WILD, A., AND T. J. FORBMAN. 1980. The relationship between otolith increments and time for yellowfin and Skipjack tuna marked with tetracycline. (In Engl., and Span.) *Inter-Am. Trop. Tuna Comm. Bull.* **17** ; 509-560.

WILLIAMS, F. 1956. Preliminary survey of the pelagic fishes of East Africa. G. B. Colon. Off. Fish. Publ. 8, 68 p.

WILLIAMS, F. 1963. Synopsis of biological data on little tuna *Euthynnus affinis* (Cantor) 1850 (Indian Ocean). *FAO Fish Rep.* 6 : 167-179.

WILLIAMSON, G. R. 1970. Little tuan *Euthynnus affinis* in the Hongkong area. *Bull. Jpn. Soc. Fish.* 36 ; 9-18.

WILSON, P. T. 1963. The past, present and future status of the tuna resources of the Trust Territory of the Pacific Islands. *In* H. Rosa, Jr. (Editor), *Proc. World. Sci. Meet. Biol. Tunas Related species*. La Jolla, Calif., U.S.A., 2-14 July 1962, p. 1633-1638. FAO Fish. Rep. 6,3.

WILSON P. T. 1971. Truk live bait survey. *U. S. Dep. Commer., NOAA, Tech. NMFS* CIRC—353, 10 p

WILSON P.T. 1977. Observations on the various tuna bait species and their habitats in the Palau Islands. *In* R. S. Shomura (editor) *Collection of tuna baitfish papers*, p. 69-74. *D. S. Dep. Commer., NOAA Tech Rep. NMFS CIRC*, 408.

WOOD, H. 1930. Scottish herring shoals. Prespawning and spawning movements. *Scotland Fish. Bd. Sci. Investt* ; 1-71.

YABE, H. 1954. A study on spawning of skipjack in the Satsunan Sea area. *In* General view of fishery science, Tokyo (In Jpn.) Jpn. Assco. Adv. Sci. 181-199. (Engl. transl. by G. Y. Beard, 1959, 9 p. : in files of *Southwest Fish. Cent., Natl. Mar. Fish. Serv., NOAA, Honolulu*, HI 96812)

YABE, H., S. UEYANAGI., S. KIKAWA, AND K. WATANABE. 1958, Young tunas found in the stomach contents. *Rept Nankai Res Fish Res. Lab.*, 8 ; 31-48.

YABUTA, Y., AND M. YUKINAWA. 1957. Age and growth of yellowfin tuna (*Neothunnus macropterus*) in Japanese waters by size frequencies. *Rept. Nankai Rep. Fish. Res. Lab.*, 5 : 127-133.

YABUTA Y., AND M. YUKINAWA 1959. Growth and age of yellowfin tuna (*Neothunnus macropterus*) in the equatorial Pacific. Study of length frequency distribution—I. *Nankai Reg. Fish. Res. Lab. Res.*, 11 ; 77-87.

YABUTA, Y., M. YUKINAWA, AND Y. WARASHINA. 1960. Growth and age of yellowfin tuna. Age determination (Scale method), *Rept Nankai Reg. Fish. Res. Lab.*, 12 ; 63-74.

YASUI M. 1975. Some observations on the frigate mackerel which migrates into Japanese coastal waters. (In Jpn.) Proceedings of the 1974 Tuna Research Conference, Shimizu, Japan, February 4-6, 1975, p. 219-225. Fish Agency, Far Seas Fish. Res. Lab.

YESAKI, M. 1983. Observations on the biology of yellow in (*Thunnus albacares*) and skipjack (*Katsuwonus pelamis*) tuna in the Philippine waters. IPTP/83/WP/7. SCS/83/WP/119. 66 p.

YOIOIA, T., M. TORITAYA, F. KANA, AND S. NOFFRA 1961 Studies on the feeding habit of fishes. (In Jpn.) *Rep. Nankai Reg. Fish. Res Lab.* 14 ; 1-234.

YOSHIDA H. O., AND E.L. NAMIALURA. 1965. Notes on schooling behaviour, spawning and morphology of Hawaiian frigate mackerels, *Auxis thazard* and *Auxis rochei. Copeia*, 1965 : 111-114.

YOSHIDA, H. O. 1966. Skipjack tuna spawning in the Marquesas Islands and Tuamotu Archipelago. *U. S. Fish Wildl. Serv., Fish. Bull.* 65 ; 479-488.

YOSHIDA, H O. 1971. The early life history of skipjack tuna, *Katsuwonus pelamis*, in the Pacific Ocean. *Fish. Bull., U.S.* 69 ; 545-554.

YOSHIDA, H. O., N. UCHIDA, AND T. OTSU. 1977. The Pacific tuna pole and line and live bait fisheries *In* R. S. Shomura (Editor) *Collection of tuna bait fish papers*. p. 36-51. *U. S. Dep. Commer. NOAA Tech. Rep.* NMFS CIRC. 408.

YUEN, H. S. H. 1955. Maturity and fecundity of bigeye tuna in the Pacific. *U. S. Fish Wildl. Serv. Spec. Sci. Rep.*, 150, 30 p,

YUEN, H. S. H. 1977. Desired characteristics of a bait for skipjack tuna, *Katsuwonus pelamis*. *In* R. S. Shomura (Editor), Collection of tuna bait-fish papers, p. 52-54. *U.S. Dep. Commer., NOAA Tech. Rep.* NMFS CIRC. 408.