A PRELIMINARY REPORT ON BOTTOMFISHING IN THE NORTHWESTERN HAWAIIAN ISLANDS

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ABSTRACT

Regional and day-night differences in the distribution and catchability of bottomfishes are shown through analysis of catch data collected by the National Marine Fisheries Service on cruises of the NOAA ship Townsend Cromwell in the Northwestern Hawaiian Islands. Large catches of opakapaka, Pristipomoides filamentosus, in the Nihoa to Gardner Pinnacles region are replaced by those of hapu'upu'u, Epinephelus quernus, further up the chain. Mean fish weight for several species increases going up the chain, possibly due to fishing pressure in the Nihoa to Gardner Pinnacles region. Day fishing results in a greater catch rate than night fishing. Preliminary growth estimates indicate that opakapaka takes 3.25 yr. and kahala, Seriola dumerili, takes 1.75 yr. to attain a 70-cm fork length.

bottomfish
age and growth
distribution and relative abundance

INTRODUCTION

With the creation of the 200-mile Fishery Conservation Zone in 1976 and the extensive fishing pressure around the main islands of Hawaii came the need for marine resource assessment of the Northwestern Hawaiian Islands (NWHI). Under the Tripartite Cooperative Agreement, the Southwest Fisheries Center Honolulu Laboratory, National Marine Fisheries Service (NMFS) assumed responsibility for the quantitative fishery assessment and survey of benthic slope and pelagic resources of the NWHI (Uchida et al., 1979). One major portion of our responsibility is the deepwater bottomfish resource.

At present, the NWHI bottomfish resource supports a small commercial fishery which has been in existence since at least 1948. Due to the long distance between the NWHI and marketing ports, most of the commercial fishing effort has been limited to the area between Nihoa and Gardner Pinnacles.

The Insular Resource Task of NMFS has examined various aspects of biological and fishery data on the NWHI demersal fishery. Studies on the feeding habits (see paper by Humphreys), spawning and fecundity (see paper by Kikkawa), occurrence of ciguatoxin (see paper by Ito and Uchida), and age and growth (J.H. Uchiyama, Southwest Fisheries Center Honolulu Laboratory, NMFS, NOAA, Honolulu, Hawaii 96812, personal communication, March 1980), are in various stages of completion. This report will discuss the distribution and relative abundance of the demersal fishes obtained from our survey cruises and the progress on age and growth studies on opakapaka, *Pristipomoides filamentosus*, and kahala, *Seriola dumerili*.

MATERIAL AND METHODS

The sole source of information used in this paper is the catch data obtained by NMFS on cruises of the *Townsend Cromwell* from October 1975 to May 1979. During this period, the *Cromwell* occupied 112 handline fishing stations on eight cruises in the NWHI. Except where otherwise stated, all references to catch refer to the catch of the eight most important commercial species caught by the *Cromwell*: opakapaka; ehu, *Etelis marshi*; onaga, *E. carbunculus*; kalekale, *P. sieboldii*; gindai, *P. zonatus*; butaguchi, *Caranx cheilio*; kahala; and hapu'upu'u, *Epinephelus quernus*.

Fishing operations were conducted while drifting near the edge of the banks at bottom depths varying from 30 to 200 fathoms. Our handline gear consisted of lines with from 2 to 15 hooks (Nos. 20 to 30) per line. We generally used hydraulic or electric gurdies to aid in line retrieval and occasionally fished manually retrieved lines as well. The most commonly used bait was stripped squid. In processing the catch, we recorded species, sex, weight, and both standard and fork or total length measurements. Where appropriate, we preserved gonads, stomachs, tissue samples, and otoliths for future analysis at the laboratory.

On the *Cromwell* we usually retrieve lines as soon as one fish is on, regardless of the number of hooks we are using. For this reason, I chose line-hours rather than hook-hours as an estimate of fishing effort. In data analysis, I used catch per unit effort (CPUE) by station both for weight (kilogram) and numbers of each species as two measures of relative abundance and catchability.

I used analysis of variance (ANOVA) to test the null hypothesis that location in the chain, species, and day-night factors have no effect on CPUE. Since there were insufficient data to allow for a bank-by-bank analysis, I divided the project area into three regions. Region I, Nihoa through Gardner Pinnacles, represents the area fished by commercial vessels on a regular basis. Region II, Raita Bank through Lisianski Island, is separated from Region III, Pearl and Hermes Reef through Kure Atoll, by a natural break in the chain. In the test for day and night differences in catchability, the separations between day and night stations were not distinct, so I arbitrarily placed data into day or night categories depending on whether most of the fishing effort occurred before or after 0600 and 1930 hours.

We followed the methods of Struhsaker and Uchiyama (1976) in cleaning, mounting, and reading otoliths for age determinations.

RESULTS

The CPUE of the combined catch of all commercial species varied considerably among stations. Many stations had no catch at all whereas at one Midway Island station, the catch rate was 43.3 kg/line-hour (9.3 fish/line-hour). On a bank-to-bank basis, overall catch rates ranged from 0 at Salmon Bank and an unnamed bank northeast of Midway to 12.6 kg/line-hour (3.1 fish/line-hour) at Pearl and Hermes Reef. A portion of this variation may be due to the wide range in fishing effort at the various stations and banks (0.5 to 32.3 line-hours and 3.3 to 231.7 line-hours, respectively). Regional catch data for each species are presented in Table 1 for day, night, and overall catches. Table 2 compares day and night CPUE by weight for each species. Catch composition of the five major species in numbers by region is displayed in Figure 1 (onaga, gindai, and kalekale make up such a small portion of our catch that they are not included in this figure). Table 3 lists the incidental species caught with their overall catch rates.

In a three-way ANOVA of CPUE in terms of weight, significant differences in CPUE were found among regional ($P = 0.02$), species ($P = < 0.01$), and day-night ($P = 0.01$) classifications and with region to species ($P < 0.01$) and species to day-night ($P = 0.02$) interactions. In a three-way ANOVA with CPUE in terms of numbers, however, significant differences were found in only three cases: species, day-night, and region to species. In a one-way ANOVA of mean fish weight by region for each species, significant differences were found for ehu between Regions I and II, and I and III; hapu'upu'u between Regions I and II; kahala between Regions I and III; and gindai between Regions I and II. Results of a chi-square test of the number of fish caught by species by region show significant differences in species composition by region.

We have collected otoliths from fish of all of the commercially important species mentioned in this paper. Preliminary growth curves for opakapaka (Figure 2) and kahala (Figure 3) have been estimated from otolith examinations (Uchiyama, personal communication, March 1980). Laboratory, NMFS, NOAA, Honolulu, Hawaii 96812, personal communication, March 1980).

TABLE 1. COMMERCIAL CATCH DATA FOR BOTTOMFISH IN THE NORTHWESTERN HAWAIIAN ISLANDS

Species	Region I				Region II				Region III			
	Catch		CPUE		Catch		CPUE		Catch		CPUE	
	No.	Weight (kg)	No.	Weight (kg)	No.	Weight (kg)	No.	Weight (kg)	No.	Weight (kg)	No.	Weight (kg)
All species												
Day	589	2,028.6	1.815	6.251	321	1,506.2	1.785	8.377	178	769.2	1.841	7.954
Night	219	707.2	1.117	3.608	72	369.2	0.769	3.944	113	456.0	1.447	5.839
Total	808	2,735.8	1.552	5.256	393	1,875.4	1.437	6.860	291	1,225.2	1.665	7.009
Ehu												
Day	99	132.2	0.305	0.407	90	195.8	0.501	1.089	67	136.8	0.693	1.415
Night	62	105.7	0.316	0.539	21	42.8	0.224	0.457	30	46.1	0.384	0.590
Total	161	237.9	0.309	0.457	111	238.6	0.406	0.873	97	182.9	0.555	1.041
Opakapaka												
Day	245	817.3	0.755	2.519	40	163.4	0.222	0.909	0	0	0	0
Night	89	255.0	0.454	1.301	4	15.8	0.043	0.169	7	34.3	0.090	0.439
Total	334	1,072.3	0.642	2.060	44	179.2	0.161	0.655	7	34.3	0.040	0.196
Hapu'upu'u												
Day	75	424.9	0.231	1.309	79	562.2	0.439	3.127	57	338.4	0.589	3.499
Night	17	114.1	0.087	0.582	22	147.0	0.235	1.571	47	203.2	0.602	2.602
Total	92	539.0	0.177	1.036	101	709.2	0.369	2.594	104	541.6	0.595	3.098
Butaguchi												
Day	66	409.1	0.203	1.261	55	297.4	0.306	1.654	32	162.7	0.331	1.683
Night	7	24.5	0.036	0.125	8	37.1	0.085	0.396	7	35.8	0.090	0.458
Total	73	433.6	0.140	0.833	63	334.5	0.230	1.223	39	198.5	0.223	1.136
Kahala												
Day	36	173.6	0.111	0.535	30	232.3	0.167	1.292	8	96.8	0.083	1.001
Night	22	183.0	0.112	0.934	11	114.4	0.118	1.222	15	117.2	0.192	1.501
Total	58	356.6	0.111	0.685	41	346.7	0.150	1.268	23	214.0	0.132	1.224
Gindai												
Day	25	35.3	0.077	0.109	22	36.3	0.122	0.202	0	0	0	0
Night	5	8.6	0.026	0.044	5	11.0	0.053	0.117	0	0	0	0
Total	30	43.9	0.058	0.084	27	47.3	0.099	0.173	0	0	0	0
Kalekale												
Day	42	28.5	0.129	0.088	2	1.2	0.011	0.007	8	3.8	0.083	0.039
Night	16	9.8	0.082	0.050	1	1.1	0.011	0.012	5	3.7	0.064	0.047
Total	58	38.3	0.111	0.074	3	2.3	0.011	0.008	13	7.5	0.074	0.043
Onaga												
Day	0	0	0	0	3	15.8	0.017	0.088	6	30.7	0.062	0.317
Night	1	6.6	0.005	0.034	0	0	0	0	2	15.6	0.026	0.200
Total	1	6.6	0.002	0.013	3	15.8	0.011	0.058	8	46.3	0.046	0.265

TABLE 2. OVERALL CATCH PER UNIT EFFORT FOR DAY AND NIGHT FISHING STATIONS

Species	CPUE (weight)		Ratio
	Day	Night	
Ehu	0.77	0.53	1.45
Opakapaka	1.63	0.53	1.96
Hapu'upu'u	2.21	1.26	1.75
Butaguchi	1.45	0.26	5.58
Kahala	0.84	1.13	0.74
Gindai	0.12	0.05	2.40
Kalekale	0.06	0.04	1.50
Onaga	0.08	0.06	1.33
All species together	7.16	4.17	1.72

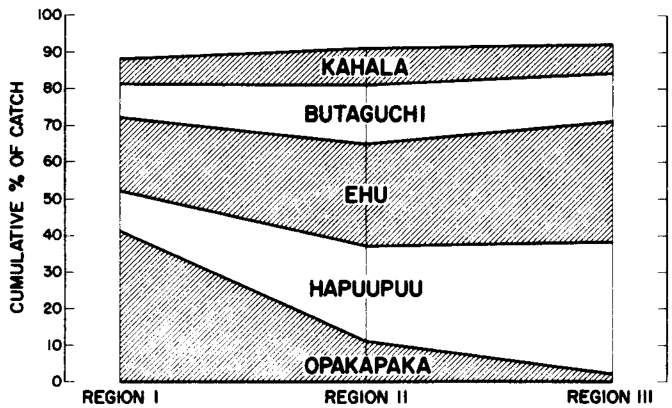

Figure 1. Catch composition by region in terms of numbers

TABLE 3. CATCH OF INCIDENTAL SPECIES IN THE NORTHWESTERN HAWAIIAN ISLANDS

Species	Catch		CPUE	
	Number	Weight (kg)	Number	Weight (kg)
Gempylidae				
Promethichthys prometheus	47	20.6	0.049	0.021
Carangidae				
Caranx lugubris	13	41.0	0.013	0.042
C. ignobilis	38	349.7	0.039	0.361
C. speciosus	1	0.9	0.001	0.001
C. sexfasciatus	1	0.7	0.001	0.001
C. melampygus	3	11.6	0.003	0.012
Carangoides ferdau	3	18.1	0.003	0.019
Elagatis bipinnulatus	2	20.2	0.002	0.021
Priacanthidae				
Priacanthus sp.	5	2.7	0.005	0.003
Holocentridae				
Myripristis sp.	6	2.0	0.006	0.002
Tetraodontidae (*Sphoeroides cutaneus* and *Lagocephalus* sp. included)	17	9.1	0.018	0.009
Scorpaenidae				
Pontius macrocephalus	9	10.7	0.009	0.011
Scorpaenopsis cacopsis	1	1.5	0.001	0.002
Scorpaena colorata	1	0.7	0.001	0.001
Labridae				
Bodianus bilunulatus	5	5.7	0.005	0.006
B. oxycephalus	7	14.1	0.007	0.015
Lutjanidae				
Aprion virescens	1	7.5	0.001	0.008
Pristipomoides auricilla	2	1.6	0.002	0.002
Scombridae				
Scomber japonicus	3	5.2	0.003	0.005
Sarda orientalis	3	13.3	0.003	0.014
Mullidae				
Mulloidichthys pflugeri	1	1.4	0.001	0.001
Parupeneus porphyreus	1	1.4	0.001	0.001
Sphyraenidae				
Sphyraena sp.	4	4.0	0.004	0.004
Synodontidae				
Trachinocephalus myops	1	0.6	0.001	0.001
Muraenidae				
Gymnothorax berndti	1	0.9	0.001	0.001
Squalidae	2	7.3	0.002	0.008
Carcharhinidae	8	--	0.008	--

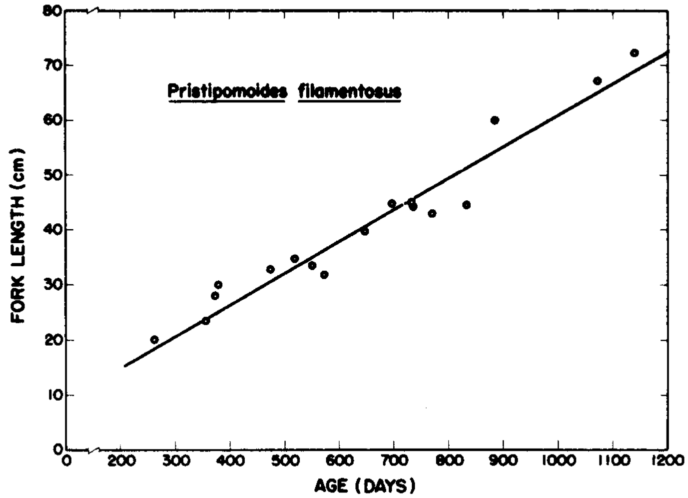

Figure 2. Preliminary growth curve for opakapaka, Pristipomoides filamentosus

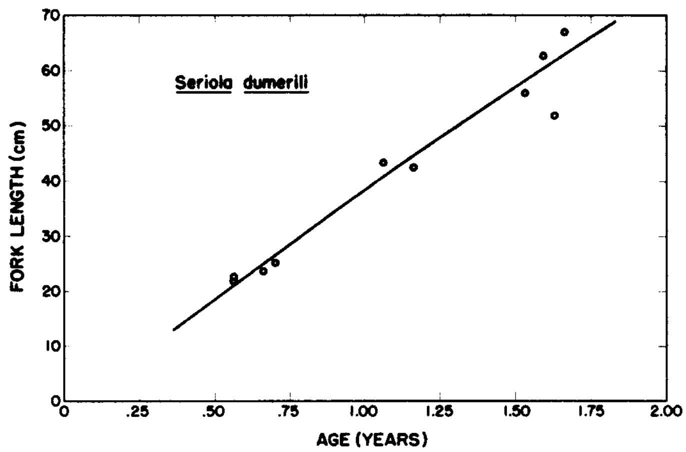

Figure 3. Preliminary growth curve for kahala, Seriola dumerili

DISCUSSION AND CONCLUSIONS

The three-way ANOVA tests showed that the regional increase in overall CPUE in terms of weight for the combination of all commercial species presented in Table 1 is significant ($P = 0.02$) whereas the change in CPUE in terms of number is not ($P = 0.12$). This results in an increase, by region, in the mean weight of the hypothetical composite commercial bottomfish. There are two possible explanations for this increase. Either the mean weight of individuals within a species is increasing or a generally larger species comprises a greater percentage of the catch on a regional basis from Regions I to III. To check on the first possibility, I ran a one-way analysis of variance of mean fish weight by region for each species. As mentioned in the results section, ehu, kahala, gindai, and hapu'upu'u showed significant regional differences in mean weight. Also, in all significant cases, mean weight increased between Regions I and II or I and III. Thus, increase in mean weight of fish by species does contribute to the overall increase in CPUE by region. This may be an indication of fishing pressure in Region I where mean weights were significantly lower for these species, or it may be due to other factors such as temperature or habitat differences between regions.

The significant difference in CPUE in terms of numbers by species by region shown in the three-way ANOVA indicates that there is a change in species composition by region, as well. Cell values for variance in the chi-square test showed that opakapaka and hapu'upu'u are major contributors in this difference. These changes in relative abundance for opakapaka and hapu'upu'u are shown graphically in the species composition by region (Figure 1). The difference in overall mean weights for opakapaka (4.0 kg) and hapu'upu'u (6.8 kg) indicates that the regional change in the species composition is also a factor in the regional increase in CPUE in terms of weight.

Day and night differences in catchability are also significant. Results of the three-way ANOVA show that day and night CPUE in terms of weight is significantly different on both an overall and by-species basis. Differences in day and night CPUE are presented in Table 2 as the ratio of day CPUE to night CPUE. As can be seen, the day CPUE is, in general, higher than the night CPUE. In fact, the only commercial species with a higher CPUE at night is kahala. The day-night difference is particularly noticeable for butaguchi where the day CPUE is over five times greater than the night CPUE. These differences in catchability may be due to changes in feeding activity between day and night or a nightly migration away from the areas that we normally fish. Similar trends were found for CPUE in terms of number, but they were not found to be significant on a species basis.

Commercially, fishing for opakapaka is usually conducted at night with night catches reported to be far better than day catches (C. Yamamoto, captain, FV *Koko*, Honolulu, Hawaii 96814, personal communication, May 1980 and W. Shinsato, captain, FV *Taihei Maru*, Honolulu, Hawaii 96814, personal communication, May 1980). That our results differ from the experiences of commercial fishermen is probably due to the differences in fishing techniques employed. On the *Townsend Cromwell* we fish close to the bottom while drifting for both day and night fishing operations. Commercial fishermen on the other hand, may drift fish during the day, but at night they usually anchor over opakapaka grounds, chum to aggregate the fish, and fish well off the bottom (up to 15 fathoms).

Our studies of age and growth of bottomfishes are still in the preliminary stages. We have made age estimates on a few specimens of each of the commercial species discussed in this paper. We still have many otoliths to read, but we do have enough data to establish tentative growth curves for opakapaka (Figure 2) and kahala (Figure 3). Because we have no data for fish outside of the size ranges of those used to generate the curves, estimates of age using these curves should be limited to fish falling within these ranges. For greater confidence in our growth estimates, we must verify the temporal nature of the suspected daily growth increments on otoliths. We are currently conducting experiments to mark otoliths by tetracycline injections in captive fish (e.g., opakapaka; akule, *Trachurops crumenophthalmus*; papio, *Caranx* sp.; and malu, *Parupeneus pleurostigma*) to verify the temporal periodicity of otolith growth increments.

FUTURE RESEARCH NEEDS

Much work remains to be done in this project. At the conclusion of the field work, we should have enough catch information to make a bank-by-bank analysis of distribution and relative abundance of bottomfishes in the NWHI. We should also have enough otoliths read to determine reliable growth curves for all the commercial species. Reliability of these curves, of course, will be largely dependent upon verification of the daily nature of the otolith growth increments. This, combined with future progress in other areas under current investigation (fecundity, spawning season, foraging habits, and ciguatoxin), will give us a fair understanding of the biology and catchability of bottomfishes in the NWHI.

There are other areas of investigation that would also be helpful. Recording the time of day that each fish is caught, rather than just the duration of the station as we presently do, would give a much better picture of the catchability of each species throughout the day. It is possible that there are some interesting relationships, such as increased catchability at dawn and dusk, that are obscured by present methods of data collection.

Fishing operations should be conducted while at anchor using chum to aggregate fish. This technique should produce high catches. Catch results using this technique could then be compared with those obtained while drift fishing.

A study of recruitment has been proposed by NMFS which is designed to exert heavy fishing pressure on a small bank followed by monitoring the recovery of fish stocks. Results from this study would produce a better estimate of bottomfish stocks in the NWHI than is now available.

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