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Baitfish Study in Majuro, Marshall Islands

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INTRODUCTION

With the yellowfin tuna, Thunnus albacares, and skipjack tuna, Katsuwonus pelamis, probably being exploited at or near maximum levels in the eastern Pacific (Rothschild and Uchida, 1968), there has been an increased interest in the skipjack tuna resources in the waters of the Trust Territory of the Pacific Islands where the Japanese operated a substantial fishery prior to World War II. During the prewar years, the Japanese vessels operated from bases in Palau, Truk, Yap, Saipan, Ponape, and Jaluit utilizing the available local baitfishes. There is very little information on the baitfish resources in the Trust Territory and since live-bait fishing for skipjack tuna is dependent upon the supply of baitfish, the National Marine Fisheries Service's RV Townsend Cromwell was dispatched to the area to assess this resource.

This project was undertaken as a result of findings made on three cruises of the Townsend Cromwell in 1971 and 1972. Although all island groups of the Trust Territory were surveyed, the best baitfish concentrations observed during the cruises were in the Marshall Islands. A school of sardine, Herklotsichthys punctatus, seen in Jaluit Atoll on cruise 53 of the Cromwell (June-July 1971) was estimated to exceed 2.5 metric tons (MT) and other schools of sardine and silverside, Pranesus pinguis, plus a few other bait species estimated at "several thousand" buckets (3.5 kg equals a bucket) were also seen (Hida, 1971). Since the sardine and silverside were found to be in quantities suitable for conducting live-bait fishing for skipjack tuna, it was thought desirable to learn about the distribution, abundance, and biology of these species for management purposes.

Although the best concentrations of baitfishes were seen at Jaluit Atoll, Majuro Atoll was chosen as the site to carry out our baitfish observational program because it is serviced by a commercial airline and has the necessary facilities and supplies. Majuro Atoll, which is located in the southern part of the Marshall Islands, is roughly 32 km (20 miles) long and 6 km (4 miles) wide. Northeasterly and easterly trade winds prevail there and the weather is usually cloudy with the annual rainfall averaging about 356 cm (140 inches). Surface water temperature and salinity samples taken at various places in the lagoon showed that the temperatures ranged from 27.8°C in December to 32.8°C in June and that the salinities were relatively stable ranging from $33.88^{\circ}/_{\circ\circ}$ to $34.32^{\circ}/_{\circ\circ}$.

OBSERVATIONAL PROGRAM

The sampling and observational methods used in this program were not ideal, but under the circumstances, the most feasible. Quarterly field trips were made by two or three observers from the Honolulu Laboratory for about 10 days per trip. The field trips were made in May of 1972, August-September of 1972, November-December of 1972, and April of 1973. In addition, a resident Micronesian was employed to scout for and to sample baitfish on a weekly basis. In this way, the program was carried out continuously from May 1972 through April 1973. Observations were carried out each month except for July, when the Micronesian observer was ill or the weather was bad, and October because of adverse weather conditions.

SCOUTING METHODS

Fig. 1

Scouting for baitfish was conducted in the lagoon close to the shoreline of Majuro (Figure 1), usually from a 4-m skiff powered with a 20 hp outboard motor. Conditions for scouting were usually good during low tide except that maneuvering of the boat was difficult because of the numerous exposed coral heads. The scouting runs, which covered most of the northeastern half of the lagoon as shown on Figure 1, were made daily during the quarterly visits. However, rough and murky waters or the necessity for carrying out other types of sampling did alter this routine. Occasionally, scouting was conducted from shore with automobiles. In this case, stops were made frequently and whenever it was possible to gain access to a beach. About half a mile of shoreline was scouted on foot on these stops. The Micronesian observer did his scouting during weekends.

SAMPLING METHODS

CAST NET

Monofilament cast nets of 1.27 and 1.9 cm stretch mesh size were used to collect sardine and silverside during the scouting runs. Samples were collected whenever possible. The baitfish sampled were limited mostly to the larger sizes due to gear selectivity, especially in the case of the silverside. However, since there were usually only two observers, and because of the reefs and coral heads in the area, it was not possible to use a beach seine. The cast net was believed to be the most practical sampling gear under the circumstances. The collected samples were preserved in 10% Formalin[2] or 75% isopropynol and returned to the Laboratory for examination.

NIGHT-LIGHT

During the quarterly visits, night-light stations were conducted by the field team with the skiff whenever the schedule allowed; a few were conducted by the Micronesian observer. Either a double mantle gas lantern or a 50-watt bulb powered by a 12-volt gasoline generator was used as the light source. The invertebrates and fishes that were attracted to the light were dipnetted.

HANDLINE

Small handlines were used to capture bigeye scad, *Selar crumenophthalmus*, which were usually attracted to the night-light together with other predators. The bigeye scad were sampled to see if they were feeding on baitfish. Their stomachs were collected and preserved in 10% Formalin for study at the Laboratory.

ZOOPLANKTON NET

Fine meshed plankton nets, 20.3 and 45 cm in diameter, were towed by the skiff to sample zooplankton in the lagoon. Most of the samples were collected by the field team during the quarterly visits but a few were collected by the Micronesian observer. The tows were taken at the surface and at 5- or 10-m depths for durations of 15 to 20 minutes. The tows were made in the late afternoon, mid-morning or early evening hours. The occurrence of large numbers of large jellyfish at the surface at night precluded night tows. The samples were preserved in 10% Formalin and returned to the Laboratory for study.

TROLLING

Trolling was conducted during the quarterly visits by using a small spinner with a lure and a trolling rod and reel. Trolling was usually carried out routinely while heading out for the scouting grounds, but at times it was done directly into an actively feeding school of fish or around feeding bird flocks.

DISTRIBUTION AND ABUNDANCE

On cruise 53 of the *Townsend Cromwell*, June-July 1971, an estimated 2,500 buckets of silverside and 1,000 buckets of sardine were observed in Majuro lagoon. On *Cromwell* cruise 55, in November 1971, an estimated 800 buckets of sardine and 700 buckets of silverside were seen. In April 1972, on *Cromwell* cruise 57, it was estimated that there were about 1,000 buckets of sardine and silverside (mostly sardine) in Majuro. Most of the baitfish were seen in scattered schools in fairly shallow (2 m or less) waters along the eastern shoreline of the main island and along the many small islets on the northeastern part of the atoll. In May of 1972, on the first quarterly survey, about 100 buckets of sardine and 80 buckets of silverside were seen in scattered schools on the scouting runs. The largest school was estimated to consist of about 100 buckets of sardine and silverside. The baitfishes were often seen in quiet waters over fairly good seining grounds with sandy bottom and at times in areas with reefs and coral heads. Up until September of 1972, a few small schools totaling about 50 buckets were seen on the scouting runs. The month of October was stormy and no observations could be made. From November 1972 through May 1973, there were no visible signs of baitfish concentrations in Majuro. Only a few small schools of fewer than five buckets of sardine and scattered small schools of silverside were seen. This study showed that the abundance of sardine and silverside in Majuro lagoon had apparently declined considerably since our first observations. Whether this apparent decline in abundance is an annual occurrence or whether this was an abnormal year is not now clear.

It is conceivable that the baitfish had moved out of the lagoon to other areas or into deeper or murkier waters of the lagoon where they could not be detected on our scouting runs.

Also, in May 1972, there was a Japanese fishing vessel conducting experimental live-bait, pole-and-line fishing in the Marshalls. They reportedly baited in the Marshalls, but where they caught the baitfish and how much they caught is not known. One of the ship's representatives said that an average of 200 buckets of sardine and, at times, as much as 500 buckets was taken in a single haul of a night net. If these amounts were taken out of Majuro lagoon with any frequency, it is possible that this would have affected the baitfish population during the period of our observation.

Our Micronesian observer also informed us that there was an unusual abundance of small kawakawa, Euthynnus affinis, in the lagoon in July of 1972. It was unfortunate that we were unable to find out what these fish were feeding on. Whether the occurrence of kawakawa in large numbers in the lagoon played a part in the "disappearance" of baitfish is again left to speculation.

As of November 1973, the Micronesian observer reported that the baitfish had not returned to Majuro. However, more recently, in April 1974, the baitfish apparently had returned to Majuro lagoon as well as to Jaluit Atoll (Robert M. Oka, former Honolulu Laboratory leading fisherman, pers. comm.).

AGE AND GROWTH ESTIMATES OF *HERKLOTSICHTHYS PUNCTATUS* AND *PRANESUS PINGUIS*

Because of inadequacies in sample size and in the size range (mostly 6.0 to 11.0 cm standard length (SL)) of baitfish specimens collected, growth estimates based on size-frequency mode progressions were not possible. Pannella (1971) provided indirect evidence of the presence of daily growth increments in fish otoliths. Struhsaker and Uchiyama (in press) have provided direct evidence that these increments are present in otoliths of the Hawaiian nehu, *Stolephorus purpureus*. Similar appearing structures are apparent in otoliths from *H. punctatus* and *P. pinguis* and for this study it was assumed that they are daily growth lamellae.

The largest *H. punctatus*, 10.92 cm SL, appeared to be 265 days old while *H. punctatus*, 8.62 and 8.69 cm SL, were estimated to be 189 days old. Specimens between 8.6 and 10.5 cm SL fell

Fig. 2 linearly (Figure 2). The presence of the 10.92 cm SL specimen is an indication that growth decreases after 10.5 cm SL. The average growth in length was 0.35 mm per day for the specimens examined. *P. pinguis*, 3.2 cm SL, was 112 days old. The largest specimen, 6.7 cm SL, was 265 days old. Other specimens fell linearly between these points (Figure 2). The average growth in length was 0.227 mm per day. Interestingly, both species appeared to reach sexual maturity at the same age, between 6 and 7 months.

MATURITY AND FECUNDITY

MATERIAL AND METHOD

Specimens were pooled into groups by month of capture and then measured (SL) and the sex determined for sex ratio information. The ova diameters of the most advanced mode were measured and classified by appearance for maturity studies. Classification by appearance was believed to be more reliable than diameter measurements as shrinkage occurred during preservation in Formalin. The descriptions of the developmental stages of baitfish are the same as those used by Uchiyama and Shomura (1974) for swordfish (*Xiphias*) ova.

1. *Primordial*: The ova diameters are less than 0.1 mm and are transparent and ovoid in shape.

2. *Early developing*: The ova develop a chorion membrane and opaque yolk material deposit within the ovum. The ova are larger than the primordial ova and less than 0.3 mm in diameter.

3. Developing: The ova are completely opaque and spherical. The chorion is stretched and not visible at this stage. Ova diameters range between 0.3 and 0.7 mm.

4. Advanced developing: The ova have a fertilization membrane, a translucent margin around the yolk. Their diameters range between 0.6 and 0.9 mm.

5. Early ripe: The ova range between 0.7 and 1.0 mm in diameter. Yolk material becomes translucent, and oil globules begin to form.

6. Ripe ova: The ova are transparent and range in diameter from 0.9 to 1.1 mm. Oil globules are present.

For the fecundity study, the largest ovary of the month was examined. An attempt was made to keep the length of the fish constant. All ova in the most advanced mode were counted.

SEX RATIO

The sex ratios of sardine and silverside are presented as percentage of females in the monthly sample (Figure 3). The percentage of female *H. punctatus* in the sample was highest in May-June and lowest in September. The percentage of female *P. pinguis* was highest in September and lowest in November.

Fig. 3

MATURITY

Since the number of specimens varied monthly, the percentage composition of the six ovarian developmental stages was used for comparison. *H. punctatus* appeared ready for spawning during April and May, as ripe ova were present in some ovaries. Ovaries at the developing stage occurred throughout the year but

Fig. 4

ripe ovaries were present only in April and May (Figure 4). There were few *H. punctatus* under 7.3 cm SL in the samples and their ovaries were all immature. Ripe ovaries occurred in specimens over 9.0 cm SL.

Ripe ovaries of *P. pinguis*, occurred throughout the year. Spawning appeared to peak in August when over 80% of the ovaries contained ripe or early ripe ova (Figure 3). The smallest silverside with a ripe ovary measured 5.5 cm SL.

FECUNDITY

Tables 1, 2

Fecundity data are presented in Tables 1 and 2. The fecundity of *H. punctatus* ranged from 3,035 for a 9.3 cm specimen to 6,294 for a 9.8 cm specimen. There appeared to be a slight increase in fecundity from May through September. The fecundity of *P. pinguis* ranged from 272 for a 7.1 cm specimen to 852 for a 7.5 cm specimen.

STOMACH CONTENTS

The stomach contents of bigeye scad, sardine, and silverside were examined to see if they were feeding on juvenile baitfishes.

The bigeye scad were caught handlining from the skiff while carrying out night-light stations during August, September, November, and December 1972. Fifty-eight stomach samples were collected and examined. Among the principal food items were shrimps, isopods, ostracods, and fishes, especially of the family Bregmacerotidae.

Table 3 The organisms found in the stomachs are listed on Table 3.

About 50 sardine stomachs were examined. It was found that they fed on shrimps, lucifers, and copepods; especially, *Labidocera acutum* and *Undinula vulgaris*. The organisms found in the stomachs are listed on Table 3.

About 100 silverside stomachs examined showed that their stomachs were essentially empty. This apparent habit of not feeding during the day was mentioned by Hobson and Chess (1973).

The examination of stomach contents showed that larval and juvenile sardine were not eaten by these predators at the time of our collections. It was hoped that larval and juvenile sardine could be obtained from stomach contents since our sampling methods were unable to capture them. The bigeye scad did feed on juvenile silverside but these could be sampled under the night-light. We were unable to catch enough silverside or sardine under the night-light to compare their feeding habits with fish caught during the day.

CONCLUSION

The inability to collect adequate samples during our field trips, largely due to the apparent absence of baitfish concentrations, left much to be desired in this study. However, we did find that the apparent abundance of *H. punctatus* and *P. pinguis* can fluctuate widely in Majuro. We also found that the two species reached maturity in about 6 to 7 months at a size of 9 cm SL for *H. punctatus* and 5.5 cm SL for *P. pinguis*. From the presence of ripe ova in the ovaries,it seems that H. punctatus spawns in the spring and *P. pinguis* throughout the year with a peak in August. The remaining information on the early life history, identification and description of a few bait species will be published in the near future.

ACKNOWLEDGMENT

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TEXT FOOTNOTES

[2]Reference to trade names does not imply endorsement by the National Marine Fisheries Service, NOAA.

Table 1.--Fecundity of *Herklotsichthys punctatus* collected in Majuro.

(1972) Month	Standard length (cm)	Left ovary	Right ovary	Loose ova	Total	Maturity	Size range of ova (mm)
Feb.	10.2	2,610	1,381	151	4,042	Advanced developing	0.69-0.78
Apr.	9.3	1,840	1,171	24	3,035	Early ripe	0.86-0.94
May	9.8	3,294	1,790	33	5,117	Early ripe	0.90-0.98
June	9.8	4,508	1,663	23	6,194	Advanced developing	0.69-0.78
June	10.0	3,352	1,506	381	5,239	Early ripe	0.73-0.94
Sep.	10.6	2,322	2,821	10	5,153	Advanced developing	0.57-0.65
Dec.	10.6	3,243	1,161	0	4,404	Advanced developing	0.65-0.78

Table 2.--Fecundity of *Pranesus pinguis* collected in Majuro.

Month-year	Standard length (cm)	Fecundity	Size range of ripe ova (mm)
Apr. 1972	7.1	272	0.98-1.14
May 1973	7.3	504	0.98-1.14
Aug. 1972	7.4	504	0.82-0.94
Sep. 1972	7.1	624	0.78-0.98
Nov. 1972	7.5	852	0.82-1.10
Dec. 1972	7.0	558	0.82-1.14

Table 3.--Stomach contents of the bigeye scad, sardine and silverside sampled in Majuro.

Organisms	Bigeye scad	Sardine	Silverside
Polychaeta	x	--	--
Cephalocordata	x	--	--
Crustacea:			
Amphipoda	x	x	--
Decapoda:			
Crab megalopa	x	x	--
Shrimp	xx	xx	x
Lucifer	--	xx	--
Unidentified	x	--	--
Copepoda:			
Labidocera acutum	x	xx	--
Undinula vulgaris	--	xx	--
Unidentified	x	--	x
Euphausiacea	x	--	--
Musidacea:			
Anchialina grossa	x	x	x
Siriella vulgaris	--	--	x
Unidentified	xx	--	--
Isopoda	xx	--	x
Ostracoda	xx	x	--
Mollusca:			
Gastropod larvae	x	x	--
Pelecypod larvae	--	x	--
Fishes:			
Acanthuridae	x	--	--
Atherinidae	x	--	--
Balistidae	x	--	--
Bregmacerotidae	xx	--	--
Fistulariidae	x	--	--
Leptocephalus larvae	x	--	--
Syngnathidae	x	--	--
Unidentified	xx	--	x

x = present

xx = common

//////// = Area routinely scouted

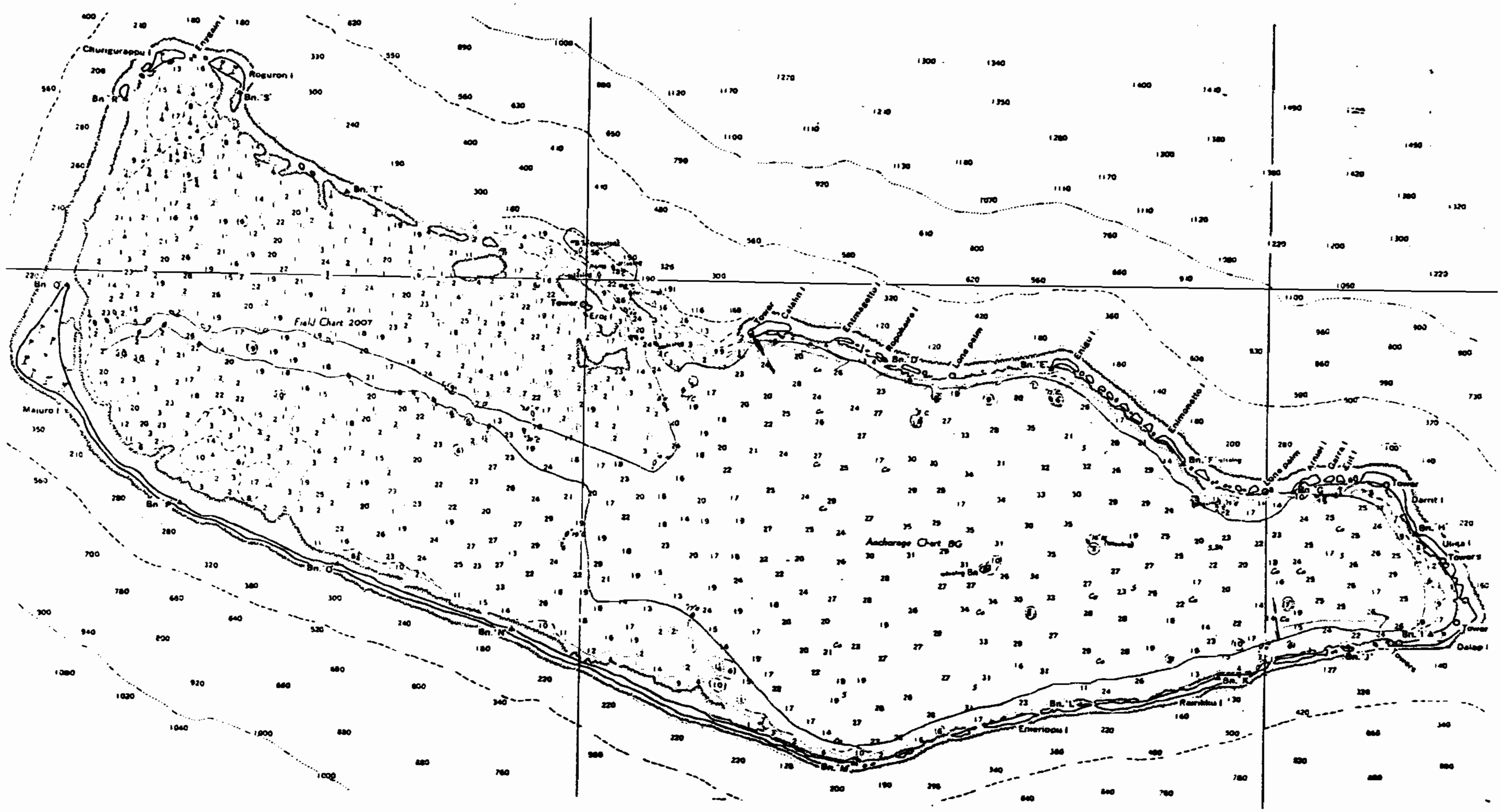

Figure 1. Majuro Atoll

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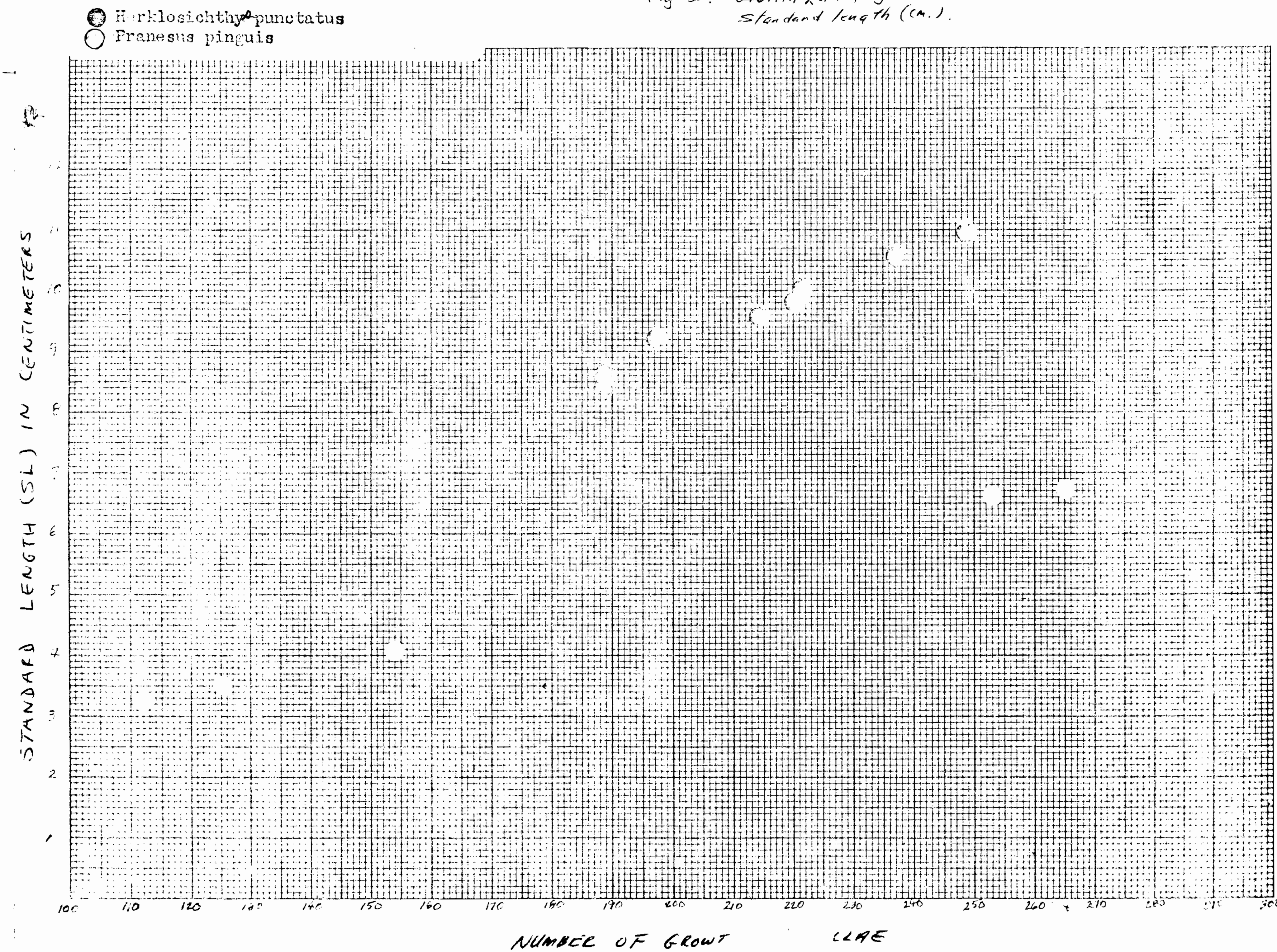
Fig 2. The number of ~~otolith~~ daily growth lamellae of H. punctatus & F. pinguis otoliths plotted against standard length (cm.).



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(12-11-46) DATA FOR → Fig. ✓. Age and Growth

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Herklotsichthys punctatus

SL	Count	Sex
10.925 cm	265	♀
9.630	214	♂
9.220	197	♀
8.620	189	♀
8.692	189	♂
9.894	220	♂
10.030	222	♀
10.553	237	♀

Pranesus pinguis

SL	Count	Sex
67.09 mm	265	♀
66.29	253	♀
35.18	125	—
40.51	154	—
32.24	112	—
49.40	200	—

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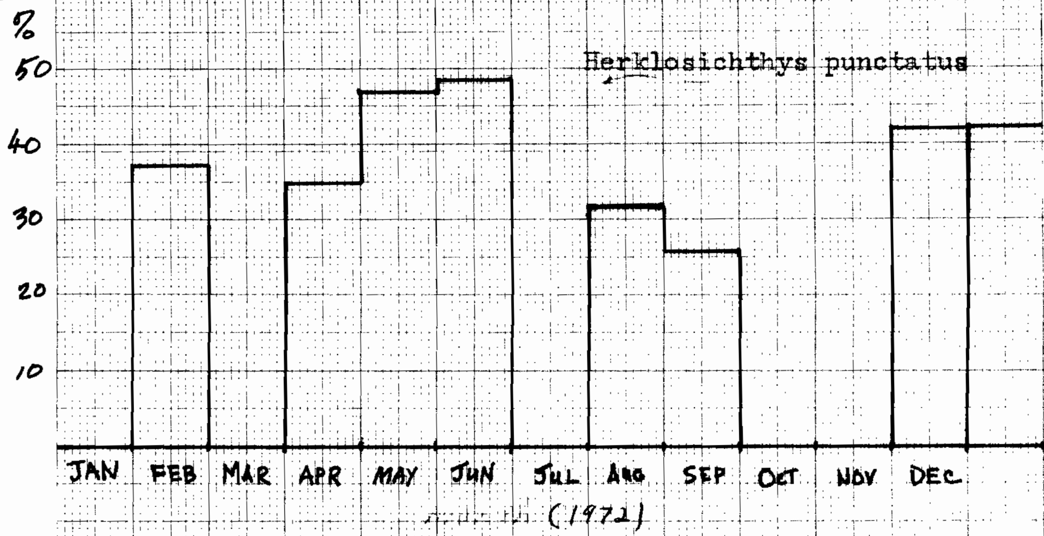
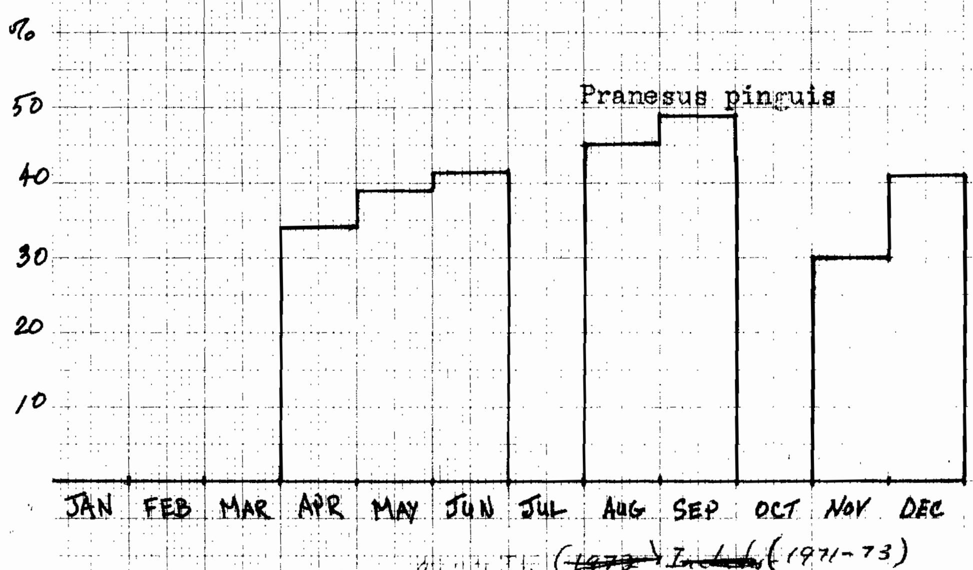
Figure 3 . Female component of monthly samples of Majuro baitfishes.





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WORKSHEET

Fig. 3. Female Component of monthly samples of Majuro baitfishes

Herklosichthys punctatus

Month	% ♀
—	—
Feb	31.5
—	—
April	34.8
May	46.8
Jun	48.6
—	—
Aug	32.0
Sep	25.9
—	—
Dec	42.3

Pranesus pinguis

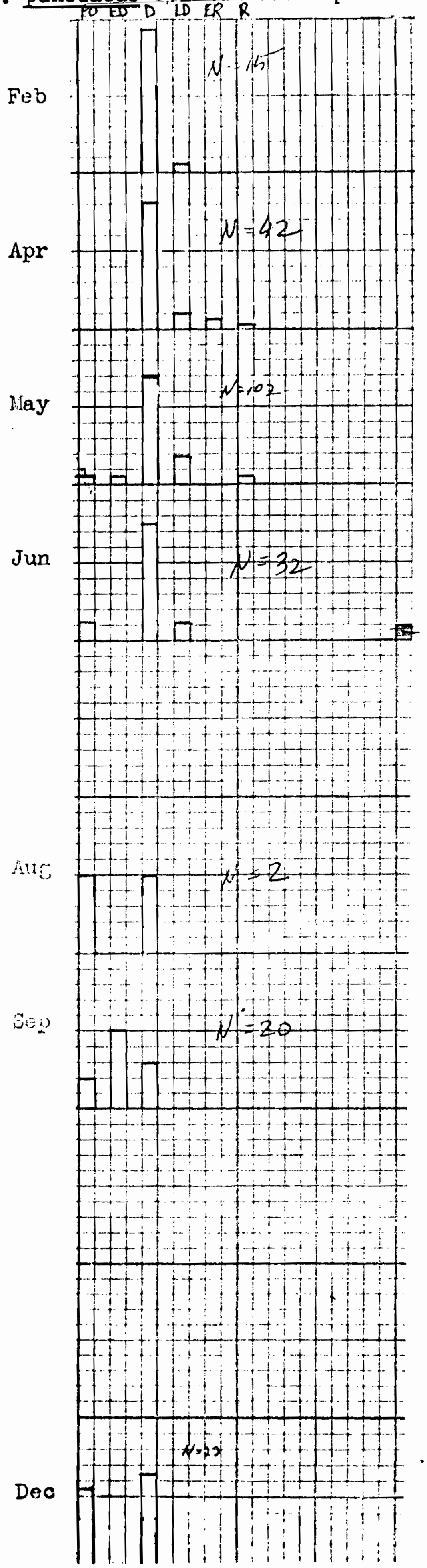
Month	% ♀
—	—
—	—
—	—
April	34.4
May	39.1
Jun	41.7
—	—
Aug	45.3
Sep	49.3
—	—
Nov	30.0
Dec	41.2

DATA

Fig. 4. Composition of H. punctatus Ovarian Developmental Stages in Month Sampled.

Month	PO	ED	MD	LD	ER	R	(STAGES)
—							
Feb	—	—	93.3	6.7	—	—	
Apr	—	—	81.0	9.5	7.1	2.4	
May	4.9	3.9	68.6	18.6	—	3.9	
Jun	12.5	—	75.0	12.5	—	—	
—	—	—	—	—	—	—	
Aug	—	—	—	—	—	—	
Sep	20.0	50.0	30.0	—	—	—	
—	—	—	—	—	—	—	
—	—	—	—	—	—	—	
Dec	~~[illegible]~~	—	~~63.0~~	—	—	—	
	54.5	4.5	36.3	4.5	—	—	

Figure 4.--Composition of H. punctatus ovarian developmental stages by month (1972).



Key:

PO - Primordial Ova
ED - Early Developing
D - Developing
AD - Advanced Developing
ER - Early Ripe
R - Ripe