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# A PRELIMINARY SURVEY OF THE UNDERWATER ACCUMULATION OF DERELICT NETS AT FRENCH FRIGATE SHOALS

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## INTRODUCTION

Derelict fishing gear has been well documented as a hazard to marine life in Hawaii (Henderson, 1984). In the Northwestern Hawaiian Islands Hawaiian monk seals, sea turtles, and seabirds are frequently found entangled in nets that have washed ashore. Often it is not clear if these entanglements occurred at the water's edge, on land, or at sea. Previous marine debris surveys have focused solely on the accumulation that occurs on the shoreline (Henderson et al., 1987; Merrell, 1984). In an attempt to understand the impact of derelict gear, several zones representing the range of an atoll's shallow topography were surveyed by divers. This work was undertaken by the Honolulu Laboratory's Protected Species Investigation.

## METHODOLOGY

Two cruises of the NOAA ship *Townsend Cromwell* to French Frigate Shoals, provided approximately 5 days of sampling on each. The first cruise took place in November 1996 (TC96-11), in inclement weather, with winds at 15-25 knots and seas up to 3 feet. The second cruise, in January 1997 (TC97-01), experienced lighter winds and seas.

In November 1996 four zones representing different areas of the atoll were searched. Three of the zones were located on the immediate inside of the barrier reef, including the northern (Area I), eastern (Area II), and southern (Area IV) parts of the atoll. These areas were of expansive barrier reef type habitats. The final zone was located in the middle of the atoll, near a small islet known as East Island (Area III) (Fig. 1). The habitat in this area was mostly patch reefs. Survey areas were approximately 4 miles long and included depths down to 10 meters. Diver survey techniques included conventional snorkeling and boat-towed divers.

Based on the November survey, the January survey concentrated near the two areas that had the most nets: Areas I and III. Sites adjacent to these areas were selected and are referred to as areas Ia and IIIa. Area Ia was chosen because it fit the topography suspected to be conducive to accumulating derelict netting. Area Ia was the drop-off behind an extensive barrier reef with coral bommies in a calm lagoon, and Area IIIa was along the barrier reef just west of East Island. Survey of the latter area represented a high-energy environment of the barrier reef and the calm lagoon conditions behind the barrier.

Area surveyed was estimated by multiplying the distance towed or dived by the width of the area scanned by the diver. The amount of net per area was estimated by dividing the total dive-surveyed area by the number of nets encountered. This value was expanded to estimate net density per kilometer.

Two small craft were deployed and supported from the *Townsend Cromwell*, with each boat staffed by a coxswain and a diver. The divers surveyed the area as previously described, with the boat either tending or towing divers. Nets were documented using video, still photography, GPS position, and in some cases, a buoy.

The sizes of nets were estimated and classified as follows:

Class 1: bits of net or line, less than 5m.$^2$
Class 2: small amount of net, ~5-10m.$^2$
Class 3: medium amount of net, ~10-25m.$^2$
Class 4: large amount of net, greater than 25m.$^2$

Also noted was the degree of net encrustation and if any organisms were entangled in the net. If a net was marked for removal, a boat would stand by to pick it up. Removal of nets required divers to cut them free from the bottom and either haul them into small craft or tow them to the ship. Additional lines were used to bundle nets before the ship craned the nets aboard. Nets were then transported back to Honolulu, where they were weighed, sampled, and properly disposed of.

## RESULTS AND DISCUSSION

High variability was evident in the number and class of nets encountered (Table 1). The overall average encounter value was 94 nets/km.$^2$ Area III and IIIa had more than twice the second highest net density (Table 1). There are two possible reasons for this high density. Much of the net was in smaller pieces, possibly the result of a large net being broken up over the area. This was suggested by the presence of many pieces of similar monofilament net. There is also the possibility that because of its central location in the atoll, Area III may accumulate nets not only from the north or east, but from the south and west as well. The atoll is open on the western end, with no expansive barrier type reef to the south, so nets may get blown in from all directions, depending on wind or current direction. In contrast, the structure of the barrier reef around Areas I and II would collect nets mostly from the north and east.

Nets were found at an average depth of 2 meters and in some cases as deep as 10 meters. Assuming nets drift on the surface, unweighted and presenting a minimal draft, shallow reef sites would collect more debris than deeper reef sites, as shown by the data. Areas with the most net (Areas I and III) were the shallowest with portions of the reef awash. Areas II and IV were deeper and collected substantially less net.

Nets that were removed were of the classes 2-4. Removal times ranged from 30 minutes to 3 hours using two divers and a coxswain. Often these nets contained some coralline and filamentous algae growth. One net, which was not removed, was completely encrusted and nearly undistinguishable from the bottom. Floating sections of partially encrusted nets were removed. The rest of these nets was left on the bottom because their hazard to marine life seemed minimal and because the encrustation had become part of the environment. Coral heads

were also found deeply tangled in the nets, making the nets heavier. These heads were mostly intact and had broken off at the base, which suggests that when a net washes across a reef, it briefly snags on the coral. Then large surf or storm causes the net to break the coral head and carry it off. The largest amount of netting was found in deeper water adjacent to shallow reef flats or in reef flat depressions. The nets, weighted with entangled coral heads, sank into the relatively calm, deeper water (<4 m) behind the flat. Larger nets sometimes contained two or more different types of net, which tended to be extremely tangled with one another. Whether they became tangled outside the reef or upon the reef is unknown, but these large nets frequently contained the most coral heads.

Differences in the reef configuration and wave energy in an area greatly influenced the condition of the nets. A notable difference occurred between Area Ia and Area IIIa, which contained a high number of small nets. Area Ia contained primarily large nets. Area IIIa may be a good example of what could be happening on the exposed ocean side of the barrier reef. Large surf was encountered at this site, and the net here appeared to be torn and shredded. Most of the net was found tangled along the edge of the reef on the quieter lagoon side. A strong current encountered along the western shore of East Island likely moved the bulk of the debris into the lagoon area. Once in the lagoon the nets were entangled on the patch reefs of Area III.

The large nets in the calmer waters of Area Ia doubled removal times. In one of these nets divers encountered two entangled Hawaiian monk seals. A pup entangled on the surface was freed by the divers. The other was a 4-year-old found drowned at the base of the net which had snagged on the bottom. The net in which the seals were found was the third largest net recovered. It differed from other nets in that it was unencrusted with growth, was tangled with fewer coral heads, and was floating in the water column with one corner snagged on the bottom. The net's condition suggested that it was a new arrival, indicating that nets are most dangerous when they first arrive at the atoll. A similar incident was reported at Midway Atoll in which two seal pups and a turtle were freed from a large mass of net found floating just outside the barrier reef (Lucy Kieth, pers. commun.)

Evidence of other entanglements included four vertebrae of an unidentified dolphin species. The bones were clean of flesh and had some tube worm growth, indicating that they had been in the net for a long time. Two shark teeth were found in another net. The condition of the two seals found entangled suggests that they had been there no more than 24 hours. No decayed seal remains (e.g., bones) were found in any nets surveyed or collected. This may be due to the large population of sharks and jacks in these waters that would likely remove any evidence soon after an entangled seal died. Estimating seal mortalities from entanglements is not possible but could be related to the accumulation rate of newly arrived nets.

Coral found entangled in the nets suggested that a degree of reef damage was occurring. Nets from the January survey weighed approximately 1,563.6 kg. These nets were analyzed for entangled corals. The entangled coral weighed 47 kg. Given that the average net weight was approximately 45 kg, which would contain approximately 1.35 kg of coral at the average density of 94 nets/km$^2$, there would be approximately 4,230 kg of net, tangled with 132 kg of coral per square kilometer. The shallow waters (<10 m) of French Frigate Shoals could hold 29,328 nets

with 916.5 kg of coral. How this directly or indirectly impacts the atoll's reef fish community and perhaps the seal's forage base is unknown.

## PROJECTIONS FOR CLEAN-UP

While only shallow areas <10 m deep were searched, general habitat surveys have sampled wider and in deeper waters of the atoll (Unpublished data, Frank Parrish). Towed diver surveys were used inside the atoll; outside the barrier a remote video camera was deployed by ship. The intent of the habitat survey was to sample every 3 square kilometers down to 100 meters. The towed diver surveys covered 37 km linearly, ranging in depth from 2 to 30 meters. While the divers were not specifically looking for netting, one recalls seeing a small amount at 20 meters, but the rest do not remember seeing any significant debris. The videotape record of the towed surveys does not show any net or debris. Cumulatively, the drop camera tows surveyed approximately 40 km linearly focusing on depths between 20 to 100 meters. These videos have been reviewed and no marine debris was noted. The data from these habitat surveys support the hypothesis that derelict nets are concentrated almost exclusively in the shallows (<10 m).

The net density of the present surveys was estimated at 94 nets per square kilometer. Total area estimates were derived using NOS charts 4171 and 19401. Using this value, the time estimated to clean the reefs of debris was calculated by using the efforts of two boats, two divers, and two coxswains working an 8-hour day. To clean the reefs at French Frigate Shoals, 20 meters and shallower, would take approximately 594 15-day cruises or 17 years with the present effort. To clean areas only 10 meters or shallower would take approximately 367 15-day cruises or 10 years. If we were to concentrate our efforts to only areas of high net density near pupping areas, such as the islands of Trig, Whaleskate, and East, it would take approximately 33 15-day cruises or 1 year. The present effort would clean 1 square kilometer in 12 days. If we were to change our efforts to four boats, four coxswains, and 12 divers working an 8-hour day, the estimate for cleaning the reefs near Trig, Whaleskate, and East Islands is 17 15-day cruises or 6 months. This effort would clean a one kilometer square in 6 days. These estimations do not include accumulation rates of nets on the reefs, which at present are unknown.

The implications of derelict nets to the seal population on an archipelago scale could be significant. Anecdotal reports from diving activities at Peal and Hermes Reef and Maro Reef indicate similar or more severe accumulations.

## CONCLUSION

The accumulation of nets in shallow water is a potential threat to monk seals, other

wildlife, and the reef. Nets that are newly arrived and are floating near the surface pose the greatest threat. The accumulation rate at French Frigate Shoals must be determined. Future surveys should concentrate on areas with the greatest amount of netting. Increased survey coverage will require more divers and more survey time. Net removal should focus on the medium and large nets because these represent a greater hazard of entanglement and cause the most reef damage.

## ACKNOWLEDGMENTS

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## CITATIONS

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Table 1.--Summary of area surveyed, nets found, nets removed, and nets per square kilometer, TC-96-11 and TC-97-01.

| Area weight | Area surveyed | Nets found | Nets removed | Net encounter rate | Total net (in kilograms) |
|---|---|---|---|---|---|
| I | 0.12 $km^2$ | 11 | 7 | 92 nets/$km^2$ | 387 |
| Ia | 0.098 $km^2$ | 14 | 14 | 143 nets/$km^2$ | 1465 |
| II | 0.15 $km^2$ | 1 | 1 | 7 nets/$km^2$ | 140 |
| III | 0.05 $km^2$ | 17 | 5 | 340 nets/$km^2$ | 55 |
| IIIa | 0.054 $km^2$ | 21 | 21 | 389 nets/$km^2$ | 98 |
| IV | 0.19 $km^2$ | 0 | 0 | 0 nets/$km^2$ | 0 |
| Total | 0.684 $km^2$ | 64 | 48 | 94 nets/$km^2$ | 2145 |

Table 2.--Removal times of nets by class using various boat, diver, and coxswain combinations.

| Net class | Average Removal Time with: | | |
|---|---|---|---|
| | 1 boat, 2 divers, 1 coxswain | 2 boats, 4 divers, 2 coxswains | 4 boats, 8 divers, 4 coxswains |
| Class I | 1 - 10 minutes | 1 - 2 minutes | 1 - 2 minutes |
| Class II | 10 - 30 minutes | 1 - 15 minutes | 1 - 5 minutes |
| Class III | 30 - 90 minutes | 15 - 60 minutes | 10 - 40 minutes |
| Class IV | 90 - 180 minutes | 60 - 120 minutes | 40 - 90 minutes |

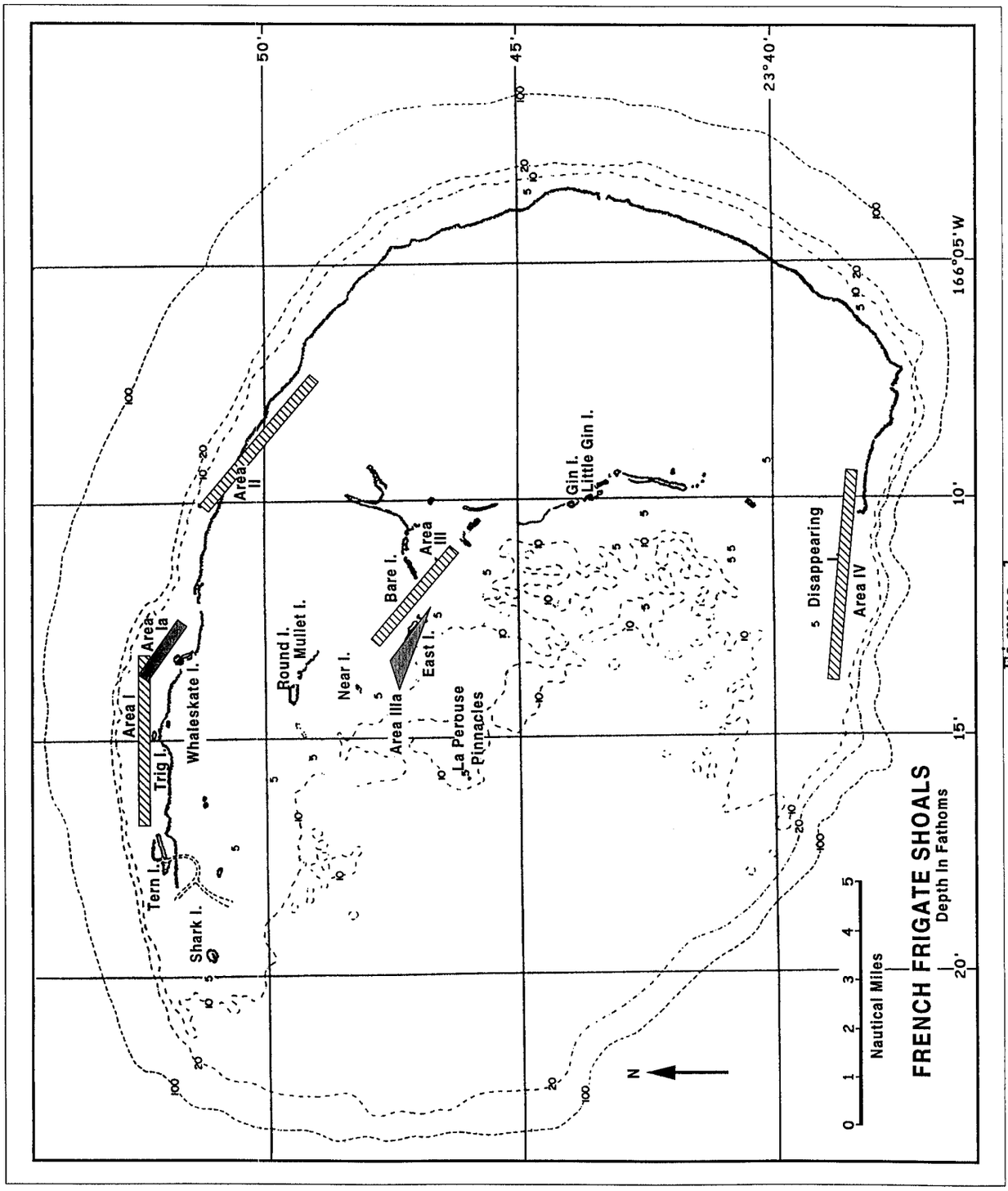
50'
45'
23°40'
166°05'W
10'
15'
20'
Area I
Area Ia
Trig I.
Tern I.
Shark I.
Whaleskate I.
Area II
Round I.
Mullet I.
Near I.
Bare I.
Area III
East I.
Area IIIa
La Perouse Pinnacles
Gin I.
Little Gin I.
Disappearing
Area IV
N
0 1 2 3 4 5
Nautical Miles
FRENCH FRIGATE SHOALS
Depth In Fathoms

Figure 1