Proc. Res. Inv. NWHI
UNIHI-SEAGRANT-MR-84-01

SPAWNING AND GONADAL MATURATION OF THE EHU, *ETELIS CARBUNCULUS*, IN THE NORTHWESTERN HAWAIIAN ISLANDS

Alan R. Everson

Southwest Fisheries Center Honolulu Laboratory, National Marine Fisheries Service, NOAA, P.O. Box 3830, Honolulu, Hawaii 96812

ABSTRACT

Ehu, *Etelis carbunculus*, ovaries were collected from various banks throughout the Northwestern Hawaiian Islands during 1977-81. Ovaries were microscopically examined to determine the most advanced developmental stage. Mean monthly gonadal somatic indices indicated that maturation began in May and spawning occurred from July to September. Ehu were found to be serial spawners, i.e., they spawned multiple batches of ova during the season. Most females spawned by the time they reached 35 to 40-cm fork length and older (>45 cm) fish were found to remain in spawning condition longer. The overall sex ratio in a pooled sample of 833 ehu was in favor of females by 2:1. Females also predominated in the larger size ranges (45 to 65-cm fork length) and during certain times of the year, indicating possibly that they live longer or aggregate during spawning. Fecundity of ehu 38.3 to 50.8 cm was estimated at 349,500 to 1,325,600 ova.

ehu	maturation
ova	spawning
sex ratio	fecundity

INTRODUCTION

In 1976, following the enactment of the Magnuson Fishery Conservation and Management Act (FCMA), the Southwest Fisheries Center Honolulu Laboratory, National Marine Fisheries Service (NMFS), in cooperation with the U.S. Fish and Wildlife Service (FWS) and the Division of Aquatic Resources (DAR), Hawaii Department of Land and Natural Resources (DLNR), initiated a 5-year assessment of the marine and terrestrial resources in the

Northwestern Hawaiian Islands (NWHI). An important goal of this study was to describe the distribution and abundance of commercially valuable deepwater snapper. Ehu or red snapper, Etelis carbunculus Cuvier, was the bottomfish species most frequently caught (in numbers) during this period. It ranked third in total weight. Little is known about reproduction in Hawaiian deepwater snappers and there has been nothing reported on the spawning and maturation of ehu. To better understand the recruitment of this species into the fishery, a study was initiated to determine the ehu's spawning season, fecundity, and other important aspects of its reproductive potential.

The range of ehu is limited to the Indo-western Pacific, and within this region the distribution is considered discontinuous and is restricted to the Indian Ocean, southern Japan, and Polynesia (Druzhinin, 1970; Forster et al., 1970). Within the Hawaiian Islands ehu is caught on nearly every major bank from the island of Hawaii to Kure Atoll (Figure 1). Their major habitat is the bottom in areas of deep (200 to 350 m) dropoffs around ledges, rock outcrops, and pinnacles (Ralston and Polovina, 1982). During the sampling period they were most abundant in the area northwest of Lisianski bank (see paper in this proceedings by Uchiyama and Tagami), comprising 45 to 86 percent of the total number of bottomfishes caught. Ehu is a very important food fish in Hawaii and is of high commercial value (Uchida et al., 1979).

The major objectives of this study were to determine the spawning season, size at first maturity, and sex ratio of ehu and to determine any differences in these aspects of spawning among banks within the NWHI chain. All of this information is important for any future management of the fishery.

METHODS

Fish were sampled during cruises of the NOAA ship Townsend Cromwell over a 5-year period between 1977 and 1981. The majority of fish were caught at bottom handline fishing stations at depths ranging from 200 to 350 m from various banks within the NWHI throughout the year (Figure 1). Hydraulic handline gurdies were used usually with four Nos. 20 or 28 hooks. Stripped squid were used as bait. Of the 935 ehu caught at these stations, 273 (33 percent) were males and 553 (67 percent) were females; 109 fish were not sexed. All fish were weighed to the nearest 0.01 kg and measured to the nearest 0.1 cm. About 300 ovaries collected during fishing operations were either frozen or preserved in 10 percent Formalin. Testes were not saved. Ovarian samples were taken randomly on each cruise and were not necessarily representative of any area, size class, developmental stage, or time of year.

To evaluate differences in ehu reproduction within geographic locations in the NWHI, the area was divided into three different regions. Region I extended from Nihoa to Gardner

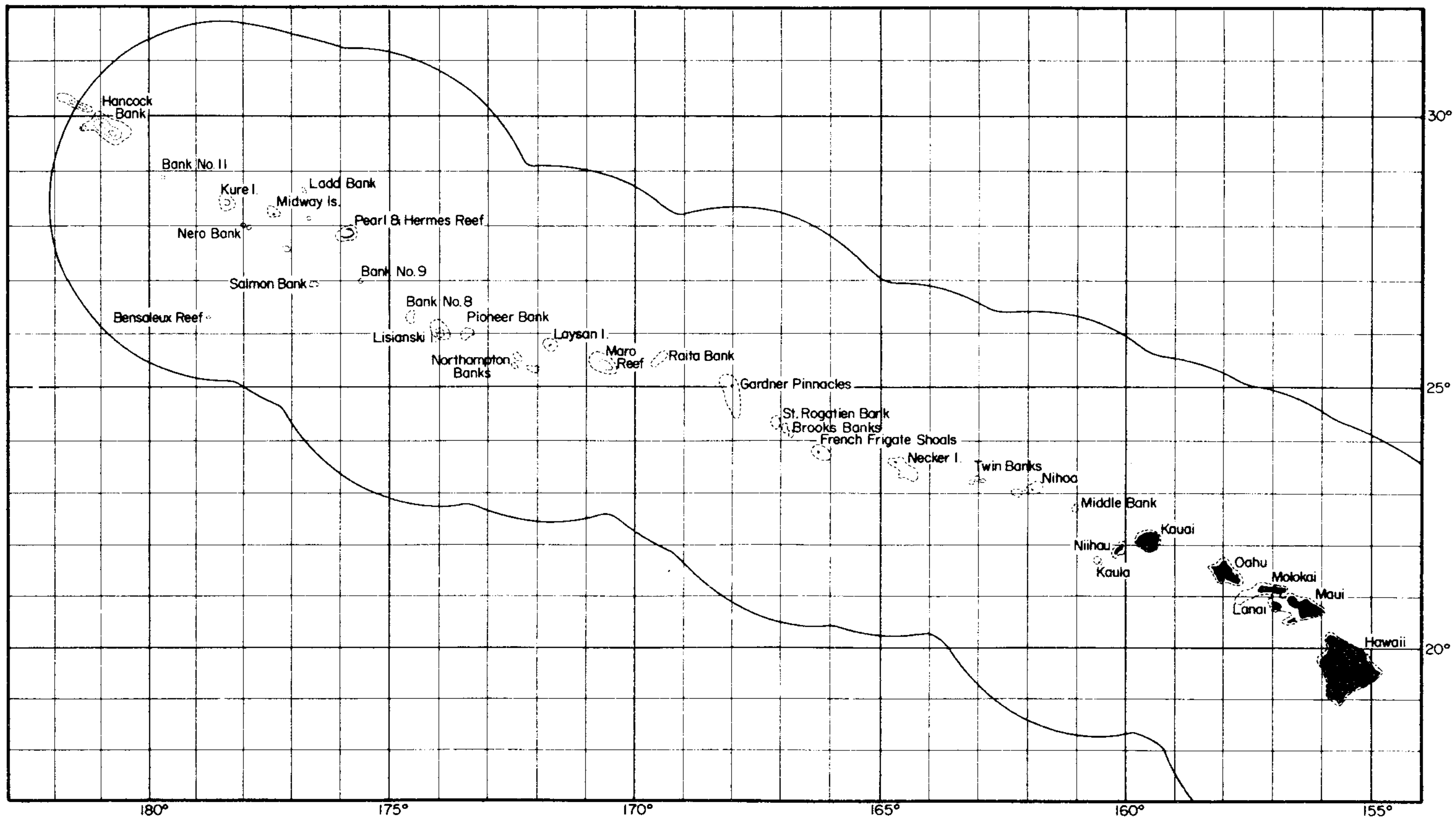

Figure 1. The Hawaiian Islands

Pinnacles, region II from Raita Bank to Lisianski Island, and region III from Pearl and Hermes Atoll to Kure Atoll (Moffitt, 1980).

Various methods have been used to define the spawning season in fishes. The main criterion used in the past has been to monitor the development of the ova, determined by ovum diameters, throughout the year. Each mode in the frequency distribution of ovum diameters was assumed to represent a distinct developmental stage. This technique was used successfully by Clark (1934) for the California sardine, Yuen (1955) for bigeye tuna, and Otsu and Uchida (1959) for albacore. Another method used was to note the developmental stage by microscopically examining the physical characteristics of individual ovum. This can be accomplished by taking a sample from an ovary and teasing out the ova (Uchiyama and Shomura, 1974) or by histologically examining a section of the ovary (Crossland, 1977). The gonadal somatic index (GSI) may also be calculated to assess the fluctuations in ovary weight as a function of body weight during the year (Bagenal and Braum, 1968; Morse, 1980; Goldberg, 1981; Love and Westphal, 1981; Baglin, 1982). A combination of these methods that allowed for a rapid assessment of maturity state and spawning frequency were used.

Each preserved pair of ovaries was blotted dry and weighed to the nearest 0.1 g. To determine stages of development, a dorsoventral sample (completely through the ovary) was taken at the posterior half of the left lobe with a cork borer. The entire sample was teased apart to separate the ova from ovarian connective tissue. All of the ova within the sample were examined under a compound microscope at 40X magnification. The proportion of ova in each development stage and the most advanced stage was noted. Random ovum diameters were measured to determine the size range in each stage, as well as the largest ovum in each sample. The stage of development was classified according to physical characteristics not necessarily dependent on ovum diameters (Uchiyama and Shomura, 1974) (Table 1).

Fecundity was estimated from five ripe-appearing ovaries that were frozen at the time of collection. Thawed samples were placed in modified Gilson's solution (Bagenal and Braum, 1968), until the ova were freed from connective tissue following the procedure described by Kikkawa and Everson (see report in this proceedings). The diameter of 100 randomly selected ova was measured from each ovary (Clark, 1934; Yuen, 1955) to determine the most advanced mode. Ova in this modal group were counted to obtain fecundity estimates since they are most likely to be spawned in a season. These may include ova from maturity stages III to VI. Subsamples were obtained using Van Dalsen's (1977) volumetric technique, modified slightly by Kikkawa and Everson (see report in this proceedings). The ova were placed in a 2,000-ml beaker and initially mixed with a stirring rod. To create a counterflow a magnetic stirrer was then switched on until a homogeneous mixture was obtained. At this time a 5-ml

TABLE 1. DESCRIPTION OF REPRODUCTIVE STAGES OF EHU BASED ON EXTERNAL APPEARANCE OF OVARY AND MICROSCOPIC EXAMINATION OF OVA

Maturity Stage	External Appearance of Ovary
I. Primordial (diameter 0.04 to 0.13 mm)	1. Immature
Oocytes are transparent and irregular in shape with no sign of vitillogenesis. These comprise the oocytes from which smaller numbers of ova mature. Individual ovum are invisible to the naked eye and very difficult to separate from connective tissue.	Ovaries are small and firm in texture and ribbonlike in shape. Very light (white) in color. Sex may be discernible by gross examination. Individual ova are not visible.
II. Early developing (0.10 to 0.16 mm)	
Oocytes are semitransparent and ovoid in shape. A chorian membrane has begun to form around the ovum and yolk granules have started to be deposited within. Barely discernible to the naked eye.	
III. Developing (0.26 to 0.52 mm)	2. Developing
Ova are spherical in shape and have become completely opaque and yellow due to yolk material. They are readily visible within the follicles and can be separated from connective tissue fairly easily.	Ovaries enlarged, elongated, and slightly swollen in girth. Individual ova discernible through the ovarian membrane. Ova, visible to the eye, are small, white, and granular. Ovary appears yellow due to the presence of yolk material.
IV. Advanced developing (0.39 to 0.52 mm)	
A translucent margin bordered by a fertilization membrane is visible. Oil droplets are just starting to form.	
V. Early ripe (0.44 to 0.58 mm)	3. Ripe
Oil droplets have begun to cluster into a single oil globule. The yolk material appears translucent, and ova have become completely round.	Ovary is greatly enlarged reaching its maximum size as it fills the abdominal cavity and hydration takes place. Large ripe ova are discernible through the thin ovarian membrane; ova are easily dislodged from follicles and connective tissue. Ovary is yellow to orange in color.
VI. Ripe (0.5 to 0.78 mm)	
Ova have become almost completely transparent. A single, pronounced yellow oil globule has formed. Ovary wall has become considerably thinner, oil globule (diameter 0.13 to 0.2 mm).	
VII. Residual (atretic)	4. Spent
Ova have become shrunken, wrinkled, and translucent in appearance. Degeneration and resorption in progress.	Ovary empty, flaccid in appearance, and dark gray in color — only primordial ova left. Ovary wall very thick and tough. Residual oocytes may be present.

sample was drawn. This procedure was repeated for each ovary examined. Fecundity estimates were obtained from the formula

$$F = \frac{1}{2} (N_1 + N_2) \left(\frac{V}{5 \text{ ml}}\right)$$

where

F = fecundity
N_1 and N_2 = number of ova in each subsample
V = total volume of the mixture in milliliters

RESULTS

Seasonality of Spawning

Stages of maturity, based on the physical characteristics of the ova, were compared with GSI calculated for ehu captured at various times throughout the year. The GSI increased with advancing stage of maturity and was highest at stage VI (ripe stage). The GSI and stages of maturity were positively correlated ($r = 0.8562$, $N = 286$, $P < 0.01$) (Figure 2). A plot of the mean GSI by month (data for all years pooled) (Figure 3) showed a similar trend when compared with the percentage frequency of maturity stage versus month (Figure 4). The mean GSI values were relatively low from January to April when females were exclusively in stages I and II. In May-June, however, as evidenced by the mean GSI and maturity stages, maturing females were more prominent in the samples. The highest mean GSI's and the most advanced maturity stages were found in July-September. The GSI values decreased and the number of advanced stages declined sharply in October and remained low the rest of the year. Based on these results, the spawning season can be divided into four separate phases: resting phase (January-April), maturing phase (May-June), spawning phase (July-September), and postspawning or recovering phase (October-December). Similar results were obtained when monthly mean GSI's were compared for each individual year from 1977 to 1981.

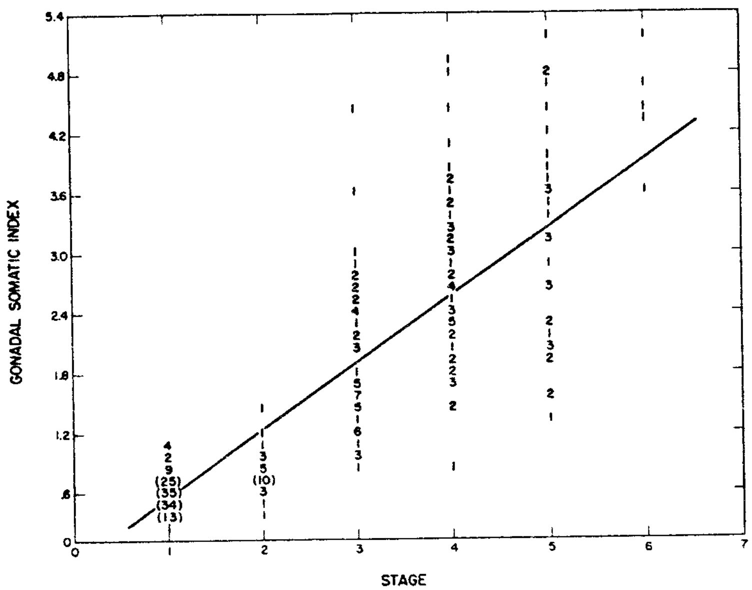

Figure 2. The relationship of gonadal somatic index and maturity stages (I-VI) for 286 ehu ovaries collected between 1977 and 1981.
Y = 0.67422x - 0.2355
r = 0.8562

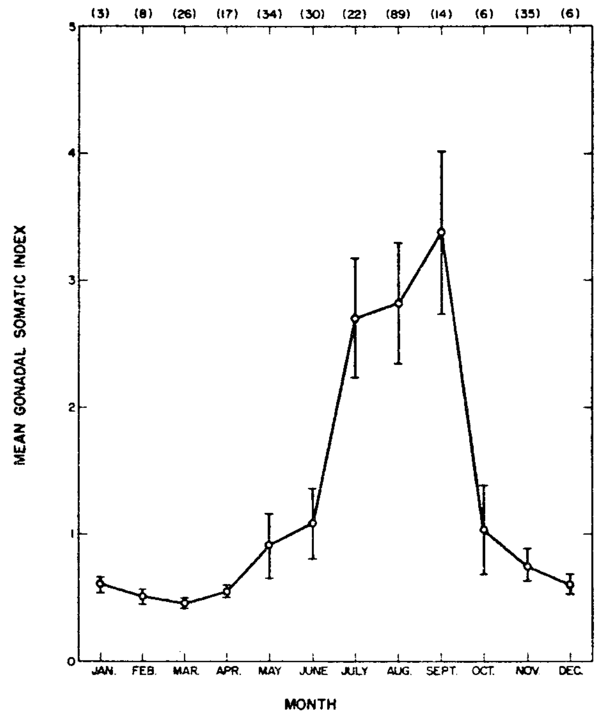

Figure 3. Monthly mean gonadal somatic index for 286 ehu collected between 1977 and 1981. Vertical lines indicate 95 percent confidence limits.
(N) = Number of samples per month

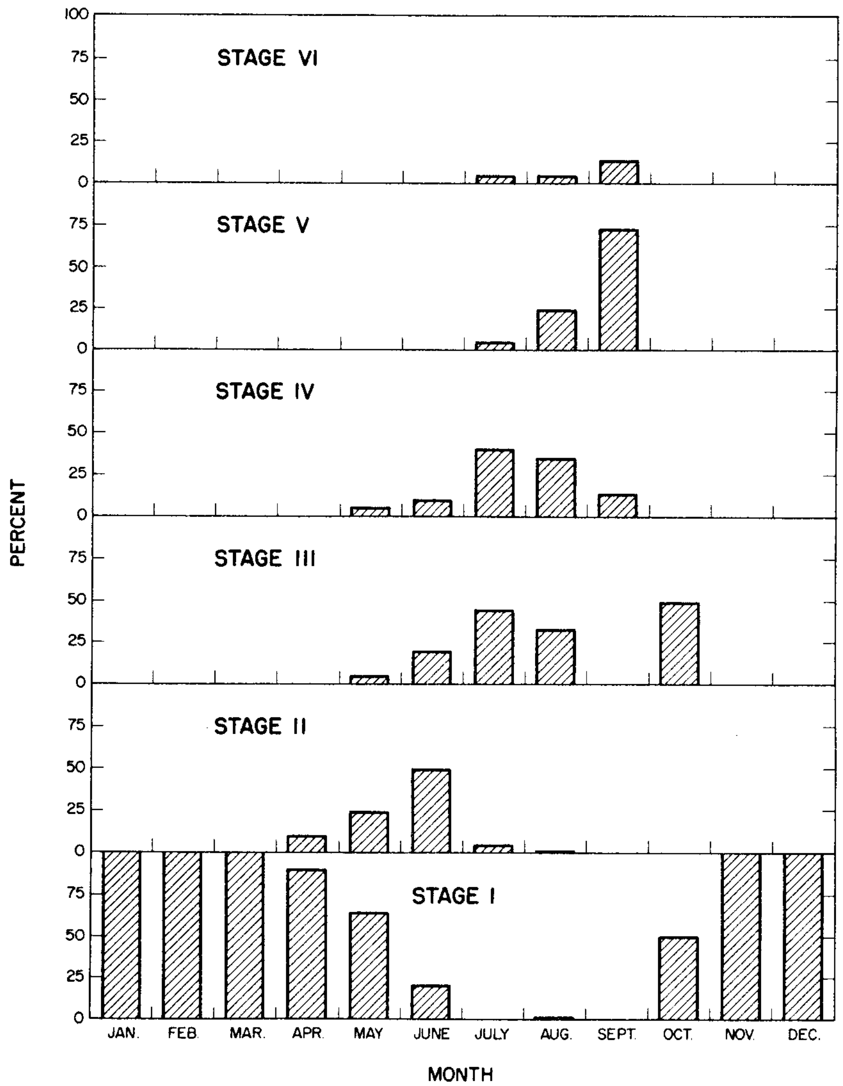

Figure 4. Monthly percentage of ehu ovaries in various stages of maturity, 1977-81

The presence of residual ova (Table 2) was highest (37 percent) in the postspawning phase of maturity and lowest in the maturing phase (3.4 percent).

TABLE 2. OCCURRENCE OF RESIDUAL OVA BY MONTH FOR EHU OVARIES 1977-81. MATURITY STAGES I to V OF DEVELOPING OVA ARE ALSO NOTED FOR EACH OVARY.

Month	Stage	Number	Percent
January	I	1	1.7
February	I	5	8.5
March	I	8	13.6
April	I	7	11.9
May	I	2	3.4
June	--	--	--
July	III	3	5.1
August	III, IV, V	8	13.6
September	--	--	--
October	I	2	3.4
November	I	19	32.2
December	I	2	3.4

Ova diameters were compared with maturity stage for five ovaries in different stages of development. Ova size increased with each advancing stage of development (Figure 5).

The results show that ehu may be multiple spawners and may release several batches of ova during a season. Evidence for multiple spawning is the presence of multiple modes in the ova diameter frequency distribution (Figure 6). Additionally, mature ovaries found during the spawning season contained residual ova (Table 2), and no ehu were found with ovaries that were completely spawned out (containing only stage I ova) until the end of the spawning season.

Maturation

Two separate criteria were evaluated to determine the relationship between maturity and size of fish. In this study, mature fish are defined as those with ovaries that contain developing (stage III) ova and have the potential to spawn during the current season. In contrast, ripe fish are defined as those with ovaries containing ripe (transparent - stages V, VI) ova and are considered imminent spawners with at least one batch spawned during the current season.

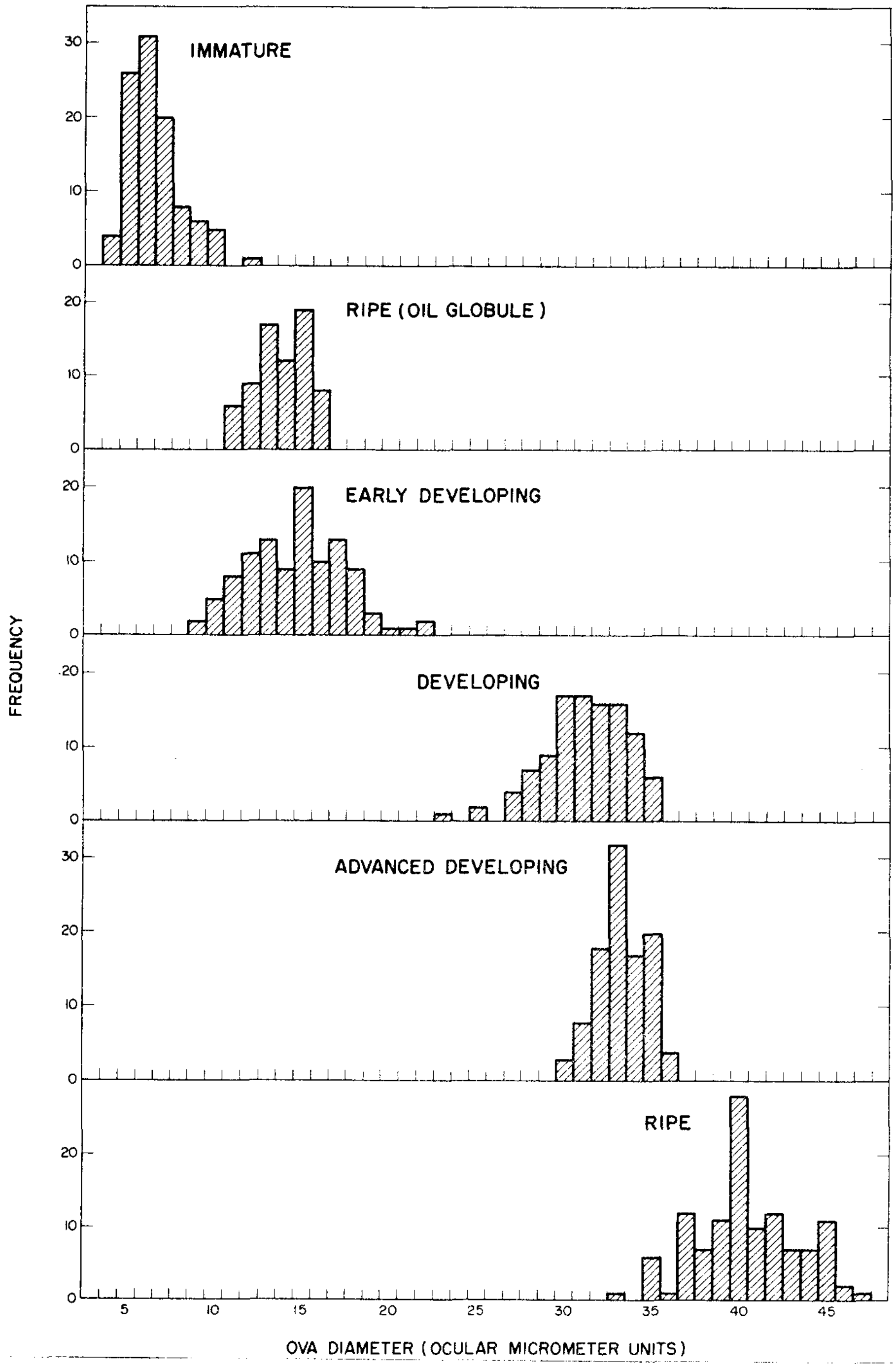

Figure 5. Ova diameter frequency distribution of the most advanced ova for five ehu in various developmental stages. Also shown is the size (diameter) frequency distribution of the oil globule in ripe ova. 1 mm = 72.5 ocular micrometer units

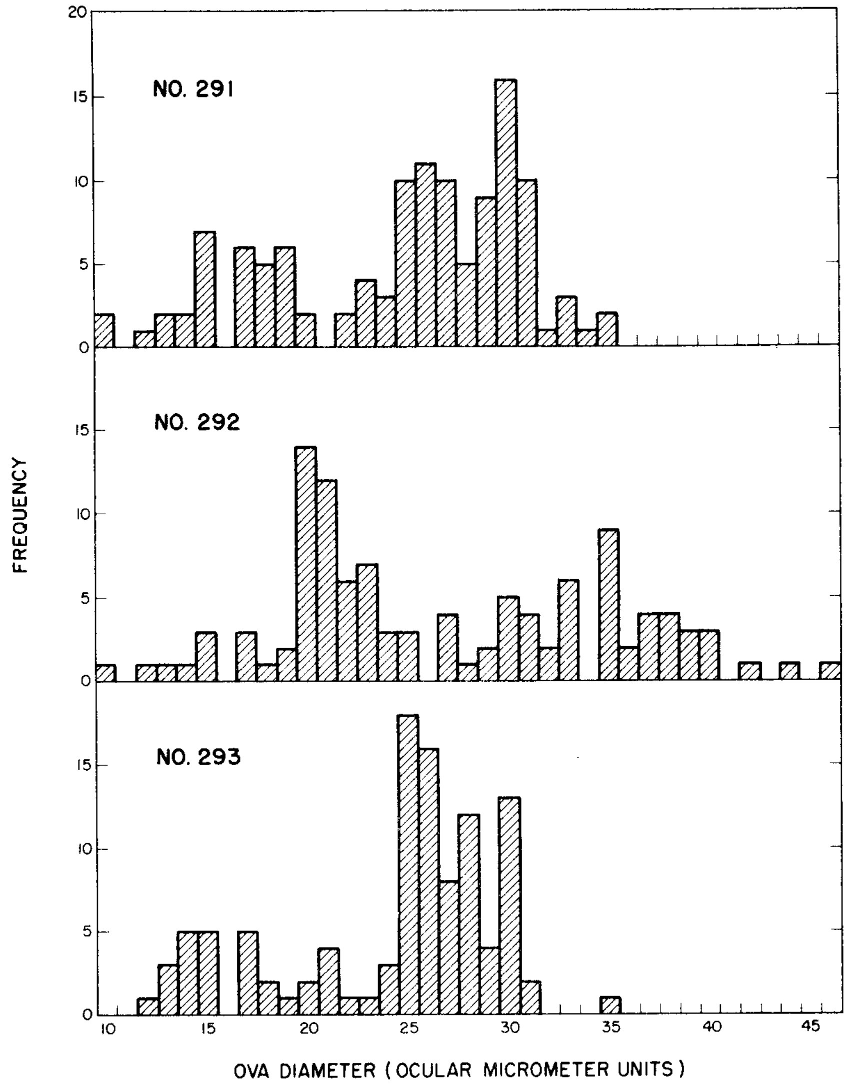

Figure 6. Ova diameter distribution in three ehu ovaries used in fecundity estimates. 1 mm = 72.5 ocular micrometer units

In May, 12 percent of the ehu were mature (Table 3); mature ehu increased to 95 percent by July. The fish captured from May to September ranged from 29.7 to 63.5-cm fork length (FL). Of these, the smallest fish considered mature was 29.8 cm. The proportion of mature fish in each 5-cm size class by month showed that 50 percent were mature in the 25 to 30-cm size class. The proportion increased sharply to 86 percent at 30 to 35 cm, then remained fairly stable through the rest of the size classes.

TABLE 3. THE PERCENTAGE OF MATURE (STAGES III TO VI) AND RIPE (STAGES V TO VI) EHU OVARIES BY FISH SIZE (FL) FOR EACH MONTH OF THE SPAWNING SEASON

Size Class	May	June	July	August	September	Total
25 - 30						
N	1	--	1	--	--	2
% M	0	--	100	--	--	50
% R	0	--	0	--	--	0
30 - 35						
N	--	1	1	5	--	7
% M	--	0	100	100	--	86
% R	--	0	0	33	--	33
35 - 40						
N	3	1	5	13	--	22
% M	0	0	80	100	--	77
% R	0	0	0	23	--	23
40 - 45						
N	7	6	5	19	--	37
% M	0	50	100	90	--	68
% R	0	0	0	26	--	13
45 - 50						
N	12	6	4	21	4	47
% M	17	50	100	90	100	68
% R	0	0	25	24	75	19
50 - 55						
N	4	9	2	21	2	38
% M	0	22	100	100	100	71
% R	0	0	0	24	100	18
55 - 60						
N	6	6	1	7	6	26
% M	33	17	100	100	100	65
% R	0	0	0	43	83	31
60 - 65						
N	--	1	1	--	2	4
% M	--	0	100	--	100	75
% R	--	0	100	--	100	75
Total						
N	33	30	22	86	14	185
% M	12	30	90	98	100	71
% R	0	0	9	27	86	20

Due to the limited number of samples at the lower size classes, it was difficult to determine the smallest size at which ehu reach sexual maturity. The available data indicate that at least some of the females are mature at 25 to 30 cm for age I (Uchiyama et al., in preparation) and that the majority are mature by the time they reach 35 to 40 cm or age II.

Ripeness as an indication of maturity showed a slightly different trend with size (Table 3). There were no ripe fish in the 25 to 30-cm range; the smallest fish with ripe ovaries was 31.8 cm; however, the small sample size at the lower end of the range may bias the data. The 30 to 35-cm range showed a 33 percent increase in the number of ripe fish. In July, 9 percent of the ehu had ripe-appearing ova and no fish <45 cm was ripe. By August, small (<45 cm) ripe fish began to appear and the number of ripe to nonripe increased to 27 percent. In September, 86 percent of all fish caught were ripe, but fish <45 cm were not represented.

Sex Ratio

Sex ratio was determined from a total of 833 ehu collected over a 5-year period. The overall ratio for the period between 1977-81 deviated significantly from the expected 1:1; 557 (66.9 percent) were female and 276 (33.1 percent) were male. Each separate year also showed a significant deviation from 1:1. The sex ratio, calculated for each 5-cm size class, showed that for small ehu (25 to 30 cm), the female to male ratio was 1:1, but among larger (older) fish, there was a gradual increase in the percentage of females. The percentage of females in the 45 to 50-cm class was 65 percent, 84 percent in the 50 to 55-cm class, and 96 percent in the 55 to 60-cm class (Table 4). Contingency table analysis showed that sex ratio and size are not independent (χ^2 $P < 0.05$, d.f. = 7). An analysis of the difference in sex ratio for October and May to test for possible variation due to behavioral factors such as spawning aggregation or female feeding dominance showed no significant difference (Table 5). During the spawning months, however, the percentage of males in the sample dropped from 41 percent in June to 18 percent in August, rose slightly to 26 percent in September, before approaching near normal levels (for this population of ehu) of 38 percent in October. This suggests that sex ratio and season are also dependent (χ^2 $P < 0.01$).

TABLE 4. TEST TO DETERMINE THE DEPARTURE OF THE SEX RATIO OF EHU FROM 1:1 BY 5-CM FL INTERVALS. (DATA POOLED OVER 5 YEARS)

Fork Length (cm)	N	Females (%)	χ^2
25 - 30	12	50.0	0
30 - 35	48	45.8	0.33
35 - 40	114	59.6	4.24*
40 - 45	211	53.6	1.07
45 - 50	199	65.3	18.70*
50 - 55	162	84.0	74.68*
55 - 60	74	96.0	62.48*
60 - 65	10	90.0	6.40*

*$P < 0.05$

TABLE 5. TESTS OF THE HYPOTHESIS THAT SEX RATIO DID NOT VARY SIGNIFICANTLY WITHIN MONTHS OF THE YEAR FROM THAT OF THE ACTUAL POPULATION OF EHU (2:1)

Month	N	Females (%)	Contribution to Total χ^2
January	33	60.6	0.6
February	33	69.7	0.1
March	59	55.9	3.2
April	96	69.8	0.3
May	57	68.4	0
June	176	58.5	5.5
July	50	62.0	0.6
August	138	81.9	14.1
September	57	73.7	1.2
October	21	61.9	0.3
November	96	63.5	0.5
December	17	70.6	0.1

Note: Total $\chi^2 = 26.50$, d.f. = 11, $P < 0.01$

Fecundity

A linear regression using natural log transformed data provided the best fit when fecundity (F) was compared with fork length (FL)in centimeters and total body weight (W) in kilograms. The regression equations were $F = 0.05413\ (FL)^{4.32}$ and

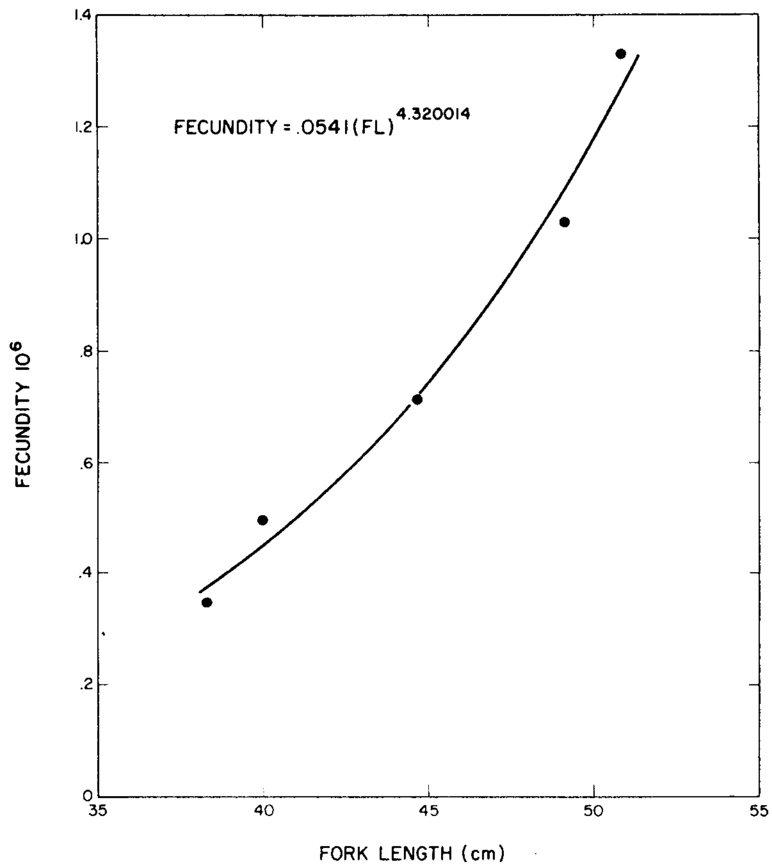

Figure 7. Length-fecundity relationship of ehu

$F = 3.412 \times 10^5 (W)^{1.38}$. This indicated that fecundity increased as a function of both length (r = 0.991) and weight (r = 0.987) (Figure 7). Because of the sample size (N = 5), the estimates of fecundity should be considered tentative, although the correlation for both indicators was quite high. The data did give an approximation of the number of ova spawned by a particular size range of fish. The estimated fecundity ranged from 349,600 to 1,325,600 for ehu between 38.3 and 50.8-cm FL and between 0.97 and 2.49 kg.

Regional Comparisons

To test for differences in spawning season among the three regions within the NWHI, monthly mean GSI versus region was compared. All three regions showed a similar trend of low GSI in January-June, increasing in July-September, then decreasing in October-December. The available data did not show any significant differences in monthly mean GSI among regions.

The sex ratio in regions 1 and 3 did not differ from that of the population ratio (2:1) whereas in region 2 the ratio was slightly skewed in favor of females (2.8:1).

DISCUSSION

Spawning Seasonality

Ehu begin maturing throughout the NWHI in May and spawn in July-September. This corresponds to the time of year when environmental conditions such as temperature and photoperiod are at a peak in this area (Uchida, 1977). Similar observations were made by Grimes and Huntsman (1980) on the vermilion snapper, *Rhomboplites aurorubens*, of North and South Carolina, by Crossland (1977) on the porgy, *Chrysophrys auratus*, in the Hauraki Gulf, and by Ralston (1981) for opakapaka, *Pristipomoides filamentosus*, in Hawaii. All of these investigators found snappers to be summer spawners. Ehu seem to have a shorter, more defined spawning season than many other snappers. Druzhinin (1970) reported that the spawning period of lutjanids may be very protracted, extending over a period of several months. In contrast, ehu in spawning condition were found only during a 3-month period. Spawning ceased in October when GSI values dropped and ovaries containing ripe ova were no longer found. Further degeneration takes place in November-December as indicated by a high percentage of residual ova in the ovaries during this period. Goldberg (1981) found atretic ova near the close of the spawning period when the ova that failed to complete yolk deposition underwent resorption.

Ehu appear to be serial spawners, that is, they release multiple batches of ova during the season. The actual mechanism for this type of spawning varies considerably among different species and depends to a large degree on the environmental conditions. In the Japanese horsemackerel, *Trachurus japonicus*, a dominant egg batch is spawned in the most favorable breeding period, then smaller batches are spawned under less favorable environmental conditions (Chigirinskiy, 1970). Crossland (1977) reported similar results in which serial spawning took place on an annual cycle where successive batches of ripe eggs matured from a stock of developing eggs. Results of this study indicate that a similar pattern occurs with ehu where a developing group of ova matures each year from a core of primary ova and various batches of ova ripen and are spawned each season from this developing stock. Further evidence of serial spawning is that spawned-out ovaries containing mainly primordial ova were not found until the end of the spawning season. This observation was also made for the black croaker, *Cheilotrema saturnum* (Goldberg, 1981). In addition, ehu ovaries contained ova in various stages of development throughout the spawning season, supporting the contention of Grimes and Huntsman (1980) that this may also indicate fractional spawning.

It can be concluded that ehu ovaries develop asynchronously (Wallace and Selman, 1981) throughout the year, but during the maturation phase they develop synchronously and batches of ova ripen and are spawned. The final stage, that is, from ripe to actual spawning, occurs very rapidly (Grimes and Huntsman, 1980), as evidenced by paucity of ripe females and the complete absence of hydrated ovaries in the samples. The absence of fish with ripe or hydrated ova may also be due to behavioral factors, i.e., fish feed less prior to spawning (Reshetnikov and Claro, 1976) or that running ripe fish may shed their eggs when lifted out of the water (Htun-Han, 1978). The latter explanation is very pertinent to ehu since they are caught in deep water and often experience severe stress from the change in pressure as they are brought to the surface.

Investigators have used various criteria to determine the minimum size of sexual maturity. Many feel that the presence of developing (type III) ova indicates that the fish is likely to spawn during the current season (Clark, 1934; Crossland, 1977; DeMartini and Fountain, 1981). For ehu, the presence of ripe (types V and VI) ova gave a better indication of the percentage of fish that will actually spawn in any size class. Ehu with mature (type III) ovaries began appearing in May and were always found in greater proportion than those with ripe ovaries. These fish have the potential to spawn, but many never reach the ripe stage due to environmental conditions (Chigirinskiy, 1970) or age constraints (Clark, 1934). The ova that did not mature would cease development and be resorbed. As with other snappers (Starck and Schroeder, 1971; Grimes and Huntsman, 1980) larger ehu (>45 cm) mature earlier in the season and remained in spawning condition longer than small (<45 cm) fish.

The smallest mature ehu caught was 29.8 cm, and 50 percent of the fish in the 25 to 30-cm size class had mature ovaries. In contrast, the smallest fish that had ripe ovaries was 31.8 cm, and 33 percent in the 30 to 35-cm size class were ripe. Because of the scarcity of small size classes, due possibly to hook selectivity (Ralston, 1982) or other behavioral factors, size at maturity could not be confidently estimated. The data indicated, however, that some ehu spawn during their first year at around 32 cm and that the majority spawn after age II (39 cm).

There appeared to be no differences in spawning season, maturation, and sex ratio for the three regions within the study area. Apparently the change in the environment accompanying the change in latitude from Nihoa to Midway Islands is not significant enough to cause any fluctuation in the spawning within the NWHI.

Sex Ratio

The sex ratio of ehu (all samples pooled) deviated significantly from the expected 1:1 and also by size and season. There was a preponderance of females in nearly every category. A deviation in sex ratio among different size classes was also found in the vermilion snapper (Grimes and Huntsman, 1980). Female vermilion snapper increased to 60 percent of the sample at 25 to 30-cm total length (TL), to 70 percent at 50 to 55 cm, and to 90 percent above 55 cm, suggesting that this anomaly resulted from differential mortality and longevity. The data for ehu show an even greater disproportion of females in the upper size range (Table 5). This implies greater male mortality in the higher (>30 cm) size classes. Age and growth data for ehu are very limited; however, female _Lutjanus synagris_ grow more rapidly and survive to a greater age than males (Reshetnikov and Claro, 1976).

The data for the sex ratio of ehu over the year show that, during the prespawning month of June, the ratio of males increases to about 41 percent then decreases to 18 percent during the peak spawning period in August (Table 4). This suggests behavioral changes during the spawning season such as feeding response and spawning aggregations by females.

Fecundity

Estimates of fecundity for ehu are slightly higher than those for the vermilion snapper. Estimates of the fecundity of vermilion snapper ranged from 8,168 to 1,789,998 ova for 41 females 229 to 557-mm TL (Grimes and Huntsman, 1980). The estimates for ehu ranged from 349,000 to 1,325,600 for fish between 38.3 and 50.8 cm and are based on the total number of eggs that may be spawned under ideal environmental conditions in a given season.

Because ehu is a multiple spawner, the estimates may be less precise since it is difficult to determine the number of spawnings per year and the number of eggs per spawning (Hunter and Goldberg, 1980). Environmental conditions may determine whether some or all of the batches may be spawned (Chigirinskiy, 1970). Also, the relationship among the number of maturing ova in an ovary, the number of ova spawned, and the viable larvae produced are unknown. Therefore, considering all these factors, fecundity estimates for ehu represent an approximation of its reproductive potential.

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