

The Ichthyofaunal Composition of the
Artificial Liberty Ship Reef at
Port Aransas, Texas

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Submitted by
Scott Holt
and
Connie Arnold

The University of Texas Marine Science Institute
Port Aransas Marine Laboratory

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INTRODUCTION

Artificial reefs have been used for over a century in the U.S. to establish habitat for fishes. Artificial reefs have been constructed of scrap metal, scrap cement and cinder blocks, old tires and automobile bodies as well as other materials. Some of these were well designed and wisely placed while others were little more than excuses to dump trash into the ocean.

Most reefs placed within about 20 miles of shore are quite popular with fishermen. Fifty-nine percent of the offshore fishing out of Galveston-Freeport in 1977 was around artificial reefs, including oil rigs (Ditton and Graffe, 1978). Several studies have been conducted on the development of artificial reef communities (Randall, 1963; Fager, 1971; Smith et al. 1979). While it is clear that most reefs develop an epibenthic or fouling community and at least attract recreationally important fish, the role of these reefs in increasing production of recreational and commercial fish species has not been documented.

During the winter 1976, three Liberty Ships were sunk in 115 ft of water 18 miles offshore from Port Aransas by the Texas Coastal and Marine Council to produce an artificial reef. Although no research was initiated to follow the early development of the reef community on the ships a study was begun in June 1977 (Vetter and Roels, 1977) to assess the use of the ship reef for recreational fishing and subsequent studies (Vetter and

Roels, 1978a, 1978b) examined the fish populations on the ship reef. This report details continued investigation into the population dynamics of recreationally important fish species on the Liberty Ship reef with special emphasis on red snapper.

METHODS

One four-day trip, 5 two-day trips and 2 one-day trips were made on the R/V LONGHORN to the Liberty Ship reef between March 1979 and January 1980. These trips were spaced evenly throughout the year to determine the seasonal composition of the ichthyofauna. Several trips were also made to the near shore oil rigs and one trip was made to "Steamer", a natural rock outcropping at a depth of 29m off Padre Island near Port Mansfield.

A variety of collecting techniques were used on each trip to adequately access the ichthyofaunal populations on the Liberty Ship reef. Some methods proved more successful than others. Those methods tried were: traps, fishing with rod and reel, in situ observations utilizing SCUBA, vertical longlines, horizontal longlines, and gill nets. The latter three were least successful.

Gill net

A 30.5 cm stretch mesh 18.25 m monofilament gill net was used for this study. The net was heavily weighted on one end with a 12 kg cement block and suspended vertically from the deck of a Liberty Ship. Two small floats were placed at the

upper end of the net to keep it vertical in the water. Six pieces of 1.9 cm diameter PVC, spaced evenly throughout the length of the net, were used as spreaders to keep the 1.8 m wide net fully open.

The net was placed on the deck of one of the three ships and left for 1 hour. One set was made on each trip and all sets were made during the day.

Horizontal Longline

The longline consisted of a .95 cm diameter hard laid nylon line, 300 m in length, with mustad tuna circle hooks spaced approximately 2 m apart along the length of the line. The longline was stretched taut and held with anchors and a float line marked each end. The line was baited with cut fish, usually mullet, and squid.

One end of the longline was set as near the ships as possible, the other end was set offshore from the ships such that the longline was fishing the area from adjacent to the ships to 300 m away. One set was made on each trip. The longline was fished for 2 hours and all sets were made during the day.

Vertical Longline

The vertical longline was constructed like the horizontal longline but was fished like the gillnets, with one end on the deck of a ship and the other end floated at the surface. The hooks were spaced a little closer than on the horizontal longline,

with a hook approximately every 1.25 m. One set, of two hours duration, was made on each trip and all sets were during the day.

SCUBA

Direct observation using SCUBA gear was used only sparingly in this study due to unusually poor weather conditions which prevailed in what were typically "good weather" months. This was especially true in September when several tropical storms moved through the northwestern Gulf.

Hook and Line Fishing

Hook and line fishing for demersal species was used on all trips. Records of time of day, number of hooks, and number of hours fished were kept for each fisherman. All fish were counted and measured; selected species were examined to determine sexual maturation. Fishing was done both day and night.

Bait for bottom fishing was generally squid or cut fish. Two types of fishing gear were used. One was a typical rod and reel arrangement with two hooks per line and the other was a hand line made of 300-500 lb test cotton line and one hook per line. The hand line was used primarily for large fish such as warsaw which usually could not be kept out of the holes in the ships deck with a rod and reel. Difficulty was encountered in positioning the LONGHORN directly over the ships for fishing, therefore much of the fishing was done over soft mud bottom rather than directly on the deck of the ships but

it was not possible to distinguish the exact proportion of time spent fishing in one area or the other.

Fish Traps

The fish traps used in this study were described by Vetter and Roels (1978a). The initial plan was for SCUBA divers to place all five traps on the deck of one ship using a procedure developed by Vetter and Roels (1978b). This procedure was developed during ideal weather conditions in late summer and proved unworkable and dangerous during more typical weather conditions encountered in a year-round sampling program. During the first two sampling periods (March and May) one trap was placed on the deck of a ship and the remaining four were placed on the mud bottom as close as possible to the ships. There was no difference in species composition or abundance of fish caught in traps placed on the ships and those on mud bottom; therefore on subsequent trips all traps were placed on mud bottom adjacent to the ships (Fig. 1). Sets were made for 24 hours and usually begun at mid-morning (0800-1000 hrs) and terminated the next morning at the same hour. All traps were baited with cut-up fish. Invertebrates and fish, except red snapper, were counted, measured, and returned to the water. Those red snapper in good condition were measured (standard and total length), and tagged with a numbered internal-anchor tag provided by Texas Parks and Wildlife Dept., and returned to the water immediately above the ship reef.

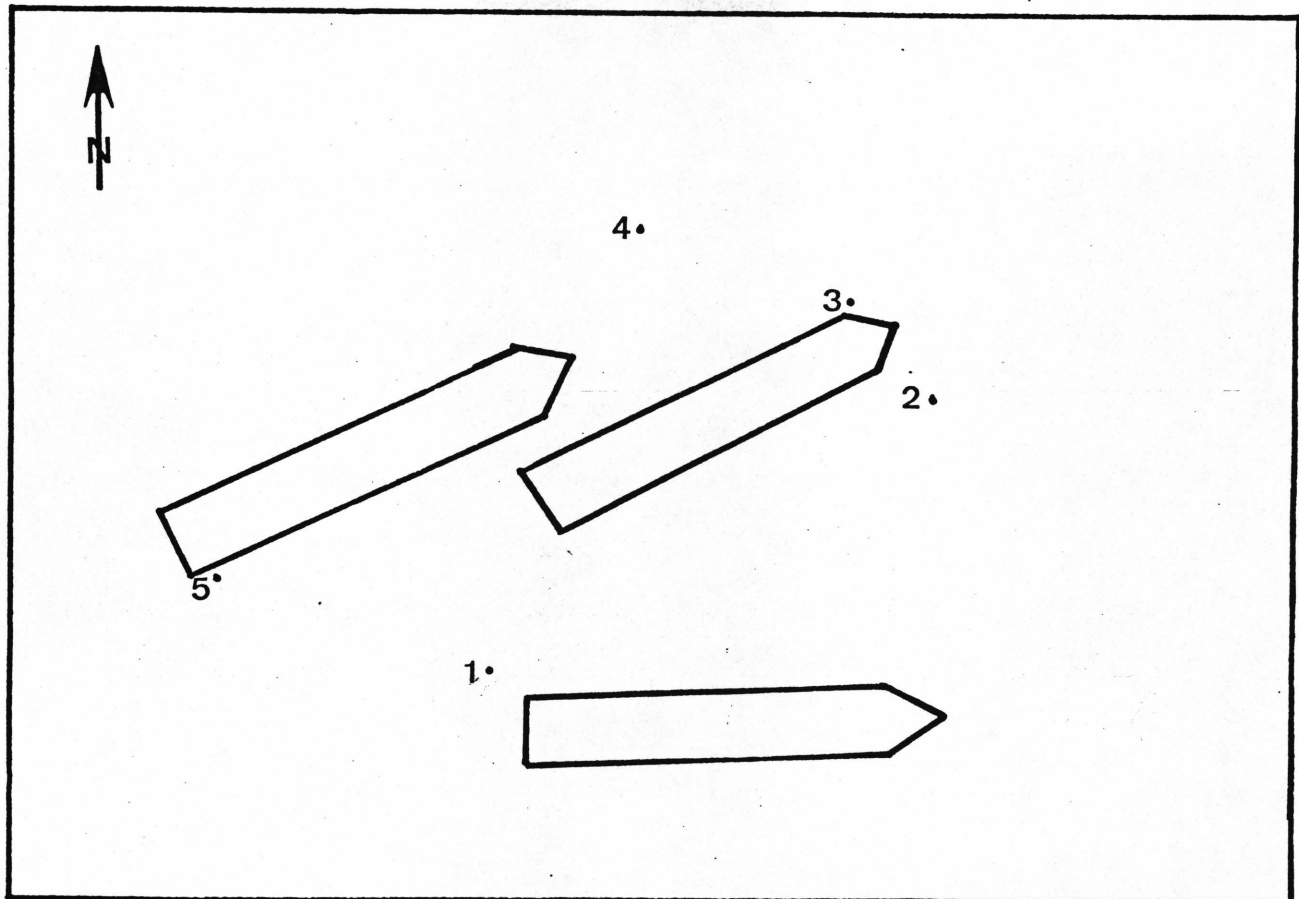


Figure 1. Orientation of the three Liberty ships in the Port Aransas Liberty Ship Reef and the position of the 5 fish traps.

Typically about 80% of the snapper in a trap could be tagged.

On the September trip, 1/3 of the red snapper were released 1/2 km north (on the down current side) of the ships, 1/3 were released 1/2 km south (the up current side) of the ships and the remainder were released directly above the ships. This was done to see if current direction might influence red snapper's ability to return to the ships.

RESULTS AND DISCUSSION

The scientific names of all organisms mentioned by common name in the text are provided in Appendix I.

Gill net

The gill net and the vertical longline were designed primarily to sample the pelagic fish typically found in the water column above the ships. In this respect, both sampling schemes were unsuccessful. A single spadefish was the only fish taken in the gill net. On several occasions the net had large holes torn in the webbing and once a large section of the lead line was torn away. We assume these holes were made by sharks or barracuda which were caught in the net or, more likely, had come to eat other fish which were caught in the net. This problem has been reported by other researchers trying to use gill nets in the Gulf of Mexico.

Vertical longline

The reasons for lack of success with the vertical longline were less obvious. A total of four fish were taken with the vertical longline. Three of these were Atlantic sharpnose sharks. All three sharks were taken on hooks near the surface rather than near the deck of the ships. Sharks were never reported by SCUBA divers on the ships but sharks were often seen near the surface around the LONGHORN. The other fish taken on the vertical longline, a sand trout, was taken about midway between the surface and the deck of the ships. Sand trout are not typically thought of as mid-water fish.

Horizontal longline

The horizontal longline was much more successful than the previous two sampling gears. The most commonly caught fish was Atlantic sharpnose shark (Table 1). Eighteen were caught on 8 May and 23 were caught on 12 November. It is interesting to note that on the other three trips no sharks were taken at all. The only other species of shark taken with the longline was a finetooth shark on 12 November. There was no correlation between distance from the ships and number or size of sharks captured. When sharpnose sharks were in the area they were caught both on the bottom and up in the water column.

The only fish taken on the longline which are typically associated with reef environments were two warsaw grouper and one red snapper. The red snapper, taken on 8 September, was very close to the ships but does indicate that red snapper move off the "reef" to feed. This behavior has been found by other investigators (Bradley and Bryan, 1975; Mosely, 1966). One of the warsaw was also taken near the ships but the other was taken approximately 225 m from the ships. This indicates that warsaw move some distance from the ship reef while feeding. Little is known about the movements of warsaw grouper in the northwestern Gulf of Mexico. The occurrence of warsaw on the Liberty Ships is considered seasonal by local fishermen, with winter and spring being the peak period.

Table 1. Horizontal longline catch data. Hook no. 1 is closest to ship reef. A --- indicates the last hook (farthest from ship reef). Numbers in () indicate standard length in mm.

Hook #	7 March '79	8 May 1979	**19 July 1979	**8 September 1979	12 November 1979
1					
2					
3					
4		Shark (1030)*		Red Snapper (378)	Shark (950)
5		Jack Cravelle (960)			Shark (1110)
6					Shark (1010)
7					Shark (970)
8					
9					
10	Chub Mackrel (206)	Shark (1000)			Shark (1010)
11	Warsaw Grouper (950)	Shark (950)			Shark (990)
12					
13					
14		Shark (980)			
15					
16					
17		Jack Cravelle (980)			Shark (1020)
18					
19		Shark (920)			Shark (890)
20		Shark (1010)			
21					
22					
23					
24					Shark (990)
25					Shark (970)
26					
27		Shark (960)			
28					Shark (920)
29					
30					Shark (1010)
31					
32					Shark (930)
33		Shark (980)			
34					

Table 1. cont.

Hook #	7 March 1979	8 May 1979	19 July 1979	8 September 1979	12 November 1979
35					
36		Shark (1030)			
37					
38		Jack Cravelle (900)			Shark (920)
39					Shark (990)
40					Shark (970)
41					
42		Shark (940)			Shark (990)
43					
44					Shark (1010)
45					
46		Shark (1200)			Shark (1040)
47					Finetooth Shark (930)
48					
49		Ling (1030)			
50					
51					Shark (1000)
52					Shark (990)
53		Shark (1020)			Shark (970)
54					
55		Shark (1060)			Shark (990)
56					
57	Warsaw Grouper (1270)				---
58					
59					
60					
61		Shark (910)			
62					
63					
64					
65					
66					
67		Shark (1060)			
68					
69	---				
70					
71					
72					

Table 1. cont.

Hook #	7 March 1979	8 May 1979	19 July 1979	8 September 1979	12 November 1979
70		Shark (1060)		---	
71					
72		Shark (1030)			
73					
74			Banded Shrimp Eel (730)		
75					
76					
77		---	Banded Shrimp Eel (490)		
78			---		

- * All sharks are Atlantic Sharpnose Sharks except where otherwise noted.
- ** There were large numbers of portunid crabs in the area at this time and they may have eaten much of the bait.

SCUBA

Direct observation of the Liberty Ship reef was limited by poor weather conditions on many trips. Even in good weather, extensive work by divers is impractical due to the water depth. The bottom depth at the ships is 33.5 m (110 ft) and the decks of the ships are at 24.5-27.5 m (80-90 ft). At 27.5 m, maximum bottom time without decompression is 30 minutes and any subsequent dives that day must be of much shorter duration. This is also a problem for sport divers using the Liberty Ship reef since most sport divers avoid making dives requiring decompression stops.

The initial effort to put the fish traps on the ships proved not only dangerous but wasted much valuable diving time which could be used for ecological observations. Once the procedure for trap deployment was revised to exclude use of divers, much more constructive use was made of the limited diving time.

Divers found warsaw groupers to be relatively abundant on the ships during March. When divers first arrived on the ships there were few fish of any kind in evidence but after a few minutes 6 to 8 warsaw grouper appeared. The warsaw were very curious and approached so closely that they interfered with the diver's work. Warsaw were also relatively abundant in May. Red snapper, pinfish, and other small reef orienting fish were rarely encountered on the decks of the ships in these two months although one or two red snapper and occasionally a

a pinfish could be seen inside the ship through each of the holes cut in the decks. Visibility was poor (8-10 ft) on both trips and might have been partially responsible for the low numbers of fish observed, however hook and line and fish trap data (see below) also indicated low abundance of reef fish at this time. Several other species (especially sand trout) were relatively abundant in the hook and line catches but not observed by divers on the ships. A very turbid layer of water on the bottom (the "nephloid layer", typically 10-20 ft thick) prevented any observations below the deck of the ships. This turbid layer is usually present on the ships.

Water visibility was much better in July (about 20-30 ft) any many more fish were in evidence. No warsaw were seen on this trip but red snapper were relatively abundant. Several schools of 5 to 15 red snapper were seen swimming above the decks of the ships. Schools of several other pelagic species such as bonito, barracuda, chub mackeral, Atlantic bumper, and leatherjacket were also common over the decks of the ships and in the water column above the ships. Relative abundances of these species could not be obtained since they are extremely difficult to collect with qaltitative sampling gear. A list of fish and selected invertebrate species seen on the ships is provided in Table 2.

Hook and Line Fishing

Fishing with hook and line provided information on some species not obtained with other methods. Premier among these was sand trout, the fish most commonly caught with hook and line

Table 2. Fishes and selected invertebrates seen by divers on the Liberty Ship Reef and the typical habitat of these organisms: P-pelagic, R-reef or other hard structure, W-widespread.

Common Name	Species	Scientific Name	Typical Habitat
Scaled sardine		<i>Harengula pensacole</i>	R
Gulf toadfish		<i>Opsanus beta</i>	R
Belted sandbass		<i>Serranus subligarius</i>	R
Rock sea bass		<i>Centropristis philadelphia</i>	R
Warsaw grouper		<i>Epinephelus nigritus</i>	R
Rock hind		<i>Epinephelus adscensionis</i>	R
Ling		<i>Rachycentron canadum</i>	P
Leatherjacket		<i>Oligoplites sarus</i>	R
Greater amberjack		<i>Seriola dumerili</i>	R-P
Round scad		<i>Decapterus punctatus</i>	P
Red snapper		<i>Lutjanus campechanus</i>	R
Mangrove snapper		<i>Lutjanus griseus</i>	R
Tomtate		<i>Haemulon aurolineatum</i>	R
Pigfish		<i>Orthopristis chrysoptera</i>	W
Sheepshead		<i>Archosargus probatocephalus</i>	R
Pinfish		<i>Lagodon rhomboides</i>	W
Cubbyu		<i>Equetus umbrosa</i>	R
Atlantic spadefish		<i>Chaetodipterus faber</i>	W
Least puffer		<i>Sphoeroides parvus</i>	W
Queen angelfish		<i>Holacanthus ciliaris</i>	R
Spotfin butterflyfish		<i>Chaetodon ocellatus</i>	R
Great barracuda		<i>Sphyraena barracuda</i>	R-P
Chub mackerel		<i>Scomber japonicus</i>	P
Grey triggerfish		<i>Balistes capriscus</i>	R
Arrow crab		<i>Stenorynchus seticornis</i>	R
Solitary corals		<i>Astrangia sp.</i>	R
Whip coral		<i>Leptogorgia urgulata</i>	R
Rock shell		<i>Thais haemastoma</i>	W
Spiny oyster		<i>Sporidylus americanus</i>	R
Winged oyster		<i>Pteria colymbus</i>	R
Sea urchin		<i>Arbacia punctulata</i>	R
Banacle		<i>Balanus reticulatus</i>	W

(Table 3). Only one sand trout was caught with any other gear.

Fishing success was relatively poor with both rod and reel and handline, producing an average catch for all species of 0.65 fish per hour for rod and reel and 0.21 fish per hour with hand lines. Fishing success was best in March with catches of 2.04 fish per hour for rod and reel. The majority of those fish were sand trout and warsaw. Poorest success was in July, September and November when no fish were caught in 6.6, 8.0 and 2.0 hours of fishing respectively. These figures may not accurately reflect the catchable population of fish on the ships at these times since difficulty was encountered in anchoring the LONGHORN directly above the ships on all three trips. However, one fishing period in July (2.5 man hours) and one period in September (7.8 man hours) were directly over or very close to the ships and no fish were caught. Fish trap data (see below) showed an abundance of red snapper on the Liberty Ships during July and September but most of those fish were less than 200 mm which is too small to be caught with fishing gear typically used by fishermen on the Liberty Ships.

Fishing records for Steamer rock are given in Table 4. Steamer is not a single, large prominence on an otherwise flat mud bottom like the Liberty Ship Reef but is instead a large area of irregular bottom with many small and large protuberances. Fishing was done on two of these larger "rocks". On the first "rock" the catch was primarily sea catfish. On the other "rock" it was primarily red snapper. A few silver seatrout were caught

Table 3. Liberty Ship fishing records.

Date	Total man-hours fished	No. of fishermen*	Gear	**Time of day	Total no. of fish	No. fish per hour	No. of each species	No. of each species/hour	Species	Mean size
6 Mar	7.83	4	R-R	N	16	2.04	13	0.66	Sandtrout	262.8
							3	0.38	Warsaw Grouper	920.0
6 Mar	5.75	2	H-L	N	1	0.17	1	0.17	Warsaw Grouper	750.0
7 Mar	3.92	4	R-R	D	8	2.04	1	0.26	Warsaw Grouper	250.0
							4	1.02	Sandtrout	332.5
							1	0.26	Red Snapper	580.0
							1	0.26	Atlantic Croaker	260.0
							1	0.26	Pinfish	170.0
7 Mar	2.58	2	H-L	D	1	0.39	1	0.39	Banded Shrimp Eel	1450.0
7 May	1.25	1	R-R	D	2	1.60	1	0.80	Sharpnose Shark	875.0
							1	0.80	Jack Cravelle	1000.0
7 May	22.17	6	R-R	N	4	0.18	4	0.18	Sandtrout	338.8
7 May	22.42	5	H-L	N	5	0.22	3	0.13	Warsaw Grouper	1126.7
							1	0.04	Sandtrout	355.0
							1	0.04	Red Snapper	382.0
19 July	2.50	1	R-R	D	0					
19 July	1.40	1	R-R	N	0					
19 July	2.78	1	H-L	N	0					

Table 3. cont.

<u>Date</u>	<u>Total man- hours fished</u>	<u>No. of fishermen</u>	<u>Gear</u>	<u>Time of day</u>	<u>Total no. of fish</u>	<u>No. fish per hour</u>	<u>No. of each species</u>	<u>No. of each species/hour</u>	<u>Species</u>	<u>Mean size</u>
7 Sept	7.50	2	R-R	N	0					
7 Sept	2.50	1	H-L	N	0					
12 Nov	5.67	2	R-R	N	0					
11 Dec	0.67	1	R-R	D	1	1.49	1	1.49	Rock Seabass	231.0
11 Dec	3.00	1	R-R	N	4	1.33	1	0.33	Rock Seabass	163.0
							3	1.00	Red Snapper	194.3

* R-R: rod and reel
H-L: hand line

** D: day
N: night

Table 4. Steamer rock fishing records.

<u>Date</u>	<u>Total man- hours fished</u>	<u>No. of fishermen*</u>	<u>Gear</u>	<u>**Time of day</u>	<u>Total no. of fish</u>	<u>No. fish per hour</u>	<u>No. of each species</u>	<u>No. of each species/hour</u>	<u>Species</u>	<u>Mean size</u>
14 Nov	5.42	3	R-R	D	19	3.51	16	2.95	Seacatfish	285.0
							3	0.55	Silver seatrout	368.0
14 Nov	8.75	6	R-R	D	44	5.30	39	4.46	Red Snapper	374.0
							4	0.46	Silver Seatrout	385.2
							1	0.11	Sea Catfish	331.0
14 Nov	1.50	1	H-L	D	4	2.67	1	0.67	Sea Catfish	270.0
							2	1.33	Gulf Toadfish	295.0
							1	0.67	Gulf Hake	350.0

* R-R: rod and reel
H-L: hand line

** D: day
N: night

at both spots.

Catch rate for all species (4.45 fish per man hour) was much greater on Steamer than at any time on the Liberty Ships. Composition of the catch at Steamer was also substantially different from the Liberty Ships. Sea catfish were not taken at the Liberty Ships and red snapper made up a much greater proportion of the catch at Steamer than on the Liberty Ships.

Fish Traps

Fish traps were the most productive gear used in this study for catching fish on the Liberty Ship reef. Four hundred and four fish were captured during the study period. Of these, 361 were red snapper. Mean total length of fish taken in the traps are given in Appendix II. Several fish species were obtained only in fish traps, these included cubbyu, tomtate, grey triggerfish, and lane snapper. The fewest fish (1.3 fish per trap) were taken in the spring (March and May) and the largest catches (32.3 fish per trap) were in the summer (July and September).

A substantial difference was seen in species composition of the trap catches in this study compared to those reported by Vetter (1978b), using the same traps on the Liberty Ships the previous summer. The total catch per trap (21.6 vs 32.4) was not drastically different between the two studies but the catch rate for pinfish and red snapper, two of the dominant fish in the traps, were exactly the opposite. Pinfish dominated Vetter's catches (19.1 pinfish per trap) and he caught only 1.6

red snapper per trap whereas red snapper dominated our catches (29.7 fish per trap) and we caught only 0.7 pinfish per trap. Since equipment and techniques were identical in both studies this must represent a real difference in the relative abundance of these two species between years. This difference may reflect a stronger 1978 year-class than the 1977 year-class sampled by Vetter but no data are available on year-class strength for red snapper. This increase in red snapper abundance may also reflect a maturing of the Liberty Ship reef which could make it more attractive as a habitat for snapper.

Red snapper was the only species taken in sufficient numbers to allow studies of age, growth and recruitment of fish on the ships. Two hundred sixty seven red snapper captured in fish traps were tagged with numbered internal-anchor tags and released on the ship reef in July, September and November. Sport fishermen returned 28 tags and our own sampling produced seven more returns. Size and date of tagging and date of recapture are provided in Table 5. All recaptures were from the Liberty Ship reef, indicating a high degree of residency, but recaptures may be obtained from other locations in the future. The longest "free time" for any fish was 92 days but one fish which was tagged and recaptured twice was resident on the Ship reef 112 days. Sixty three percent of the fish were recaptured within 30 days.

Lengths and weights of recaptured fish provided by sports fishermen were inadequate for accurate growth determination but accurate measurements were obtained from the seven fish which we recaptured (Table 6). The opportunity for studying growth

Table 5 . Return data for red snapper tagged on the Liberty Ship Reef.
All fish were recaptured on the Liberty Ships.

<u>Date Tagged</u>	<u>Size at Tagging (mm)</u>	<u>Date Recaptured</u>	<u>Days Free</u>
22 July	299	24 July	2
22 July	179	1 August	9
22 July	253	4 August	12
22 July	326	4 August	12
22 July	278	5 August	13
22 July	228	7 August	15
22 July	276	7 August	15
22 July	238	7 August	15
22 July	225	8 August	16
22 July	321	8 August	16
22 July	318	8 August	16
22 July	350	8 August	16
22 July	213	22 August	31
22 July	287	30 August	39
22 July	117	9 September	49
22 July	121	9 September	49
22 July	138	9 September	49
22 July	141	9 September	49
22 July	144	9 September	49
22 July	167	9 September	49
22 July	235	28 September	68
22 July	172	29 September	69
22 July	173	5 October	75
9 September	202	28 September	19
9 September	227	28 September	19
9 September	175	29 September	20
9 September	315	30 September	20
9 September	150	3 October	23
9 September	221	3 October	23
9 September	160	5 October	25
9 September	175	5 October	25
9 September	179	5 October	25
9 September	153	13 October	33
9 September	150	13 November	64
9 September	141	11 December	92

Table 6 . Known size recaptures from Liberty Ship Reef.

<u>TAGGING</u>		<u>RECAPTURE</u>		<u>No. days free</u>	<u>growth (mm)</u>	<u>growth (mm) per day</u>
<u>date</u>	<u>size (mm)</u>	<u>date</u>	<u>size (mm)</u>			
22 July	141	9 September	168	49	27	.55
22 July	144	9 September	150	49	6	.12
22 July	167	9 September	178	49	11	.22
22 July	117	9 September	132	49	15	.31
22 July	138	9 September	150	49	12	.24
22 July	121	9 September	133	49	12	.24
9 September	141	11 December	167	62 41	26	.42 .28

growth and recruitment of red snapper was greatly enhanced by the availability of 3 years (1975-1977) of extensive trawl data from four transects across the outer continental shelf (OCS) off Texas. Sampling stations and trawling procedures are given by Wohlschlag (1976). These data provide a survey of the OCS between Port O'Connor and Port Isabel and span a depth range of 10 to 132 m.

Other information available in the literature on size and growth of red snapper is relevant to our assessment of their population dynamics on the Liberty Ship reef. Rabalais et al. (in press) found that laboratory spawned and reared red snapper were 2.2 mm at hatching and both the eggs and larvae are planktonic. L. A. Collins (pers. comm.) found L. campechanus larva of 3.8 to 7.9 mm from July through September in plankton from the Texas continental shelf waters.

The size at which red snapper switch from planktonic to benthic habitat is not known. Bradley and Bryan (1975) found their smallest snappers (mean size 48 mm) most abundant during August at depths of 21-27 m. The smallest fish taken in the OCS trawl samples were 10-19 mm standard length (Fig. 2) in June 1976. The smallest fish taken in 1975 were 20-29 mm in August and September and in 1977 the smallest fish were 40-49 mm taken in September and October.

To provide an estimate of average growth rate for young red snapper, the OCS trawl data from all three years plus the fish trap data from the Liberty Ships were pooled to show the size range of red snapper in each month of the year (Fig. 3).

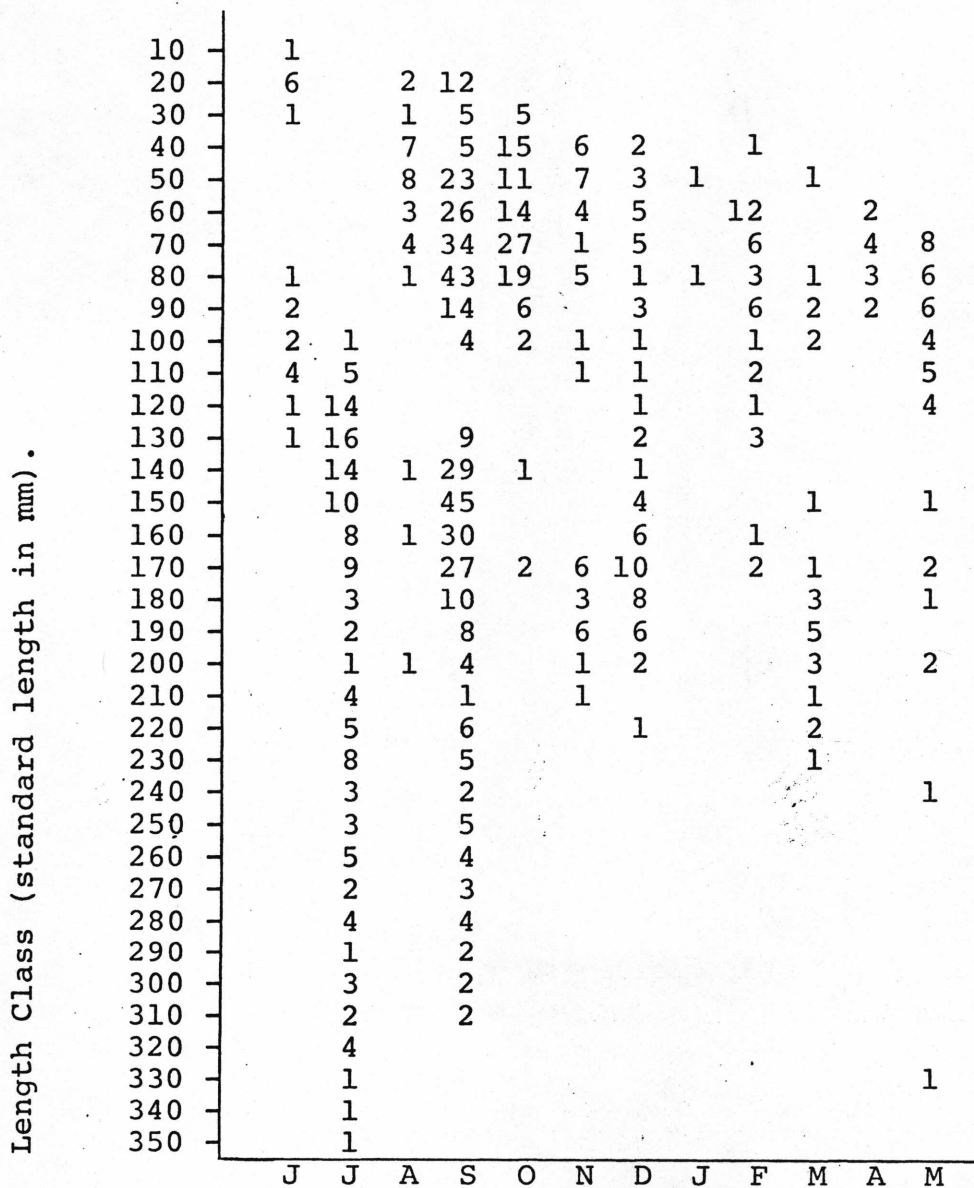


Figure 3. Composite length frequency diagram of all OCS trawl data and Liberty Ship trap data.

It should be noted that the "year" is represented as June through May rather than January through December so that the year begins with the month of first recruitment of young-of-the-year fish into the trawl catches. Two cohorts, year class 0 and year class I fish, can clearly be identified for all the data and a third cohort can be identified from the fish trap catches in July and September. These cohorts were separated and plotted (Fig. 4) to show growth over three years.

An r^2 value of .8889 from simple linear regression analysis indicates a good linear relationship between length and time. Fitting a straight line to these data through the regression equation $y = 24.364 + 8.026x$, where $x = \text{time}$ and $y = \text{length class}$, provide a calculated growth rate of about 0.28 mm^{-d} for red snapper between 20 and 350 mm. L. A. Collins estimated a growth rate of 0.5 mm^{-d} for larval red snapper. Mosely (1966) estimated a growth rate of about 90mm (or approximately 0.25 mm^{-d}) between spawnings but said that "red snapper probably grow 200 to 220 mm [fork length] during their first year". Our data indicates they are 110-130 mm standard length (120-140m fork length) the first year. Growth rates of the seven tagged fish which we recaptured ranged from 0.12 to $.55 \text{ mm}^{-d}$ with a mean of 0.29 mm^{-d} . Back calculation of size based on our regression equation indicates that most spawning occurs in the spring, primarily March and April, and there is no evidence for any spawning later than about July.

Camber (1955) reported a spawning period of July through September on Campeche Bank. Mosely (1966) calculated that spawning does not occur until late July or early August on the

Texas coast but Bradley and Bryan (1975) found the major period of spawning in Texas to be June and July. Our data suggest that spawning is earlier than others have reported.

Bradley and Bryan (1975) and Mosley (1966) found that red snapper move offshore with age. The majority of the red snapper taken by Davis (1975) on Seven and One-Half Fathom Reef near Port Mansfield (14 m water depth) were between 150 and 272 mm. Most red snapper on the Liberty Ships were between 100 and 250 mm and fish greater than 250 mm were not common at any time of year. Conversations with local (Port Aransas) charter boat captains substantiate these observations.

Apparently, it is between 100 and 200 mm that red snapper move out of the level bottom habitat and onto hard bottom, "reef" type habitats. Fish larger than about 250 mm move away from the ship reef to deeper reefs farther offshore. Mosely (1966) and Bradley and Bryan (1975) indicated that spawning does not occur regularly in fish less than 250 mm. Therefore, the Liberty Ship Reef does not maintain a breeding population of red snapper but may serve as an important stop-over point for those fish switching from the level bottom habitat of juvenile snapper to the deep reef habitat of adult snapper and serves as a temporary refuge for 1 and 2 year old red snapper.

Young snapper which come to the ship reef in late spring apparently stay there throughout the summer and early fall as evidenced by the tag returns. Although fishing pressure by charter boats was relatively light during the winter and early spring 1980, the small catch of red snapper reported by boat

captains from the ship reef and absence of any recaptures of fish tagged the previous summer indicates those fish had moved away.

The role of the liberty ships in enhancing the stock of reef oriented recreational fisheries is still unclear due primarily to a lack of knowledge of the life history of the species involved. Food habit studies have proven very difficult for red snapper but the information available indicates they feed primarily on fish and invertebrates which live on level soft-bottom and are not dependent on the reef for food. Tagging studies have shown a high degree of residency for some red snapper yet other data indicated considerable mobility, especially in the fall, for both young and adults.

No direct evidence is available on the rate of recruitment of young snapper onto the ship reef during the summer, but the high degree of residency shown by tag returns indicates that the snapper population could be easily overfished during the summer if fishing pressure was very great, and midsummer and fall recruitment was low. If snapper are continually recruited onto the ships throughout the summer and fall then overfishing would not be as great a problem. Data are not currently available to address this problem.

SUMMARY

1) A vertically suspended gill net and baited longline were ineffective in sampling pelagic species. Although pelagic species such as bonito, spanish and king mackerel, chub mackerel, and barracuda were seen by divers no quantitative measure of

their abundance was obtainable.

2) The horizontal longline caught large numbers of sharp-nose sharks in May (18) and November (23) but none were caught in March, July or September. There was no correlation between number or size of sharpnose sharks and distance from the ship reef. One red snapper (378 mm) and two warsaw grouper were taken on the longline. The red snapper and one warsaw were taken near the ships and the other warsaw was taken approximately 225 m away. No other reef type fish were taken with the longline.

3) Hook and line fishing was relatively unsuccessful, with an average of 0.65 fish per man hour for all species. The most successful time was March with 2.04 fish per man hour and the least successful was July, September and November when no fish were caught. Fishing success was much better directly over a ship than on soft mud bottom near or far away from the ship. The most commonly caught fish was sand trout. Eight warsaw grouper were caught during March and May but none were caught in the summer or fall. Only five red snapper were caught with hook and line. Hook and line fishing was much more successful on "Steamer", a natural rock outcropping near Port Mansfield where 4.46 red snapper were caught per man hour fishing. Average size of these fish was 374 mm.

4) Fish traps provided the most information about fish populations on the ship reef. The predominant fish caught in the traps was red snapper. A marked seasonal occurrence was seen in red snapper populations, with most fish occurring in summer and fall and few fish during winter and spring. Average

size range of red snapper occurring on the ship reef was 100 to 200 mm.

Using this data and other data available from the South Texas outer continental shelf it was determined that snapper spawn in the spring and early summer and grow at an average rate of about $0.27 \text{ mm}^{-\text{d}}$ or about 90-100 mm per year. They are apparently recruited onto the ship reef in late spring and possibly throughout the summer. Juvenile snapper are recruited onto the ships at a size of about 100 mm and there may be some recruitment of 2 year old fish which are 180 to 200 mm as well. Most of the snapper move off the ships (presumably to deeper water) in late fall.

The Liberty Ship Reef is apparently serving as a temporary refuge for young snapper. The majority of the snapper on the ships have spent their first year on level mud bottom and are moving to hard bottom reef habitats. The Liberty Ships do not continuously support a breeding population of adult red snapper.

5) Little information was obtainable on warsaw grouper, the other recreationally important "reef" species on the ships. Most warsaw taken on the ships were greater than 700 mm and most were caught during the spring although a few could be found year-round.

6) The encrusting, or fouling, community on the ships could not be sampled quantitatively but diver observation indicated that both kinds and abundance of fouling organisms was much lower than on inshore oil rigs and presumably much lower than on the offshore "snapper banks" reefs although a few direct observations

are available from these deep reefs.

7) The Liberty Ship reef off Port Aransas is serving an important function as a temporary refuge for young red snapper. It also serves as a focal point for recreational fishing, especially for sand trout and warsaw grouper in fall and winter and occasionally for good catches of red snapper in summer and fall. It apparently is not functioning as a complete habitat for Texas continental shelf reef species in the same manner as the natural "snapper bank" reefs.

ACKNOWLEDGEMENTS

The successful completion of a project of this nature required the assistance of many people. I would like to thank the Captain and crew of the R/V LONGHORN for their competence and assistance in doing the field work. Special thanks go to my colleagues, Steve Rabalais and Rick Kalke for their invaluable assistance with the field work especially for their help with the SCUBA diving portion of the study. Thanks go to Joan Holt for carefully reviewing the manuscript.

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APPENDIX I

Family groupings and scientific names of fishes mentioned in the text.

Carcharhinidae	
Atlantic sharpnose shark	<i>Rhizoprionodon terraenovae</i>
Finetooth shark	<i>Aprionodon isodon</i>
Clupeidae	
Scaled sardine	<i>Harengula pensacole</i>
Ariidae	
Sea catfish	<i>Arius felis</i>
Batrachoididae	
Gulf toadfish	<i>Opsanus beta</i>
Serranidae	
Belted sand bass	<i>Serranus subligarius</i>
Rock seabass	<i>Centropristis philadelphica</i>
Warsaw grouper	<i>Epinephelus nigritus</i>
Rock hind	<i>Epinephelus adscensionis</i>
Rachycentridae	
Ling	<i>Rachycentron caradum</i>
Carangidae	
Leatherjacket	<i>Oligoplites sarus</i>
Greater amberjack	<i>Seriola dumerili</i>
Crevalle jack	<i>Cranax hippos</i>
Atlantic bumber	<i>Chloroscombrus chrysurus</i>
Round scad	<i>Decapterus punctatus</i>
Lutjanidae	
Red snapper	<i>Lutjanus campechanus</i>
Lane snapper	<i>Lutjanus synagris</i>
Mangrove snapper	<i>Lutjanus griseus</i>
Pomadasyidae	
Tomtate	<i>Haemulon aurolineatum</i>
Pigfish	<i>Orthopristis chrysoptera</i>
Sparidae	
Pinfish	<i>Lagodon rhomboides</i>
Sheepshead	<i>Archosargus probatocephalus</i>
Sciaenidae	
Sand seatrout	<i>Cynoscion nebulosus</i>
Silver seatrout	<i>Cynoscion nothus</i>
Cubbyu	<i>Equetus umbrosa</i>

APPENDIX I (Cont.)

Ephippidae	
Atlantic spadefish	<i>Chaetodipterus faber</i>
Chaetodontidae	
Queen angelfish	<i>Holacanthus ciliaris</i>
Spotfin butterflyfish	<i>Choetodon ocellatus</i>
Sphyraenidae	
Great barracuda	<i>Sphyraena barracuda</i>
Scombridae	
Bonito (Little tuna)	<i>Euthynnus alletteratus</i>
Chub mackerel	<i>Scomber japonicus</i>
Balistidae	
Grey triggerfish	<i>Balistes capriscus</i>
Tetradontidae	
Least puffer	<i>Sphoeroides sarvus</i>

APPENDIX II

Mean standard length (mm) of fish taken in the fish traps
on the Liberty Ship Reef.

Date	Species	Total no.	Mean length
March 7 1979	Cubbyu	6	170.5
	Pinfish	1	163.0
	Bearded brotula	1	322.0
	Red snapper	1	120.0
	Banded shrimp eel	2	1175.0
	Rock seabass	1	240.0
May 8 1979	Red snapper	125	209.1
	Tomtate	2	165.0
	Grey trigger fish	8	201.3
	Pinfish	7	147.9
	Rock seabass	1	210.0
	Cubbyu	1	200.0
September 9	Red snapper	172	176.8
	Grey trigger fish	3	214.0
	Amberjack	2	224.0
	Lane snapper	2	174.0
November 13	Red snapper	17	187.7
	Grey trigger fish	1	191.0
December 11	Red snapper	39	176.8
	Pinfish	1	160.0
	Rock seabass	2	196.0

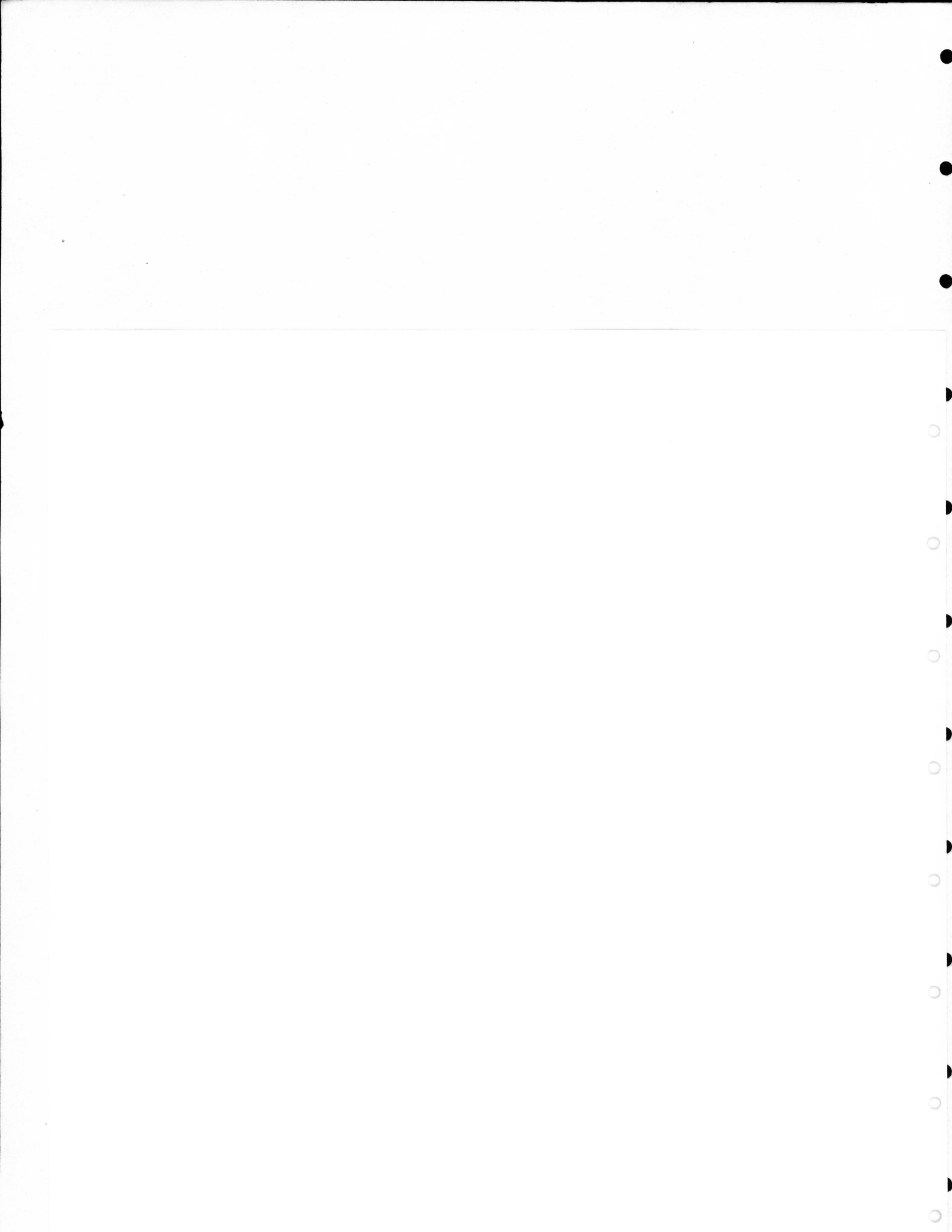
APPENDIX III

SELECTED PHOTOGRAPHS ILLUSTRATING VARIOUS ASPECTS OF
THE LIBERTY SHIP REEF RESEARCH PROJECT

Plate 1

Fish trap used for catching red snapper and other fish on the Liberty Ship reef. These traps were placed on the bottom near the ships and fished for 24 hours.





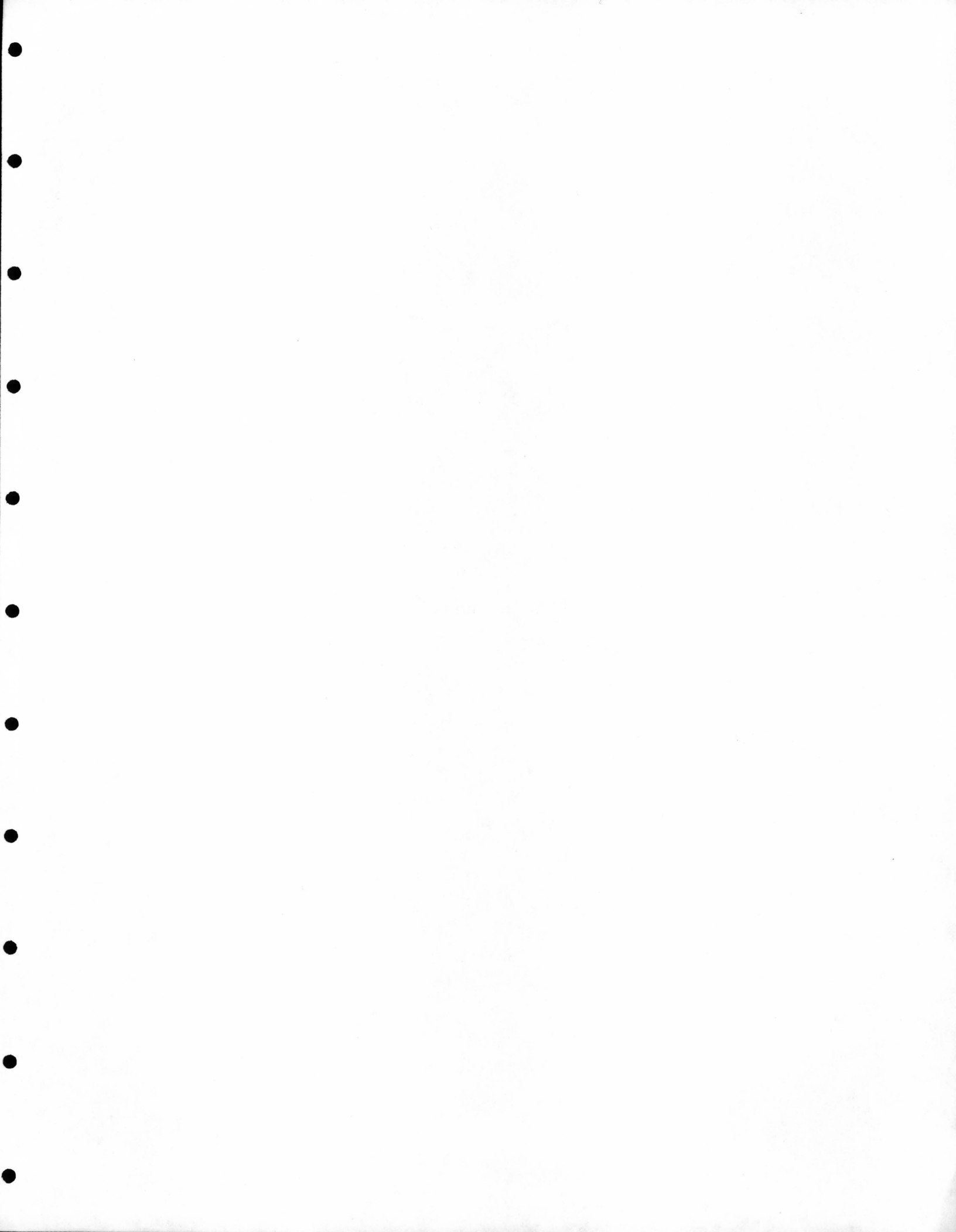


Plate 2

Red snapper in holding tank prior to tagging.





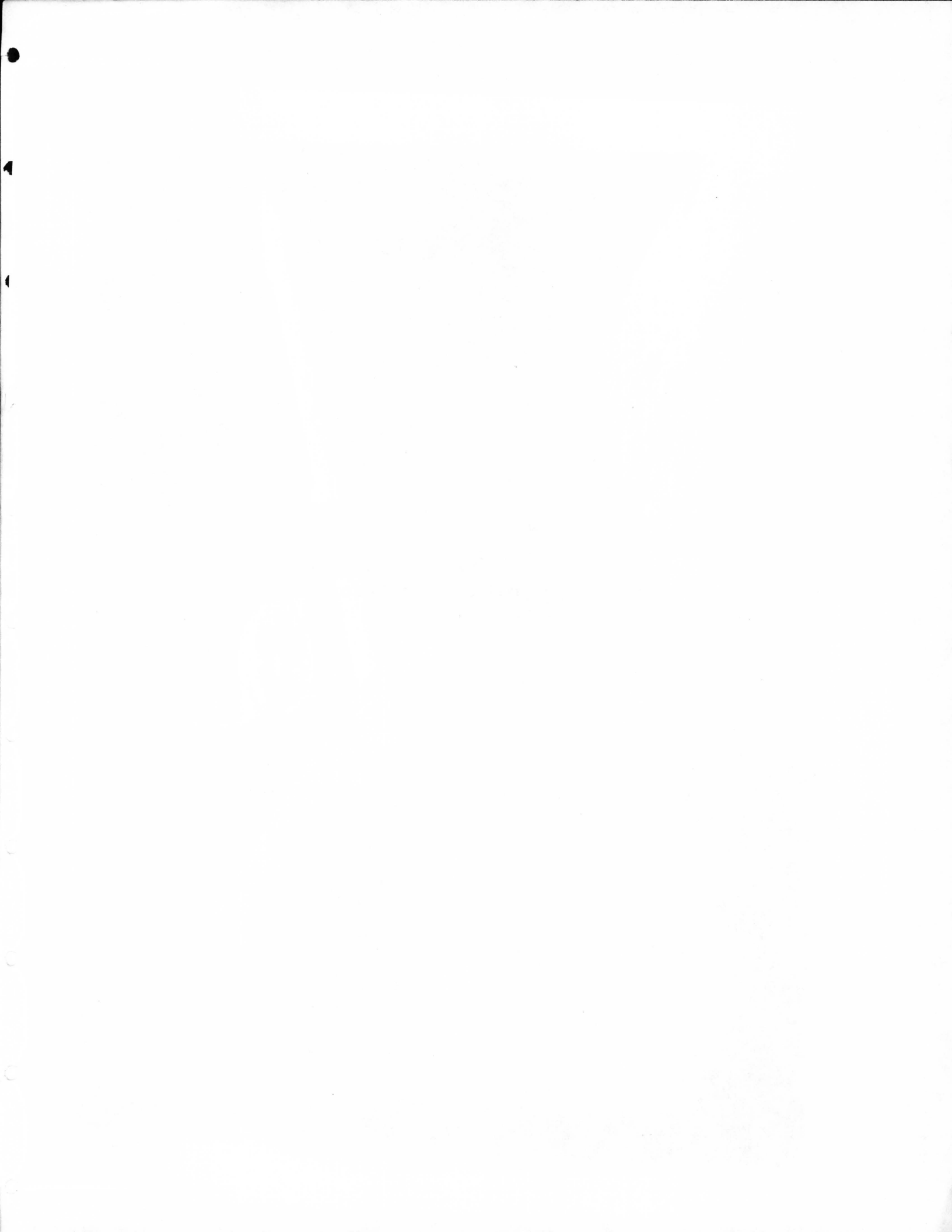
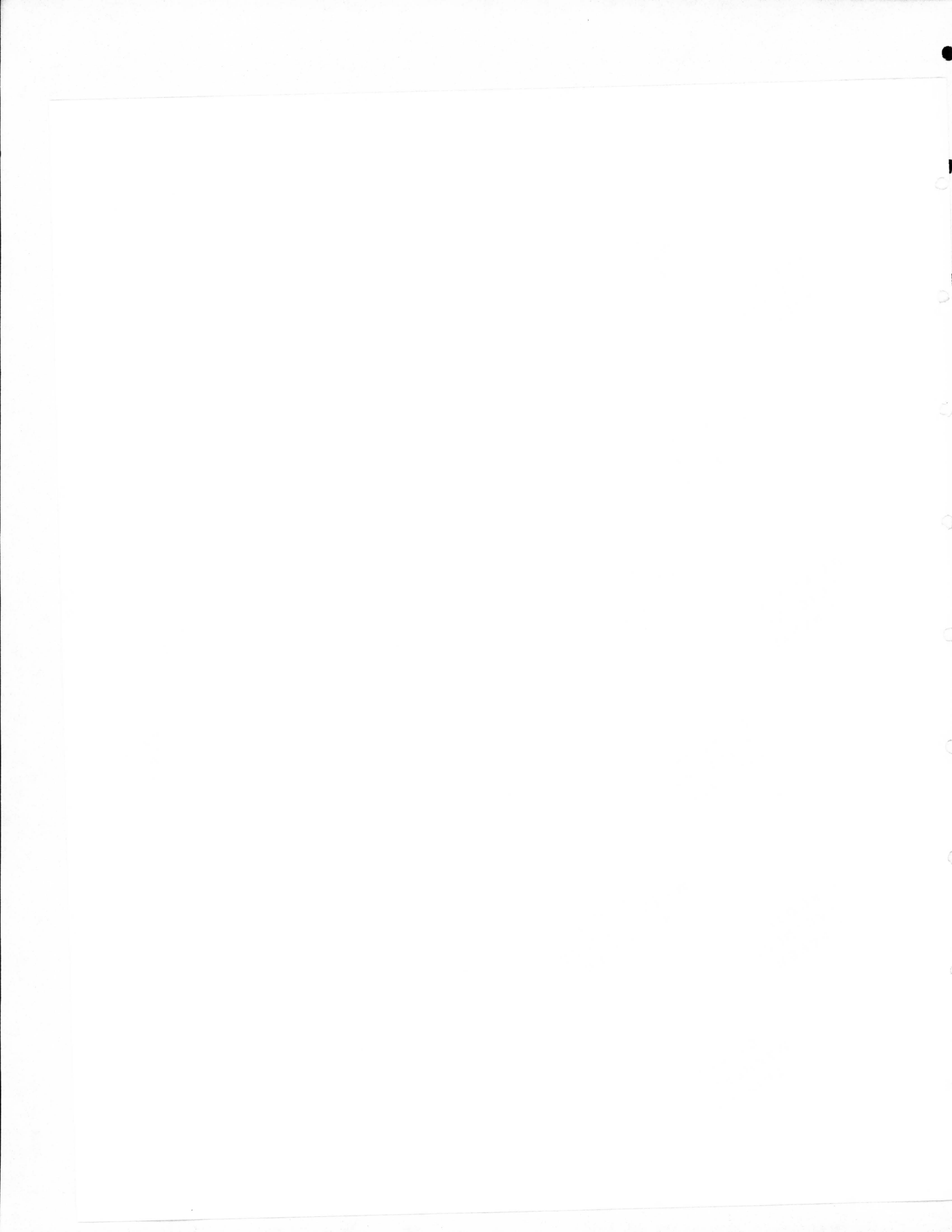


Plate 3

Measuring a tagged red snapper before its
release.





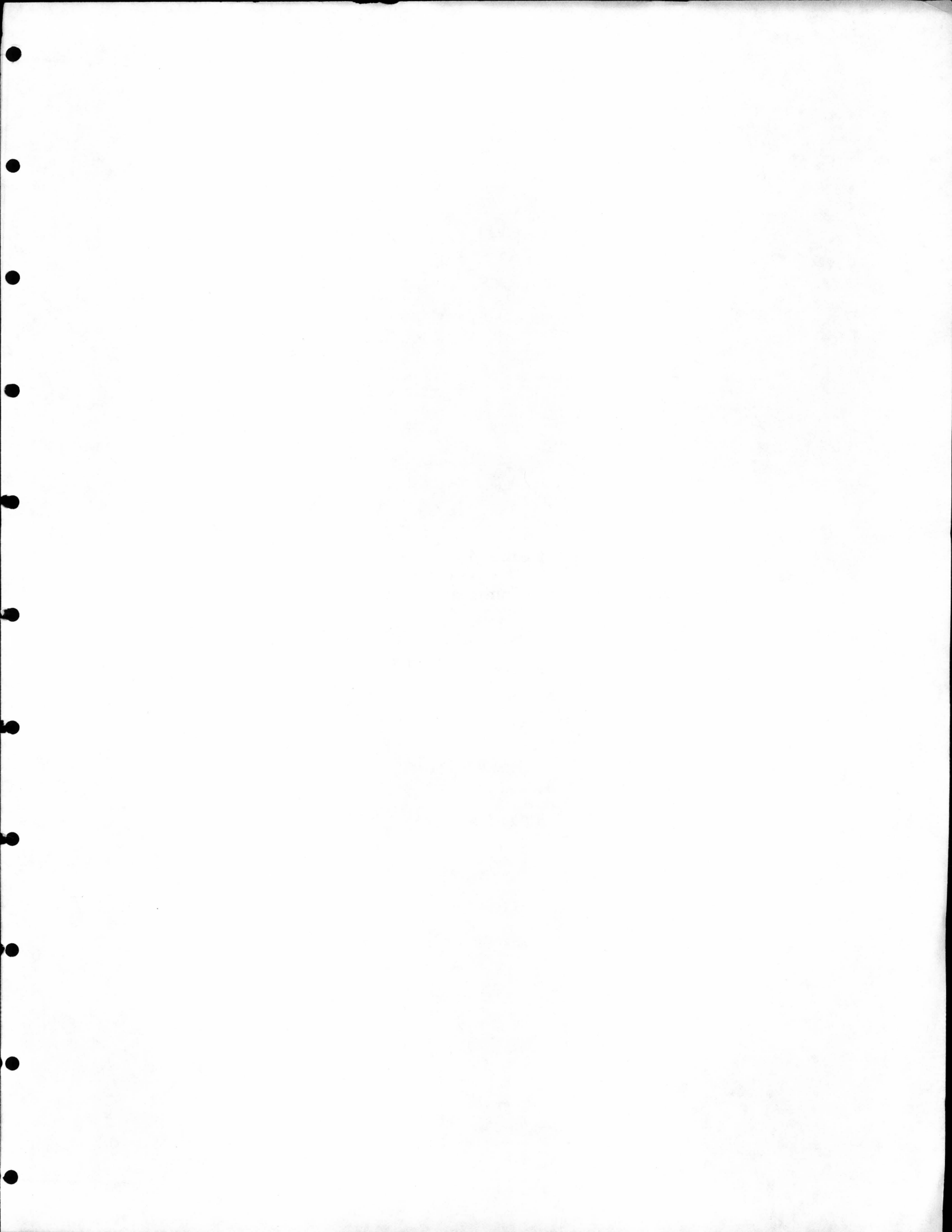


Plate 4

Sharpnose shark on longline





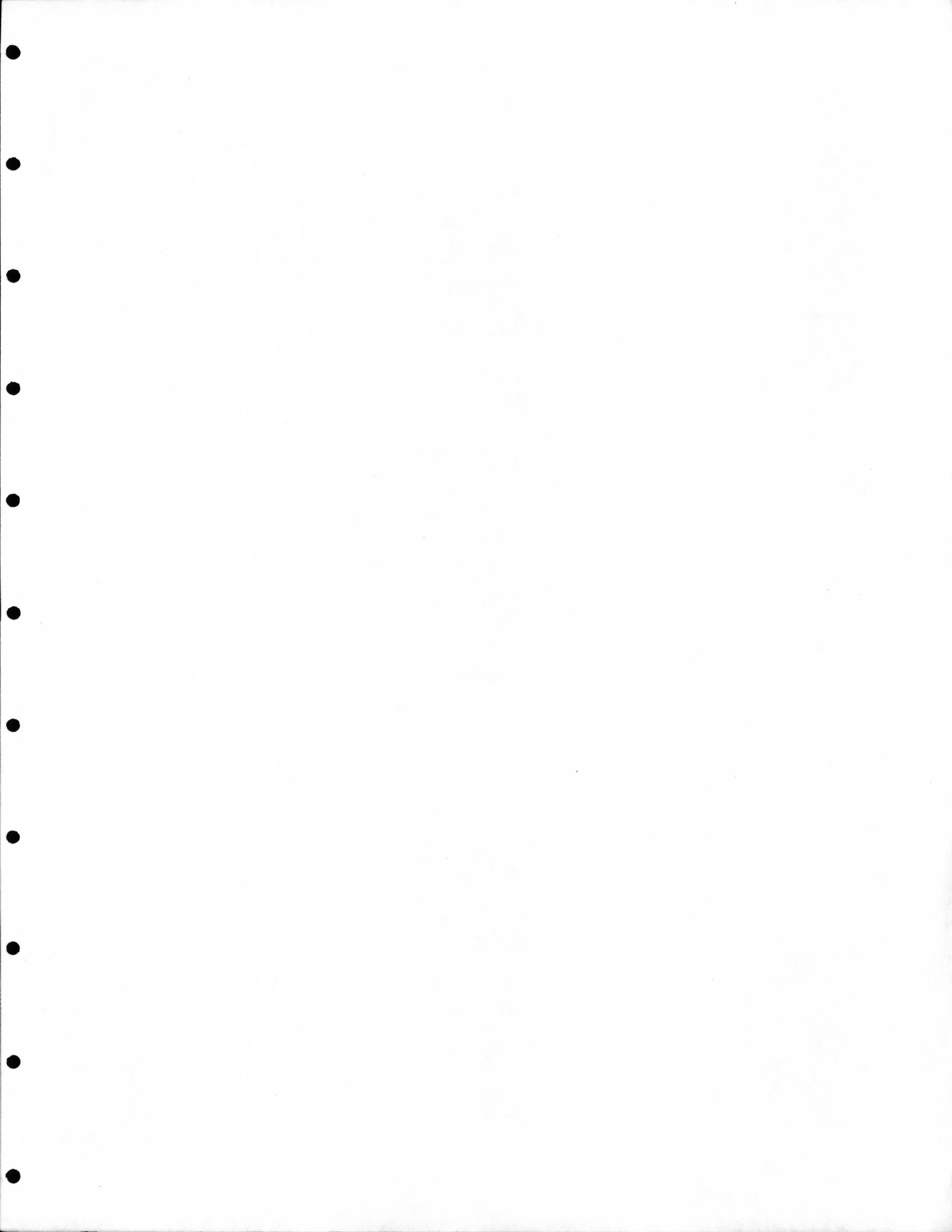
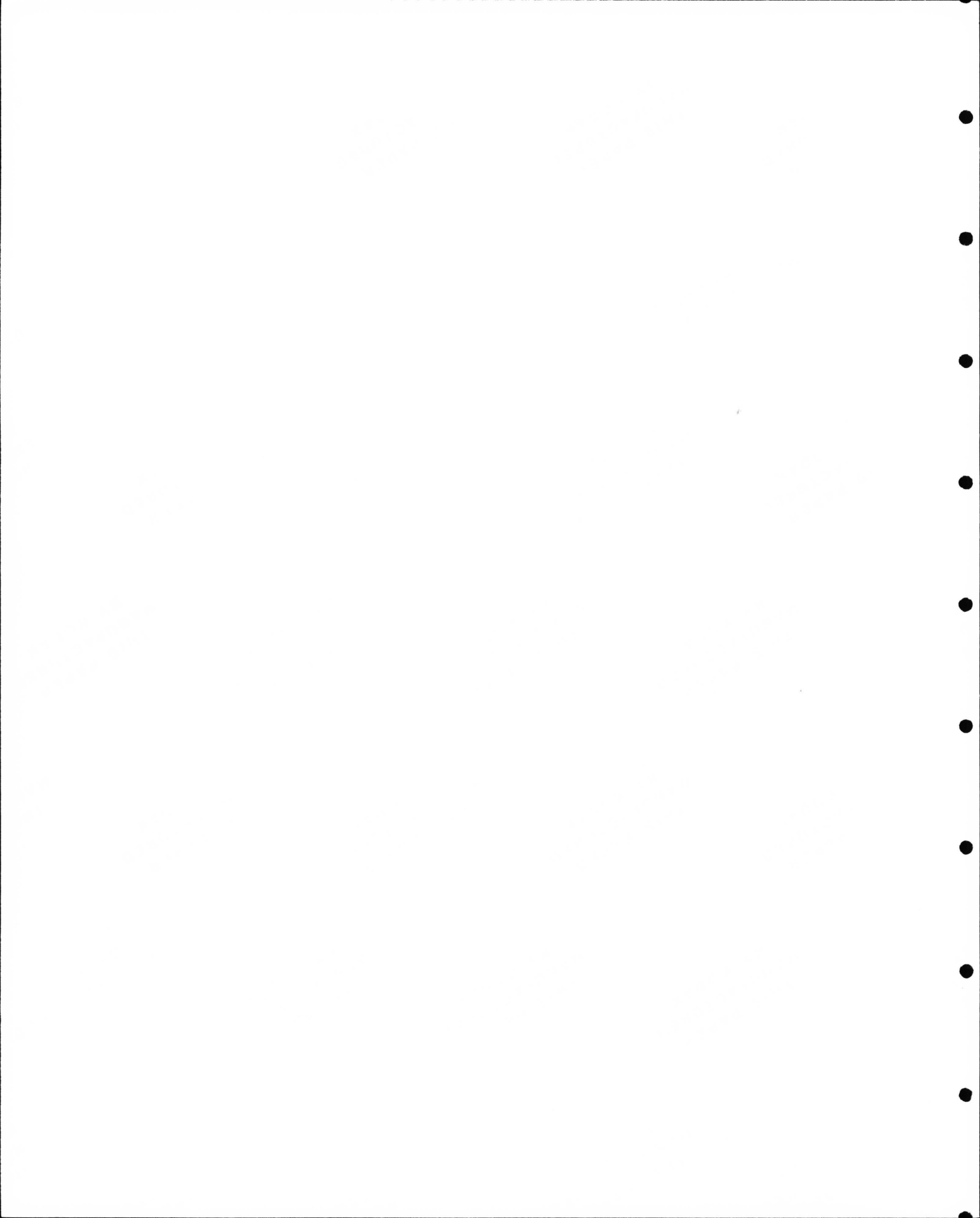


Plate 5

Sharpnose sharks and jack cravalle which were
caught on the longline.





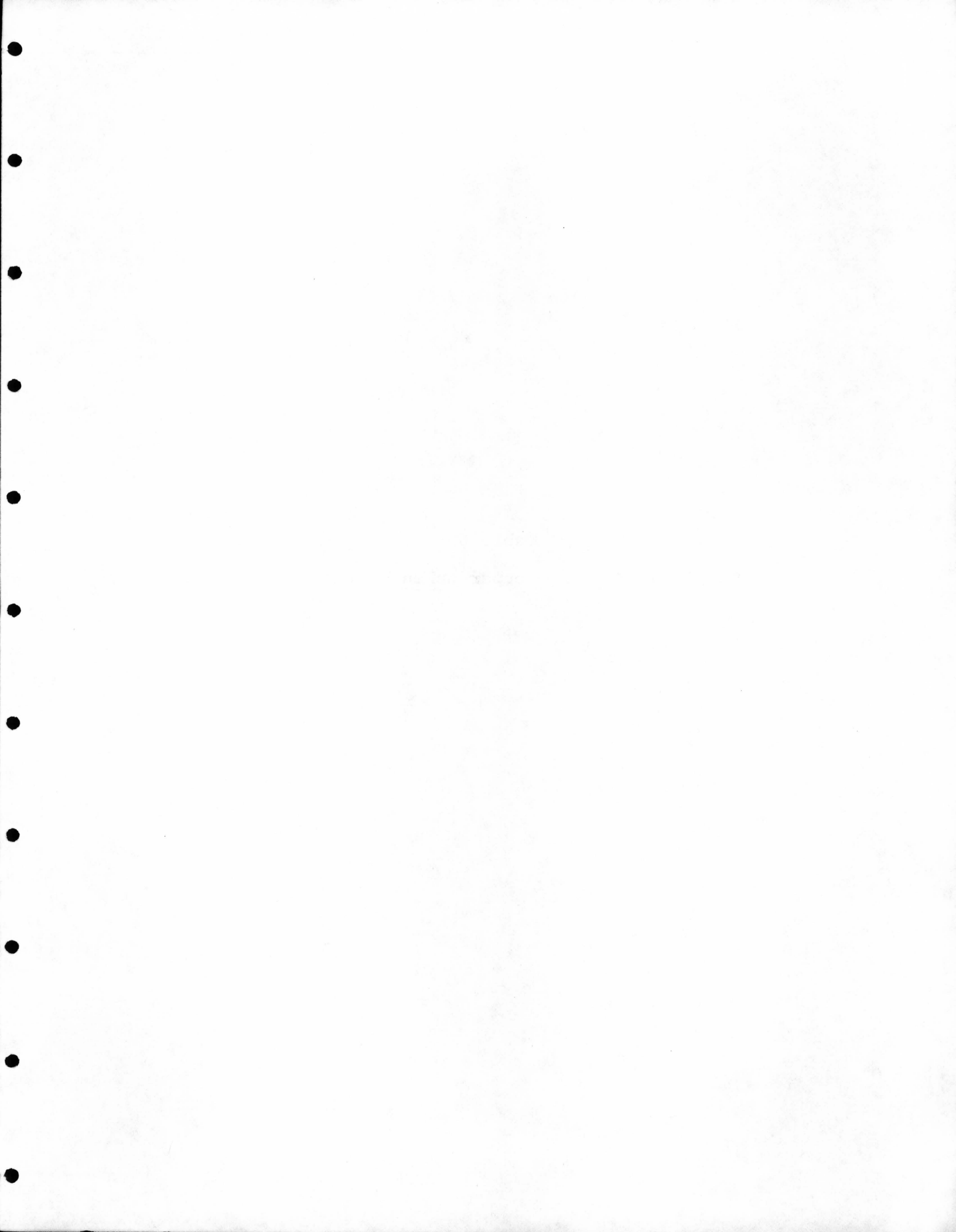


Table 6

Two large Warsaw grouper taken on the longline.





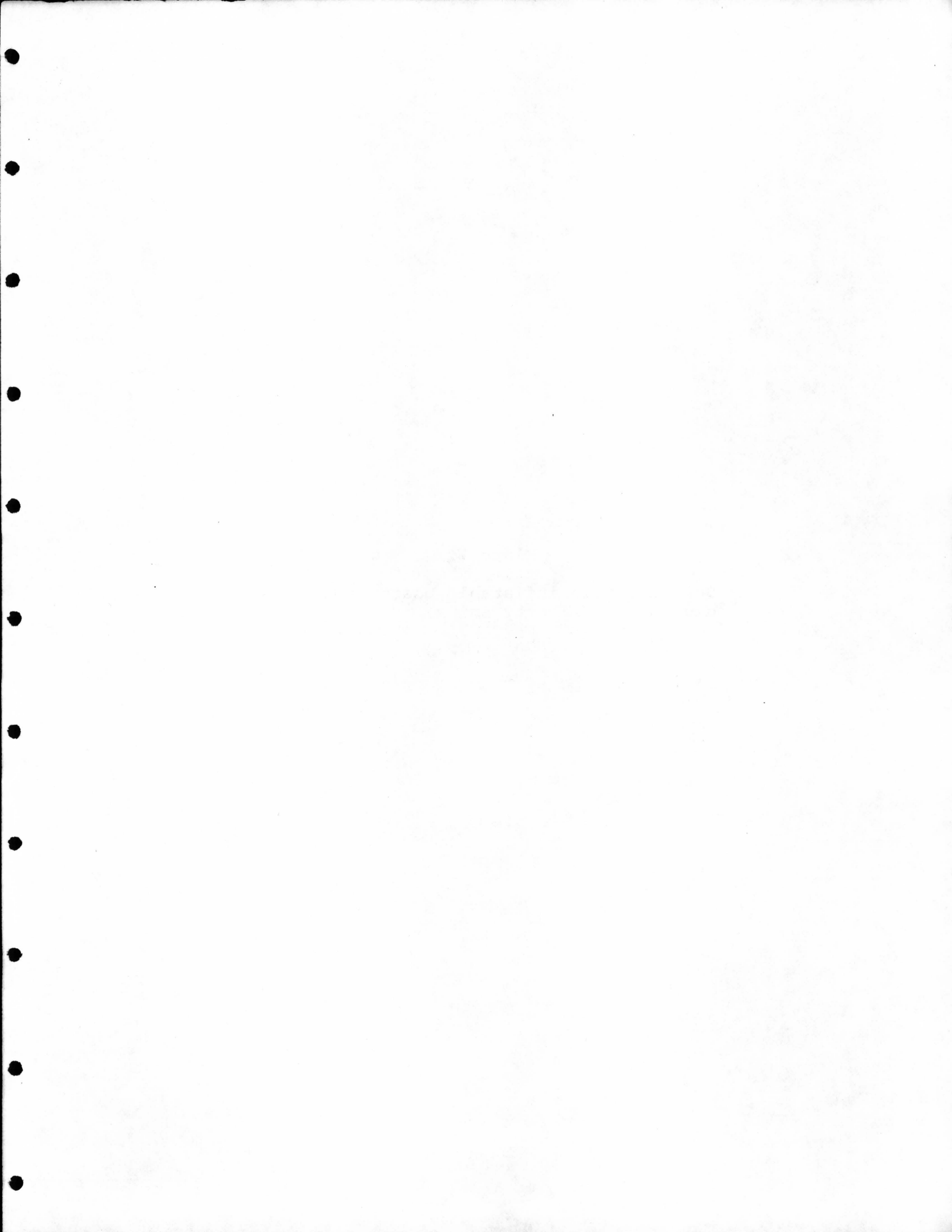


Plate 7

SCUBA divers in inflatable boat preparing for
a dive on the Liberty Ships.





