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RECOLONIZATION OF A POPULATION OF SUPRATIDAL FISHES AT ENIWETOK ATOLL, MARSHALL ISLANDS

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RECOLONIZATION OF A POPULATION OF SUPRATIDAL FISHES AT ENIWETOK ATOLL, MARSHALL ISLANDS

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INTRODUCTION

The field work and most of the identifications of fishes for this study were carried out during July 1965 at the Eniwetok Marine Biological Laboratory of the University of Hawaii while I was assisting Dr. Gerald J. Bakus in a study of the grazing effects of reef fishes. A small supratidal pool was noticed near a large quarry which we visited frequently during the fish-grazing study. Rotenone was applied to the pool early in July and yielded a large number of fishes and an especially large biomass of the moray eel *Gymnothorax picta*. It was decided at that time to repoison the pool at the end of July and compare the species composition, biomass and ecology of the fishes present in each collection in order to ascertain the rate and manner of recolonization of the fish population and something about its trophic structure.

The phenomenon of plant succession has been frequently discussed and is rather well known. The accompaying animal succession has been less well studied, but seems to closely follow the same pattern as plant succession, e.g. certain pioneer species appear initially and are replaced by a sequential series of populations until a relatively stable climax community is established. Numerous studies have been done on succession of protozoa in culture jars (Bick, 1967a; 1967b), on the establishment of marine invertebrate communities on newly constructed or specially prepared substrates (Reish, 1964, Poore, 1968) and on seral succession of fishes in ponds and marshes (Shelford, 1911a; 1911b). All these animal succession studies really involve plant succession as well. In both cases the flora and fauna are concurrently undergoing seral changes. The present study is unique in that only the fish population (and certain invertebrate species) were removed from the community. The rather sparse algal community was not apparently affected directly by the ichthyocide.

DESCRIPTION OF HABITAT

A general description of the Marshall Islands and their climate has been given by Hiatt and Strasburg (1960). The tidepool under consideration was located on the windward reef side of Eniwetok Island (11°21'N; 162°20'E) one of the chain of islands forming Eniwetok Atoll. The pool, although facing the open sea, was protected from excessive wave action by a shallow reef flat which extended about 200 meters offshore. With the aid of Coast and Geodetic Survey tide tables, the surface of the tidepool was estimated to lie about .95 m above mean sea level. Daily high tides progressed from 1.1 m on July 7 to 1.6 m on July 29. Thus, the pool in question was flooded daily throughout the study period.

The measured range of temperature variation in the pool during the study period was from 28° to 32°C. The lowest reading was taken in the morning on a rainy overcast day and probably

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approximates the true low temperature for the pool during July. The highest temperature was recorded at midday on July 7, although this was surely surpassed on other days when measurements were not taken. The water in the pool was generally clear, but turned slightly brown in color after several hours of insolation.

The study pool consisted of a 20 m by 40 m depression in old limestone pavement. The depth was a rather uniform 0.2 m, but at one point reached 0.4 m. The sides and much of the bottom consisted of coral rock and rubble; part of the bottom was covered by sand.

Little life except a few fish were evident at first glance, but a considerable number of fishes of different species were collected by poisoning. Other conspicuous larger organisms revealed by turning over rocks and by the poison were xanthid crabs, hermit crabs (Diogenidae) and octopods. The flora consisted principally of green and blue-green filamentous algae.

MATERIALS AND METHODS

All fishes were collected with dip nets and by hand after poisoning with Pro-Noxfish. Two collections were made: on July 7 and 22 days later on July 29. The behavior of fishes was observed intermittently before July 7 and during the period between the two collections. The majority of the fishes were identified at the Eniwetok Marine Biological Laboratory by means of the literature and by comparison with Laboratory reference specimens identified by Dr. John Randall. Specimens of each species were counted, the ranges in standard length taken and the moist formalin weight recorded. Later, the average weight was computed for each species in both collections (Table 1).

The trophic level of each species of fish was determined using Hiatt and Strasburg (1960) where applicable. Direct examination of gut contents was made in other cases and on 15 specimens of *Gymnothorax picta*.

The percentages by weight of herbivorous, omnivorous and carnivorous fishes were calculated for each collection (Table 2). Percentages for the first collection were determined twice: once including all fishes and the other excluding the moray eel *Gymnothorax picta*. This was done in order to better compare the trophic structure of each collection, because *G. picta* accounted for such a large percentage (44.8%) of the total biomass of the first collection and was absent from the second collection.

TROPHIC STRUCTURE OF THE FISH POPULATION

Little has been said about the community organization of tidepools. I have been unable to find any reports on the trophic structure of the fishes of a tidepool community.

Carnivorous or partially carnivorous fishes make up the greatest biomass in the first collection even if *G. picta* is excluded from the calculation. These top-heavy pyramids are, of course, based on fishes alone and do not represent the complete trophic structure of the pool. Likewise, such a predominance of secondary consumers is not surprising in a zone which receives daily a great accumulation of organic matter from the highly productive neritic zone.

When biomass distribution of the first collection (excluding *G. picta)* is compared with the trophic structure of the second collection it is seen that the percentages of fishes representing different trophic levels is roughly comparable (Table 2). Thus, the original trophic structure of the fish population was re-established within three weeks or sooner after the initial poisoning.

RECOLONIZATION OF THE FISH POPULATION

Thirty-three species belonging to 16 families were present in the two collections. Only five species, a snapper *(Lutjanus gibbus)*, two tangs *(Acanthurus elongatus* and *A. nigricans)* and two puffers *(Arothron meleagris* and *A. nigropunctatus)* were present in the second collection, but not in the first.

The species diversity was strikingly reduced in the second collection, although each family taken in Collection No. 1 was usually represented in the second collection by some specimens of the commonest species of that family. The total fish biomass was also greatly reduced even though the pool was inhabited by fishes the day after the poisoning, and free access to the pool was possible at least once a day (high tides of 1.1 to 1.6 m) during the three weeks between poisonings. The average size of specimens in Collection No. 1 was 5.26 gm (3.02 gm excluding *G. picta)* compared to 0.362 gm in Collection No. 2. At 1300 hours on the day following the first poisoning, several small specimens of *Abudefduf glaucus, Istiblennius edentulus* and *I. lineatus* were seen behaving normally. The pool apparently had been washed clean of poison and these fishes had gained entry to the pool during the high of 1.1 m at 0105 hours the night before. Two small morays *(Gymnothorax bikiniensis)* were seen lying on their backs in the middle of the pool at this time. Both were nearly dead and had probably entered the pool at night before it had been completely rinsed of poison.

Juveniles of the commonest species showed the greatest ability to repopulate the pool. Small specimens of *Abudefduf glaucus* and *Istiblennius edentulus* accounted for the majority, by weight and number, of the fishes taken in the second collection. Adults of the above mentioned species are territorial to a varying degree and perhaps for this reason adults from surrounding waters did not readily reach the barren pool. This, however, does not explain the lack of the species which do not exhibit territorial behavior.

In addition to the fishes, the only macroscopic organisms which appeared to be affected by rotenone were octopods and shrimps. Xanthid crabs and hermit crabs were not killed, and appeared to occur in equal numbers after the poisoning. The death of shrimps and possibly many smaller invertebrates could explain the decrease in numbers of omnivores and carnivores. Filamentous algae, the principal producer in the pool, seemed unaffected, but supported a much smaller herbivore population after the poisoning; acanthurids and mugilids decreased greatly in numbers and weight.

Young of the snapper *Lutjanus gibbus* appear to have replaced the four species of *Epinephelus* which were taken in the first collection. These species seem to have similar niches when young. They are carnivores and lurk around and under ledges searching for prey. The puffer *Canthigaster solandri* was collected in equal numbers (10) in both collections, but the day before the second collection an estimated 200-300 specimens were observed in the same pool. Thus the day to day fluctuation in numbers of certain species is very great and much useful information could be obtained by daily poisoning of such a tide pool.

The reduction of the invertebrate fauna by rotenone may partially explain the reduction in the fish population, but probably several other factors were involved. Perhaps the pool, while no longer poisonous to fishes, retained an odor of rotenone which was disagreeable to some species for several weeks. Tidepools may be populated irregularly, depending upon breeding periods and tidal amplitude. Certain fishes are quite wary when placed in an uninhabited aquarium and never behave normally unless surrounding by numbers of other fishes. Fishes washed into an uninhabited tidepool may experience this same sensation and avoid such a tidepool. Very small fishes are likely to be washed from pool to pool frequently, but many become territorial and remain in the same pool much longer when they reach a larger size. This may partially explain why very small fishes are the principal "pioneers" of a recently poisoned pool.

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SUMMARY

It has been shown that three weeks after poisoning a tidepool with rotenone the fish population was much reduced in species diversity, numbers and biomass, although the trophic structure was not greatly altered. Reduction of invertebrates, odor of rotenone and habits of juvenile fishes are cited as possible reasons for a delay in repopulation of the pool.

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Table 1. A COMPARISON OF NUMBERS OF SPECIMENS, TOTAL WEIGHT, AVERAGE WEIGHT AND LENGTH OF SPECIMENS FROM FIRST AND SECOND COLLECTIONS

		COLLECTION NO. 1				COLLECTION NO. 2			
Species	Trophic Level	n	Weight (gm)	x̄	Standard Length (mm)	n	Weight (gm)	x̄	Standard Length (mm)
Muraenidae									
Gymnothorax picta	C	18	2357	130.9	61.8-605				
Holocentridae									
Holocentrus lacteoguttatus	C	6	29.5	4.9	47.4-67.2	1	2.7	2.7	45
Holocentrus sammara	C	1	1.1	1.1	35.7				
Holocentrus tieroides	C	1	3.2	3.2	48.1				
Mugilidae									
Crenimugil crenilabis	H	24	137.1	5.7	52.7-76.7	2	0.9	0.5	26.3-32.5
Neomyxus chaptalii	H	6	35.4	5.9	60.0-76.8				
Mugil cephalus	H	39	54.3	1.4	24.0-69.6				
Serranidae									
Epinephelus melanostigma	C	22	257.4	11.7	55.0-104				
Epinephelus spilotoceps	C	10	49.4	4.9	58.0-63.7				
Epinephelus merra	C	4	68.6	17.2	71.1-86.5				
Epinephelus socialis	C	4	73.6	18.4	75.2-105				
Lutjanidae									
Lutjanus gibbus	C					29	17.6	0.6	22.2-50.7
Kuhlidae									
Kuhlia taeniura	C	2	8.1	4.1	56.2-58.0				
Kuhlia marginata	C	1	1.8	1.8	43.6				
Mullidae									
Mulloidichthys samoensis	C	11	85.5	7.8	77.1-83.9				
Chaetodontidae									
Chaetodon lunula	O	1	6.4	6.4	50.8	1	0.4	0.4	19
Centropyge flavissimus	H	1	0.4	0.4	19.0				

Table 1. (cont.)

Species	Trophic Level	COLLECTION NO. 1				COLLECTION NO. 2			
		n	Weight (gm)	$\bar{x}$	Standard Length (mm)	n	Weight (gm)	$\bar{x}$	Standard Length (mm)
Acanthuridae									
Acanthurus triostegus	H	152	372.5	2.5	22.5-54	28	16.9	0.6	22.0-27.5
Acanthurus elongatus	H					1	0.8	0.8	28.0
Acanthurus nigricans	H					2	1.6	0.8	26.9-28.0
Pomacentridae									
Abudefduf glaucus	O	331	438.3	1.3	13.0-51	317	48.1	0.2	12.5-24.0
Abudefduf sordidus	O	8	25.9	3.2	30.0-61.2	1	0.2	0.2	18.0
Labridae									
Thalassoma umbrostygma	C	1	0.4	0.4	28.0				
Gobiidae									
Bathygobius fuscus	C	75	224.6	3.0	13.7-77.0	13	13.9	1.1	11.5-55
Pandaka pruinosa	C	2	0.25	0.1	18.0				
Kelloggella oligolepis	C	3	0.05	0.05	13.5-17.1				
Blenniidae									
Istiblennius edentulus	O	215	981.3	4.6	12.4-102	55	42.6	0.8	18.9-78.0
Istiblennius lineatus	O	8	28.4	3.6	25.1-86.5	5	15.3	3.1	37.4-85.5
Istiblennius paulus	O	1	0.25	0.25	37.2				
Tripterigiidae									
Tripterygion minutus	C	1	0.05	0.05	18.3				
Tetraodontidae									
Arothron meleagris	O					1	0.6	0.6	17.6
Arothron nigropunctatus	O					1	0.5	0.5	16.3
Canthigasteridae									
Canthigaster solandri	H	10	15.0	1.5	18.6-38.9	10	6.8	0.7	17.0-29.0
Totals		958	5255.8	5.26		467	168.9	.362	

Table 2. BIOMASS IN GRAMS AND PERCENT OF TOTAL FOR EACH TROPHIC LEVEL FROM THE FIRST AND SECOND COLLECTIONS

COLLECTION NO. 1 (TOTAL FISHES)

	gm	%
Herbivores	614.7	11.7
Omnivores	1480.6	28.2
Carnivores	3160.5	60.1
	5255.8	100.0

COLLECTION NO. 1 (TOTAL FISHES EXCLUDING *G. PICTA)*

	gm	%
Herbivores	614.7	21.2
Omnivores	1480.6	51.1
Carnivores	803.5	27.7
	2898.8	100.0

COLLECTION NO. 2 (TOTAL FISHES)

	gm	%
Herbivores	27.0	16.0
Omnivores	107.7	63.8
Carnivores	34.2	20.2
	168.9	100.0