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Damage to Spiny Lobster Gear by Sea Turtles and Other Predators

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Final Report 29 August 1977-31 January 1978
to
Southeast Fisheries Center
NMFS-NOAA

By

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INTRODUCTION

Spiny lobster (Panulirus argus) landings totaled 7.4 million pounds worth $9.9 million to Florida fishermen in 1975, the latest year published. The fishery is pursued predominantly from the southern Florida counties, where 5 million pounds valued at $6.7 million to the fisherman were landed in Monroe County in 1975 (Snell, 1975).

Florida law is very restrictive as to method of catching spiny lobster and also is very precise as to trap design. Thus, the principal method of commercial fishing is with concrete-weighted wooden-lath traps. Usually traps are buoyed separately, but they may also be set in "strings" with each trap tied consecutively with one or two buoys per string (Craig, 1974). Cow hide is the preferred bait but it is also common practice to leave shorter than legal length lobsters (76.2 mm or 3 inches carapace length) in traps as a means of attracting other lobsters.

Wooden-lath traps are a major recurring expense to the fisherman; traps last only one to one and one-half seasons (Austin, 1977). At today's prices, a trap, line and buoy costs approximately $12.00, not including labor to rig the trap for fishing. A reasonable estimate of the number of traps operated by a full-time commercial fisherman is 800-1000. This is an investment in gear alone of $9,600—$12,000. In addition to rapid deterioration, traps are lost to storms, to vandalism, boat propellers, and to marine predators.

Import by the U.S. of sea turtles or their products was prohibited 23 May 1977 by regulations published by the U.S. Department of the Interior (42 Federal Register 10462). Certain specific exceptions to this prohibition are controlled by strict permit. This U.S. action was taken as a result of the finding by the Convention on International Trade in

Endangered Species of Wild Fauna and Flora that sea turtle populations, on a world-wide basis, were either endangered or threatened depending on the species. Having banned U.S. international trade in sea turtles, federal agencies acted to determine the status of domestic sea turtle populations. Presently the National Marine Fisheries Service and the Fish and Wildlife Service intend to declare the green sea turtle, the loggerhead, and the Pacific Ridley threatened species under the authority of the Endangered Species Act of 1973. The proposed regulations would prohibit the capture, possession, sale or use of any of the three species of sea turtles. Furthermore, in areas of substantial breeding and feeding even the accidental, innocent capture of sea turtles would be prohibited. One such breeding and feeding area encompasses the Florida Keys where there is reportedly the largest loggerhead population existing today. This same area is the center of the valuable spiny lobster fishery, as previously described.

Lobster fishermen and fishing supply companies in south Florida contend that sea turtles cause significant damage to lobster traps and anticipate that damage would increase due to the intended total protection of turtles and their expected greater abundance. We know of no documentation corroborating the claims of the fishing industry, although scientists at the University of Florida attempted to focus attention on this problem by a proposal to Sea Grant in 1974 (Graycar and Johnson, 1974). Thus the verification of sea turtle damage to spiny lobster gear and the seriousness of this problem are the subjects of this report. Such information is required by those charged with management of the spiny lobster fishery and by agencies charged with the protection of sea turtles. Reasonable decisions concerning the future of the spiny lobster fishery and

the protection of sea turtles can best be made after the severity of the problem is assessed.

OBJECTIVES

The central issue in this study was to determine whether turtle damage of lobster gear was a problem or a non-problem, i.e., was there actual turtle damage to lobster gear or was damage being caused by other marine animals, and was damage widespread or were there just isolated incidents. This study did not propose nor imply finding solutions to the problem of damage should sea turtles be the cause. For easy reference, the objectives of this study, as stated in our proposal, are repeated here:

(1) To determine the extent and location of damage to lobster gear caused by marine organisms in the middle Keys area of Monroe County during the first five months of the 1977-78 spiny lobster season;

(2) to document incidents of gear damage by interview and to photograph physical evidence as available;

(3) to critically evaluate information obtained by interviews from fishermen and others as to probable causes of gear damage; and

(4) to prepare tables and figures to summarize the data and prepare a final report.

METHODS

A reporting and communications system was established during September 1977 with the spiny lobster fishery in Monroe County. Written reports, telephone response, interviews with fishermen, and assistance from other agencies were the methods employed to obtain information about gear damage.

Instructional posters and report forms, in Spanish and English, were designed and printed (Fig. 1a and 1b).

Presentations about the project were made to Middle and Lower Keys Chapters of the Organized Fishermen of Florida; their assistance in reporting damage was solicited; report forms were distributed to the members. We briefed known lobster dealers in Monroe County on the objectives of this study and the need for and manner of reporting information. Twenty-one of these fishing companies agreed to assist by advising their fishermen, encouraging them to report damage, and permitting us to prominantly display our instructional posters and attached report forms (Table 1). Regularly scheduled trips were made to retrieve and replenish the forms and to interview fishermen. During orientation trips through the Keys in September, numerous lobster fishermen were also briefed on this study.

Liaison was established with Everglades National Park rangers through a Park biologist, with the Marine Patrol, through the Marathon Office of the Florida Department of Natural Resources, and biologists of the University of Florida Spiny Lobster Research Project in Key West. Arrangements were made to accompany fishermen on fishing trips to observe lobster gear damage and to photograph it.

The 24-hour telephone reporting service was not immediately established because of technical delays in installation. We, therefore, requested collect telephone calls as a means of evaluating the need for this method of reporting.

By these arrangements the fishery was advised of the need for information and the opportunity of reporting gear damage by telephone, by report or to other agencies concerned with the fishery.

LOBSTER GEAR DAMAGE INQUIRY

UNIVERSITY OF MIAMI

This project was begun in response to requests of lobster fishermen who reported serious problems with trap and buoy damage from various sources, particularly sea turtles. The National Marine Fisheries Service has requested the University of Miami to investigate these complaints. We will try to determine the areas most affected, the major causes of damage, and, most important, the dollar value of your losses.

Although you and other fishermen may be well aware of the problem, often, those responsible for managment of the lobster fishery are not. This project can take your complaints and present them in a form that will reach officials and administrative personel. Awareness of the problem will spread beyond your small group of fishermen. The more people aware of the problem, the better chance of someone developing a solution for all or part of it.

You can help by filling out the gear damage reports found in the folder below, and then replacing them in the folder. They will be collected every two weeks by University of Miami personel.

Thank you very much for your cooperation.

Este proyecto se inició a petición de los pescadores de langosta que han tenido serios problemas al ser dañadas las nasas y las boyas por diferentes causas, sobre todo por las tortugas. El Servicio Nacional de Pesquerías Marinas (National Marine Fisheries Service) le ha pedido a la Universidad de Miami que investigue este problema. Nosotros trataremos de determinar las áreas más afectadas, las principales causas, y sobre todo, el valor en dólares de sus pérdidas.

Aunque Ud. y otros pescadores están conscientes del problema, a menudo los administradores responsables de la pesca de la langosta no lo están. Este proyecto puede tomar su información y presentarla en forma que llegue al personal oficial y administrativo. Es necesario que el mayor número posible de personas esté consciente de la importancia de este problema y así poder encontrar su solución parcial o total.

Usted puede ayudar llenando el "reporte sobre equipos dañados" que encontrará en la carpeta que está debajo de este cartel; después que complete la forma, colóquela en la misma carpeta. Personal de la Universidad de Miami recogerá dichos reportes dos veces al mes.

Muy agrecido por su cooperación.

Figure 1a. Instructional poster placed in fish houses.

For further information contact collect:
James B. Higman phone 305-350-7533
4600 Rickenbacker Causeway
Miami, Florida 33149

LOBSTER GEAR DAMAGE REPORT

Name (voluntary) _____ Date _____

Fishing company where damage was reported _____

Location where damage occurred: Bay _____ Gulf _____ Atlantic _____

Landmark nearest damaged gear _____

Number of traps damaged and repaired at sea _____

Number of traps damaged and repaired ashore _____

Number of traps total loss _____

Number of buoys damaged _____ lost _____

Amount of line lost (best estimate) _____

How long will it take to get damaged traps repaired and back in the water _____

What was your catch (in pounds) per trap pulled on this trip _____

Description of damage _____

_____

Probable cause of damage:

Shark ____ Turtle ____ Marine Mammal ____ Vandals ____

Other _____

How did you determine the cause of damage? _____

_____

Comments and remarks: _____

Figure 1b. Report form used for reporting lobster gear damage.

Table 1. Spiny lobster producers where posters and forms were located and reported numbers of active spiny lobster boats this season

Area	Company	Florida Location	No. Boats
Key West			
	A. and B. Fish Co.	Key West	14
	Aqua Harvesters Cooperative	Key West	7
	Ming Seafoods, Inc.	Stock Island	55
	Singleton Fish Co.	Key West	14
	Stock Island Lobster Co.	Key West	31
	Two Friends Fish Co.	Stock Island	25
	Woodsy Niles Fish Co.	Stock Island	30
Big Pine			
	E. Fish Co.	Cudjoe Key	12
Marathon			
	Angelo's City Fish Market	Marathon	20
	Conch Key Fisheries	Conch Key	12
	East Coast Seafoods	Marathon	35
	Keys Fish Co.	Marathon	16
	Marathon Seafood	Marathon	20
	Pinellas Seafoods	Marathon	25
	Superior Fish Co.	Marathon	12

Table 1. continued

Islamorada			
	Charlie Brown	Islamorada	27
	Matecumbe Seafoods Coop.	Matecumbe	dr*
	Sid and Roxies	Islamorada	7
Key Largo			
	Campbell Fish Co.	Tavernier	2
	Key Largo Fisheries	Key Largo	10
	Keys Lobster, Inc.	Key Largo	16
	TOTALS (Companies = 21)		(boats = 390)

*Declined to report numbers of boats

Estimates of annual trap damage and parts of its cost to the fisherman were made using damage reports from one reliable fisherman. He reported 83% of his trips during the survey period. The relation of damage to soaktime and catch per trap pulled was explored using simple linear regression techniques.

RESULTS

Field and Laboratory Activities

The NMFS Regional Office delay in the award of this contract until 29 August 1977 prevented securing data on lobster gear damage for the first month of the lobster season. Attendance at a Southeast Fisheries Center meeting on the sea turtle program (29 and 30 August, 1977) provided background information useful in obtaining cooperation from spiny lobster fishermen. The gear damage reporting system was successfully completed in September and interviewing was begun. Scheduled trips to obtain gear-damage reports and to conduct interviews were carried out during September-December (exact dates were given in the second quarterly report). Gear damage was photographed on lobster fishing trips in September, and December. The final report was prepared during January 1978.

During the survey period, distinctly different types of trap damage were discovered. Four types were found, caused by boat propellers, divers, hard bottom, and marine predators.

Boat propellers cut off the floats from the trap. In most cases, the entire trap is lost. The fishermen did not have an accurate estimate of the magnitude of this type of damage.

Damage to traps set on hard rocky bottom is easily detectable because the damage is always on the bottom of the trap. It occurs primarily during periods of high wave action. The pull of the float lifts and rocks the

trap. This causes the bottom of the trap to be abraded; in some cases completely worn away. This is not usually a serious problem for the fishermen because they avoid setting traps on rocky bottom.

Divers damage traps by pulling off 2 or 3 laths when they are robbing a trap. This type of damage is readily distinguishable because of the pattern of lath removal, the clean breaks in the lath and no signs of crushed laths. This type of damage occurs most often in shallow water (<15 ft) near keys which have access by road. In most other areas it is insignificant.

Predator damage was the most common type reported by the fishermen. There were two types of predator damage reported. In the most common, the lath is crushed and mangled, often the broken pieces are pushed into the trap as if an animal were breaking in. The amount of damage varies from one or two laths to most of the laths on all four sides and on the top. The other type of predator damage is much less common. In that type, the lath is broken (not crushed); it is pushed out, away from the trap as if an animal were breaking out. The fishermen ascribe the most common type of predator damage to loggerhead turtles and the other type to large grouper or snapper which enter the trap and later break out.

The investigators considered several possible sources of predator damage including turtles, sharks, large groupers, stone crabs, and marine mammals.

Rogue Turtles

Fishermen state that severe and repeated damage in the same area is usually caused by a turtle or group of turtles which have established a territory or home range in that area, although most turtles may damage traps only occasionally. They further believe that turtles learn from the

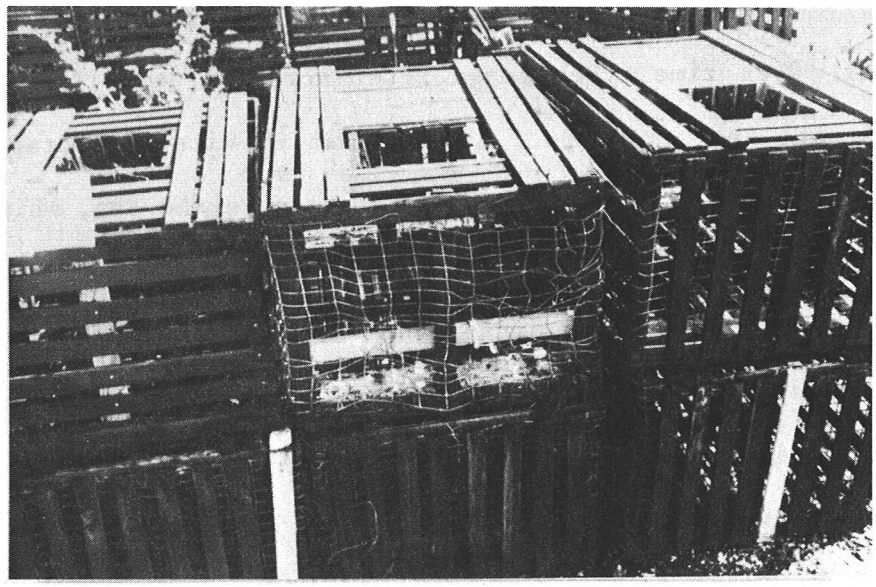
experience of breaking into traps. To support this, they cite changes in the effectiveness of various trap modifications designed to reduce damage from turtles. When a new method of trap protection, such as vertical laths or wire mesh, was introduced, damage to the new traps was minimal, at first. Over time, the damage rate increased as turtles learned how to break into the new traps. In the case of wire-clad traps, the area of damage changed from the sides of the trap to the top, which legally must not be protected by wire. In the past, when it was legal to take turtles, fishermen reported reductions in the rate of damage after several turtles were removed from an area sustaining heavy trap damage. They also observed, in areas where wire traps were used, that damage declined sharply if one or more of the captured turtles had scars on the jaw which the fishermen attribute to biting the wire mesh.

Counter Measures to Reduce Trap Damage

Two primary methods are used by the fishermen to make spiny lobster traps less vulnerable to sea turtles. These are vertical-lath traps and wire mesh (Fig. 2). Laths normally are nailed horizontally on traps. Some fishermen arrange the laths to run vertically, especially on the ends of the trap. Fishermen report this method to be effective in areas where damage is moderate, but not in areas where trap damage is severe.

Wire mesh is nailed outside of the laths of the trap enclosing all four sides (Fig. 2). Covering the top with wire is illegal. This is effective in protecting the trap sides, but an extremely determined turtle can tear off the wire. In most cases, trap damage to wire clad traps is in the top and funnel (Fig. 3).

a



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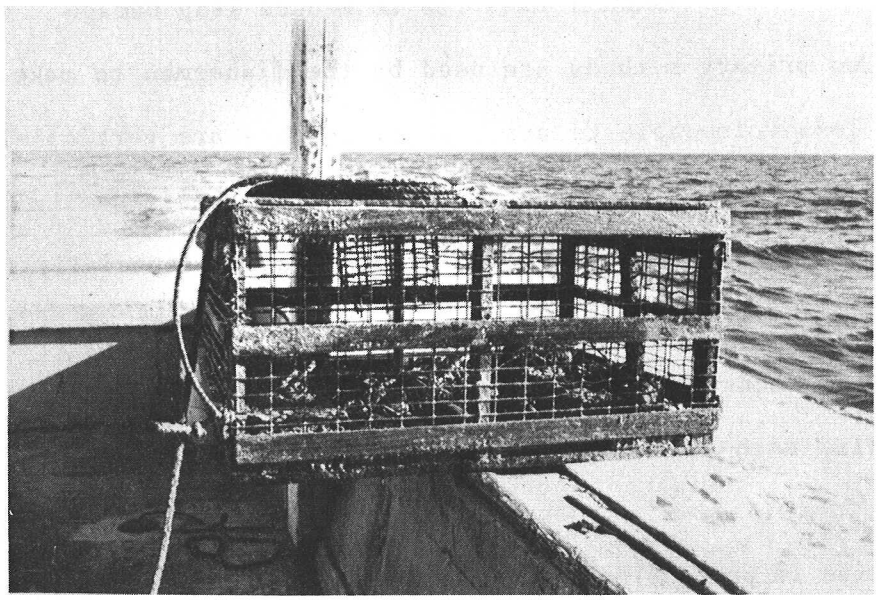
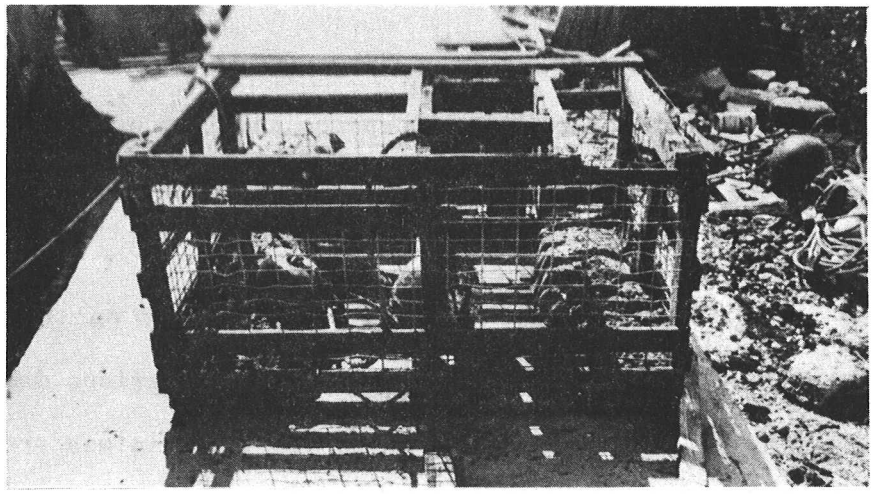


Figure 2a and b. Different trap designs (2a). Left to right upper photograph: traditional, horizontal trap laths, wire-sided trap, and vertical trap laths. Side view of a wire-sided trap (2b). Note: wire-sided trap in figure 2a shows evidence of past predation damage.

a



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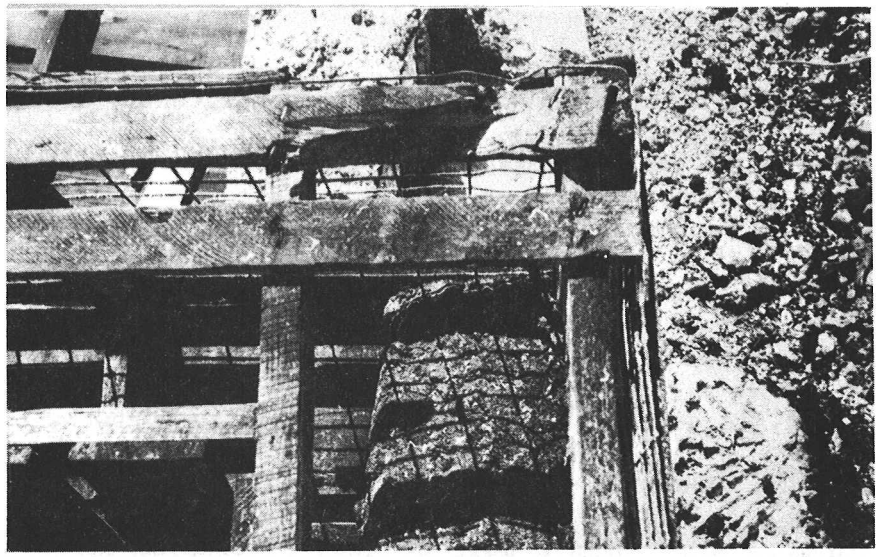

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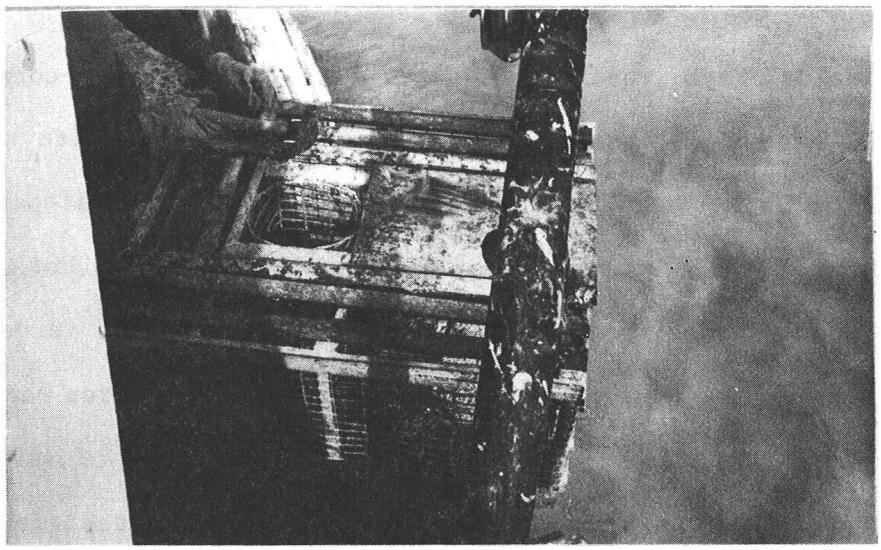


Figure 3a, b, and c. Unable to enter wire-sides of lobster traps, trap tops and funnel entrances are damaged by sea turtles.

Distribution of Trap Damage by Area

Data received from written damage reports and from numerous personal communications with lobster fishermen revealed different patterns of damage varying by area.

Predator damage to traps occurs almost exclusively on the Atlantic side of the Florida Keys. On the Gulf of Mexico side, serious damage from predators was reported only from the area of Sandy Key in western Florida Bay. The fisherman reporting damage from this area regarded it as very unusual.

On the Atlantic side, the greatest damage consistently occurred along a distinct section of the reef tract in an area of mixed sand patches and *Thalassia* beds in depths of 20 to 25 feet. These dense sea-grass beds usually are characterized by well-defined edges; often undercut and thus providing good shelter for lobster. The coarse calcareous sand bottom, with little silt, is devoid of vegetation or gorgonian growths (Carter *et al.*, 1977). This zone will be referred to in this paper as the "damage zone." The damage zone forms a more or less continuous strip along the entire length of the Keys. It is bounded on the seaward side by the crest of the Florida Keys reef (Fig. 4). This rocky live-coral ridge occasionally breaks the surface, but usually is covered with a minimum depth of 10-20 feet. Seaward of the reef crest, the bottom slopes rapidly to 100 fathoms. The landward side of the spiny lobster trap damage zone is bounded by Hawk Channel, a deep trench, from 30 to 50 feet in depth. In some areas, there is an secondary reef crest between the outer reef and the Channel. Within the damage zone, there were small areas of particularly severe damage, so devastating that fishermen are prevented from setting traps there. Fishermen report damage to 100% of their traps set in such

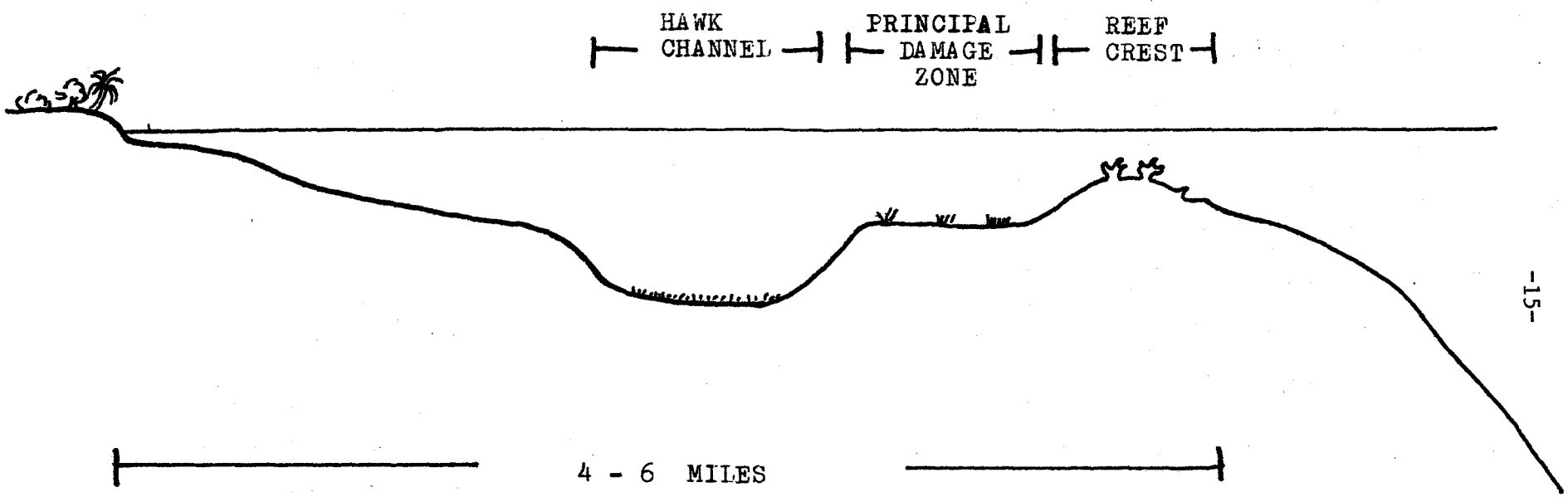


Figure 4. Typical cross section of the Florida Keys reef tract showing location of the primary trap damage zone(not to scale).

areas. Predator damage occurs in areas other than the damage zone, but we did not find a consistent pattern to this.

The severity of predator damage varied with area in the Florida Keys. Proceeding from the upper to the lower Keys, the severity of damage decreased. The most severe and wide-spread damage was reported along the reef tract off Key Largo. Insufficient damage reports make it impossible to accurately estimate the average rate of damage, but interviews with Key Largo fishermen indicated an approximate figure of eight traps damaged per hundred pulled in the damage zone. Twenty traps damaged per hundred pulled was not unusual. Many fishermen in this area use wire-clad traps exclusively, virtually all have some wire-clad traps.

In the Islamorada to Long Key area, reports were sparse. Comparatively, predator damage did not seem to be as severe as off Key Largo. Some, but not all, fishermen in the Islamorada area used wire-clad traps.

From Conch Key to Marathon, few fishermen reported predator damage. This may be partially related to the area in which they fish. One fisherman who was setting traps in the sand and grass zone experienced an extremely high rate of damage. Up to 56 traps were damaged per hundred traps pulled. Other fishermen that we contacted in this area were not placing traps in the sand and grass zone and were not experiencing problems. One fisherman in the Marathon area began using wire-clad traps only this season (1977).

From Marathon to Cudjoe Key, damage was moderate. Damage reports and personal communications with fishermen indicated an average damage rate of 3.8 traps per hundred pulled in the damage zone. Extreme damage could mean as many as 30 traps per hundred. No fishermen in this area used wire-clad

traps. They report catch rates from wire-clad traps to be less than lath traps.

In the Key West area, predator damage was minor. Few damage reports were returned and conversations with numerous fishermen and processors indicated that predator damage was negligable during the study period. However, many fishermen reported predator damage in past years particularly around the Marquesas Islands in sand and grass areas. No fishermen in the Key West area used wire-clad traps.

Factors Affecting Damage Rate

Fishermen asserted that trap damage from predators increased with the number of lobster in the trap and with increasing soaktime. It was difficult to separate the effect of each because of the small sample size. To test the theory that damage increased with the catch, damage reports from one consistent fisherman always fishing the same area were used (Table 2). The number of traps damaged per hundred traps pulled was regressed on mean daily catch per trap pulled. A positive slope was found, but the linear regression, $Y = 2.07X + 1.03$, was not significant, $r^2 = 0.29$ (Fig. 5). To test the hypothesis that trap damage increases with soaktime, the number of traps damaged per hundred traps pulled was regressed on number of days soaked (Fig. 6). The linear regression $Y = 0.35X + 0.79$ was nonsignificant, $r^2 = 0.20$. No workable method for separating the effects of soaktime, catch, or other factors could be developed.

Another type of variation in trap damage is found in the distribution of damaged traps among traps pulled on the same day. Fishermen report that on a given day, catch rates will be low in the majority of the traps pulled and very high in a few traps. This variation is not accounted for in a mean

Table 2. Data on trap damage, soak time, and mean catch per trap pulled ($\overline{CPTP}$) from 13 trips by one fisherman in one area

Trap Damage (#/100 pulled)	Soak Time (Days)	$\overline{CPTP}$ (lb)
1.5	7	.8
9.5	14	2.5
4.5	7	2.0
5.5	8	1.0
6.0	11	1.0
4.5	10	2.5
4.0	16	1.9
0.6	7	1.75
1.1	6	0.50
3.3	13	0.50
7.8	7	2.00
3.3	7	1.5
1.1	8	1.0

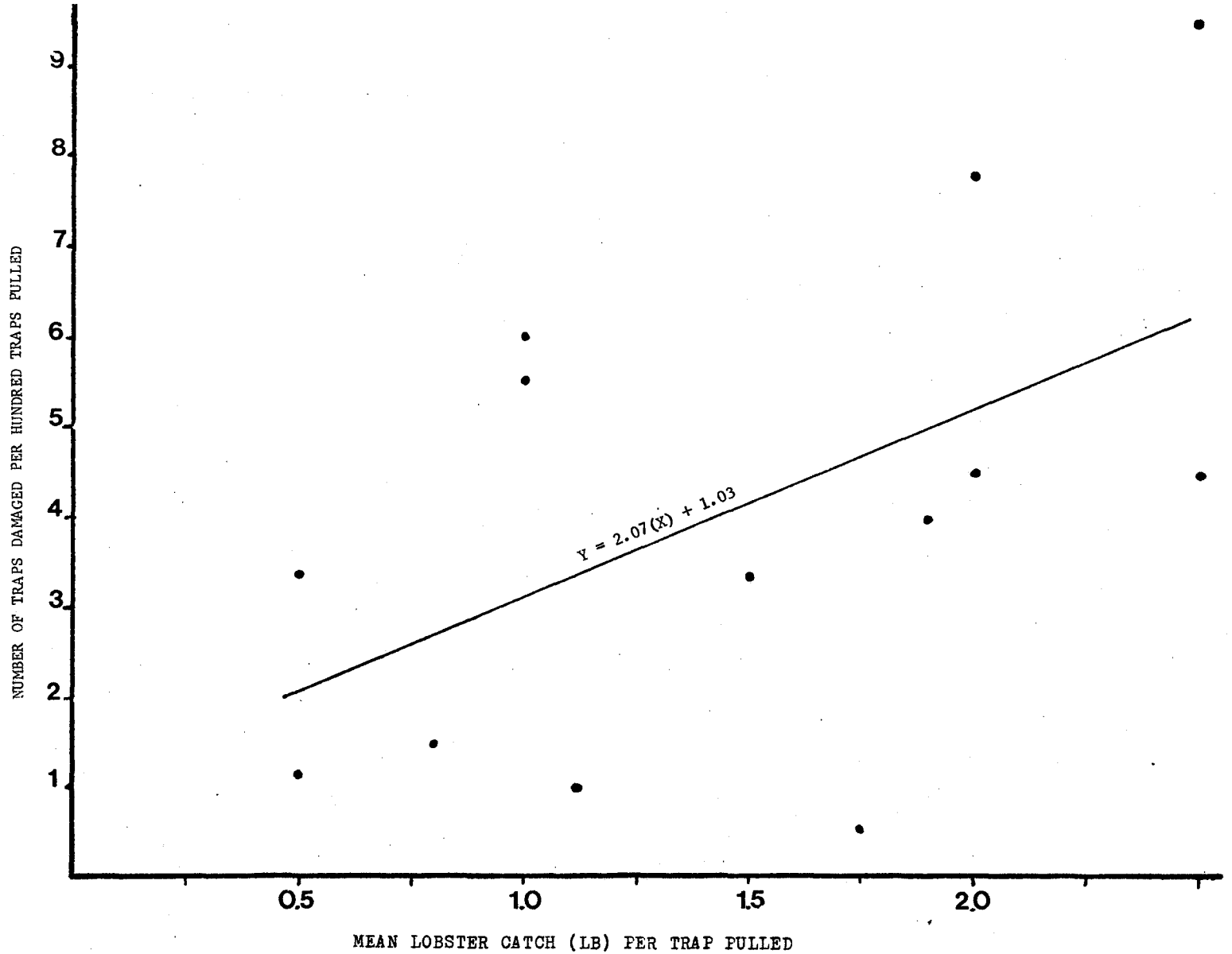


Figure 5. Repression of trap damage on catch, $r^2 = 0.29$.

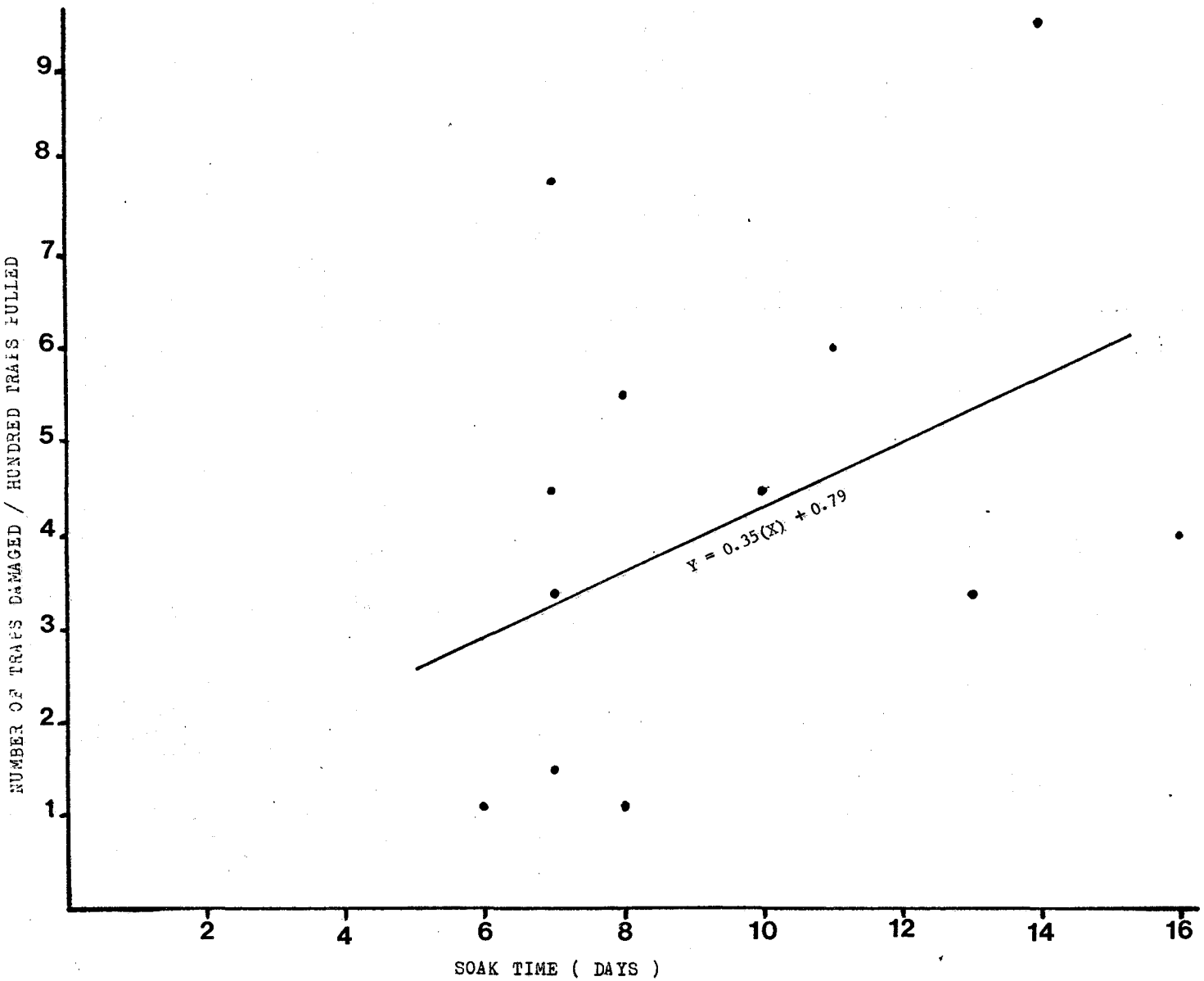


Figure 6. Regression of trap damage on soak time, $r^2 = 0.20$.

of catch per trap and could not be quantified with the available data.

Economic Loss from Trap Damage

We attempted to estimate the economic loss to the fisherman of trap damage from all sources. This proved impossible due to lack of data and to the extreme complexity of the problem when all types of damage were considered.

Consistent data were gathered from one fisherman with 850 traps between the Seven Mile Bridge and American Shoal. Approximately 380 of these were in the damage zone. These were placed in 2 sets. All traps in a given set were pulled in the same day. Most of these traps were fished from August 1 until approximately January 15. He recorded 83% of his trips during a 3-month period between 12 September and 8 December (Table 3). Total predator damage for the season was estimated from these data. The rate of damage was assumed constant over the major portion of the lobster season from 1 August to 31 December. An additional 22 fishing days were assumed. Total damage of 50 traps was estimated for the 470 traps which were fished in areas of low damage occurrence. Prices of materials and laths were obtained from the Atlantic and Gulf Fishing Supply Company catalogue (April, 1977 edition).

Loss of lobster catch was calculated using several rates of catch per trap (Table 4). Possible total loss estimates were calculated using mean catch (pounds) per trap pulled ($\overline{CPTP}$), $2(\overline{CPTP})$, $3(\overline{CPTP})$, and $4(\overline{CPTP})$. Annual loss estimates ranged from $949.00 to 3496.00.

Wire used to cover the traps to prevent predator damage is an additional cost to the lobster fishermen and is in excess of gear and catch losses. The two types of wire in use are galvanized and plastic-coated. Both types are 1 inch x 2 inch mesh, 14 gauge wire. In addition,

Table 3. Damage record of one fisherman fishing 380 traps in the damage zone.

Set 1: 200 traps, 8 trips reported

									Total	Mean
# traps damaged	1	3	19	9	11	12	9	8	72	9
catch per trap pulled (lb.)	1.75	.8	2.5	2	1	1	2.5	1.9		1.66
soaktime (days)	?	7	14	7	8	11	10	16		
lobster lost (lb.)	1.75	2.4	47.5	18	11	12	22.5	14	129.2	
Lath (bundles)									7	

Set 2: 180 traps, 7 trips reported

								Total	Mean
# traps damaged	1	2	6	14	6	2	5	36	5.02
catch per trap pulled (lb.)	1.75	0.5	0.5	2.0	1.5	1.0	2.0		1.32
soaktime (days)	7	6	13	7	7	8	22*	5	
lobster lost (lb.)	1.75	1	3	28	9	2	10	54.75	
Lath (bundles)								3.3	

*Inaccurate, two fishing days not reported.

Table 4. Economic loss from August through December 1977 to one fisherman fishing 380 traps in the damage zone

	Lobster Lost (lb.)	Dollars Lost ($1.65/lb.)	Cost of Lath ($3.15 per bundle)	Total (Rounded to $)
Set 1 (200 Traps)				
8 reported trips	129.2	213.20	22.05	235.00
10 additional trips (estimated)	161.5	266.50	27.56	294.00
Set 2 (180 Traps)				
7 reported trips	54.8	90.42	11.00	101.00
12 additional trips (estimated)	93.9	154.94	18.86	174.00
Damage to remaining 470 traps*	75	124.00	15.00	139.00
galvanized nails				5.00
TOTAL rounded to $:		849.00	95.00	949.00

Economic loss if mean loss equals:

Mean catch per trap pulled ($\overline{CPTP}$):	$849.00 + $100.00 = $949.00
2($\overline{CPTP}$):	$1698.00 + $100.00 =$1798.00
3($\overline{CPTP}$):	$2547.00 + $100.00 = $2647.00
4($\overline{CPTP}$):	$3396.00 + $100.00 = $3496.00

* Assume 50 traps damaged: $\overline{CPTP}$ = 1.5, 4.7 bundles of lath used.

galvanized wire requires a zinc anode. The cost per trap of anode-protected galvanized wire and plastic-coated wire was $3.72 and $4.42, respectively (Table 5). Total cost of wire varies with the number of traps fished.

An additional economic loss results from the reduction of fishing time required to repair damaged traps. Given an average of 15 minutes to repair one trap and seven damaged traps per day, the fisherman loses 1.45 hours fishing time each day. In this time, he could have pulled an additional 35-70 traps, depending on the distance between traps.

When predator damage is especially heavy, as in the upper Keys, fishermen must hire an additional crew member whose duty is to repair damaged traps. The extent of this cost could not be determined.

DISCUSSION

Turtle Damage of Spiny Lobster Gear

An issue of importance to this study was the verification of the claims of fishermen that sea turtles damage spiny lobster gear. Our findings support the claims of the fishermen.

Buoy Damage: The goose neck barnacle is a common food of the loggerhead turtle, and floating objects, with and without attached growths of goose neck barnacles, have been swallowed by loggerheads (Rebel, 1974 and Brongersma, 1972). This preference for goose neck barnacles and the habit of the turtle of swallowing floating objects appears to be one cause of damage to lobster trap buoys. This barnacle is prevalent on buoys and the buoy lines in the Florida Keys (Fig. 7). When biting at the barnacle the turtle can ruin the buoy or sever the line, causing loss of the trap. Buoy damage and the circular, black adhesive bases where the goose neck barnacles were attached to the buoys are shown in Figure 8. The beak of a

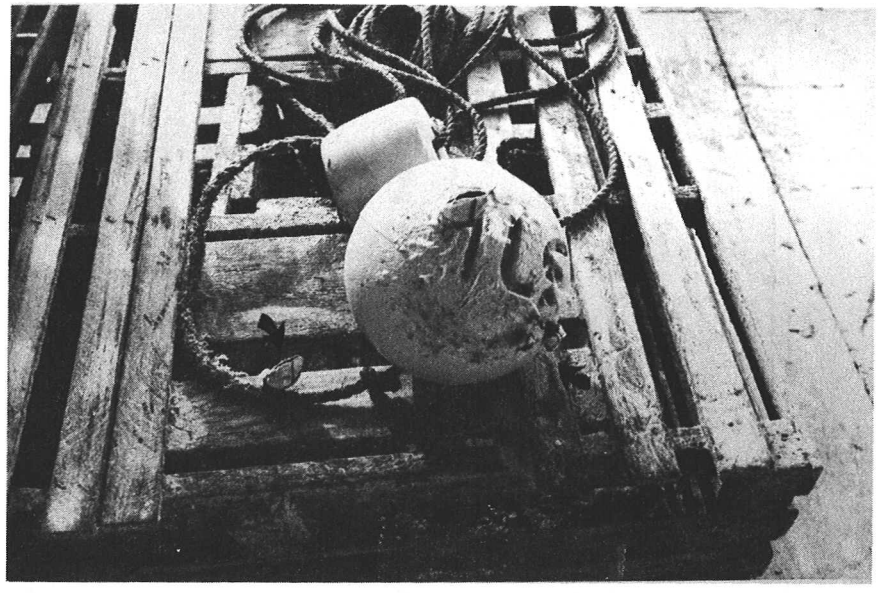


Figure 7. Lobster trap buoy and line showing attached goose neck barnacles.

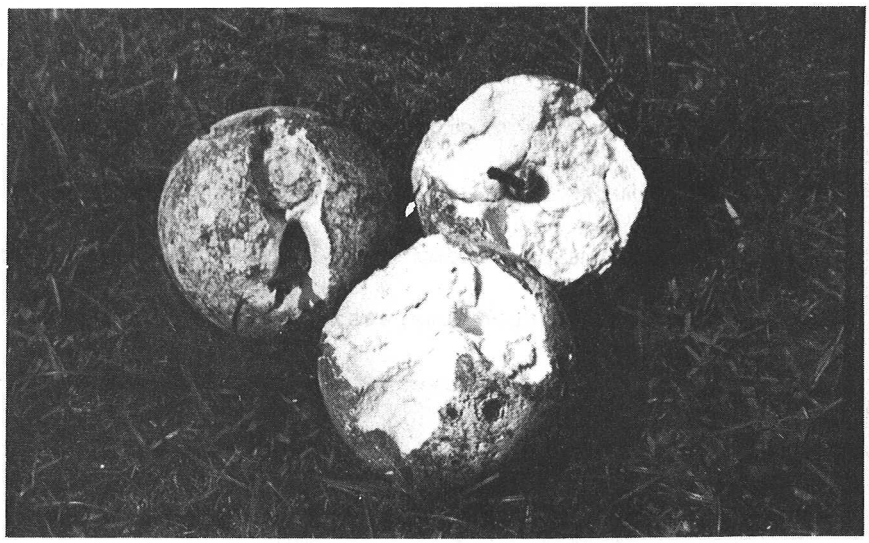
Table 5. Cost* of wire-clad traps

		Quantity	Cost per Roll	Cost per Trap**	Zinc 1 per trap per year	TOTAL
15"	vinyl-clad wire	(5-9 rolls)	$48.63	$4.42	0	$1.42
15"	galvanized wire		$35.47	$3.22	$0.50	$3.72

* Costs based on 100 foot rolls of 1" x 2" mesh, 14 gauge wire

** Average of 11 traps covered per roll.

a



b

c

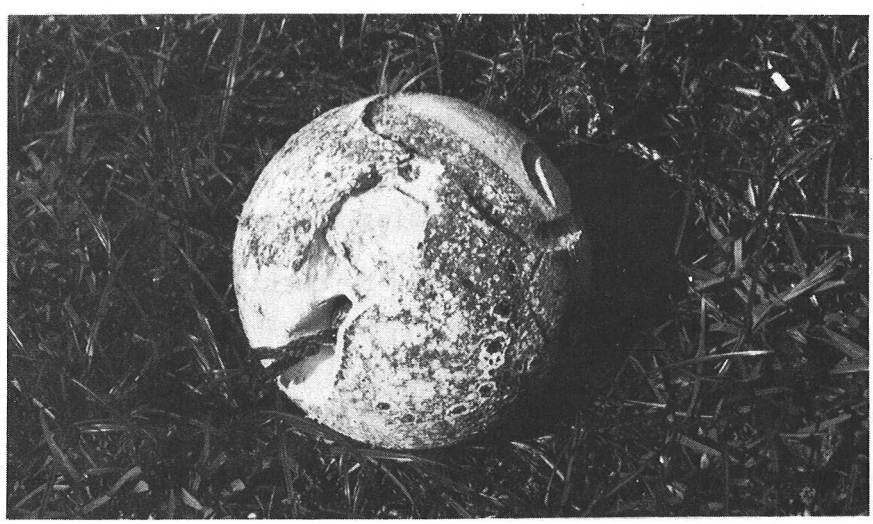


Figure 8a, b, and c. Lobster buoy damage. Damage by a large and a small turtle (8a). Buoy shows beak impression exactly matched by loggerhead turtle skull (8b). Beak bite and remaining barnacle adhesive bases (8c).

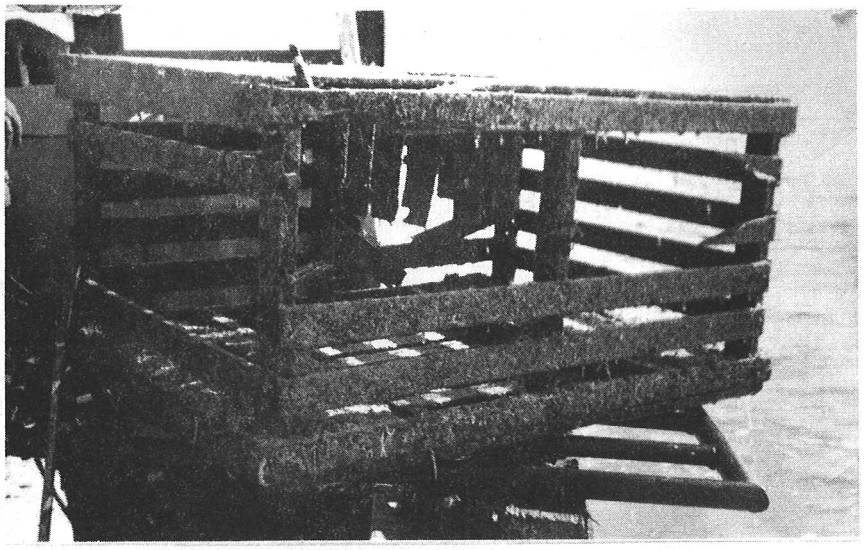
loggerhead turtle skull exactly fits the broken segment of styrofoam in Figure 8 (middle). The clearly visible beak-shaped impressions in these buoys are without teeth marks. This we believe eliminates toothed marine mammals as the cause of this type of damage. It also does not seem possible that these distinctive beak-shaped impressions could have been caused by propeller damage. The bites and removed styrofoam all are in that portion of the hemisphere of the buoy which is encrusted with marine growth. The line severage could have been accidental as growths on the line were eaten. All three float lines were shredded; the buoys were adrift. Some fishermen dip the buoys in heavily chlorinated water in an attempt to reduce this type of damage. We are convinced that sea turtles cause buoy damage.

Trap Damage: While green turtles are primarily vegetarians, Rebel (1974) reports that they also consume molluscs and crustacea. Loggerhead turtles may eat some sea grasses but they are mainly carnivorous; eating crabs, conch, fish, clams, and oysters (Carr, 1952). We did not find spiny lobster reported as a specific sea turtle food. Loggerhead turtles have been observed consuming spiny lobster "heads" discarded from commercial lobster fishing boats in the Bahamas (G. Waugh, personal communication). Lobster fishermen in the Florida Keys state that spiny lobsters are eaten by both green and loggerhead turtles. There were no direct observations of turtles damaging the lobster traps during the period of this study; thus the evidence for damage to lobster traps by turtles is circumstantial, but strongly so.

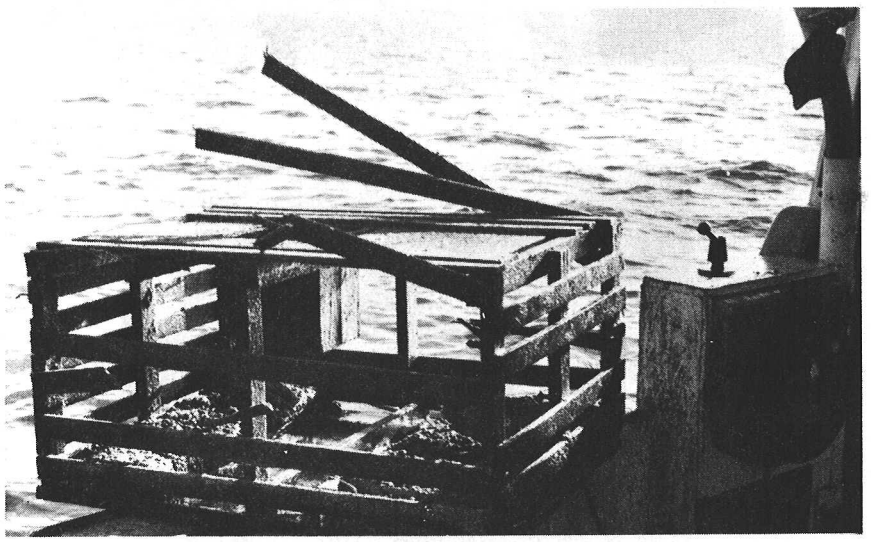
Figures 9 and 10 show lobster trap damage to side laths and top laths of several lobster traps. The crushed appearance of the ends of the broken laths lends credence to the cause of damage by turtles.

Gear damage is not restricted to lath traps. In Figures 3 and 10, damage to the sides and the tops of wire-sided lobster traps is clearly

a



b



c

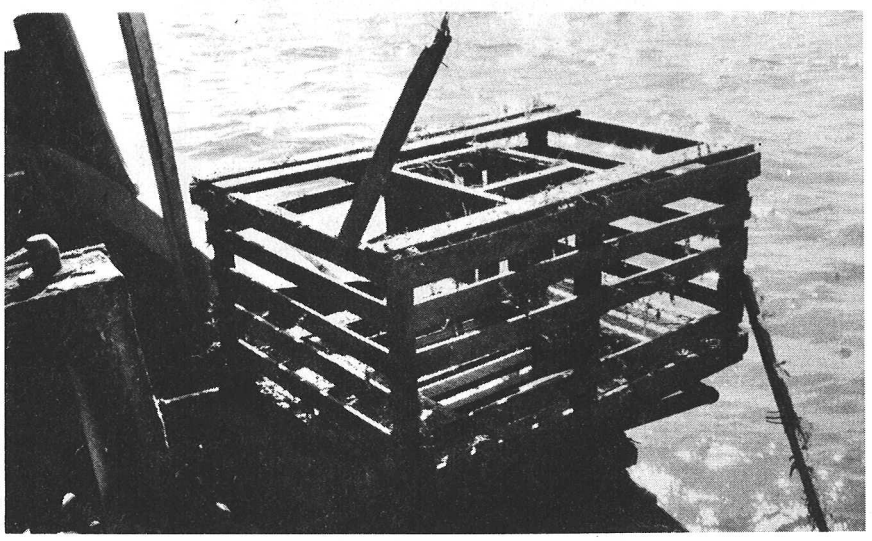
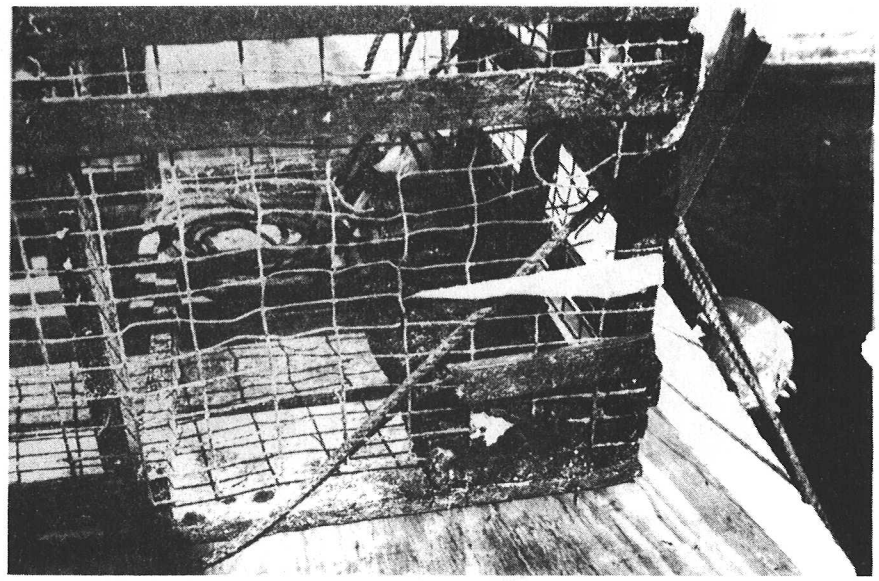


Figure 9a, b, and c. Trap damage to side laths and top. Note crushed appearance of the ends of the laths.

a



b

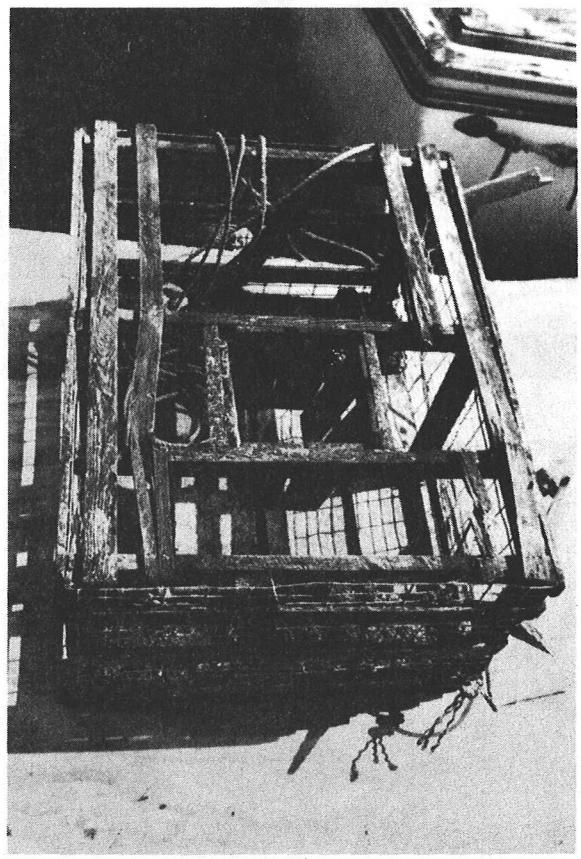


Figure 10a and b. Damaged wire-sided lobster traps. When entry is not gained through the side (10a) the trap top (lid) is destroyed (10b).

shown. Such damage is alleged to have been caused by two organisms, stone crabs and sea turtles, and it is readily differentiated. Stone crabs compress the wire meshes without causing lath damage. When sea turtles break the meshes, they also damage the laths.

Flipper marks are frequently observed by lobster fishermen in the marine growth of lobster traps. We saw these somewhat crescent-shaped markings on traps hauled from the sea.

Damage to lobster traps by divers is distinguishable from that by marine predators. Divers use a short bar to prey off laths from one side. Missing laths and ends showing clean breaks are unlike the mangled remains of lath ends damaged by predators. Marine growth on the top of the trap is usually undisturbed with no flipper marks.

In years past, when capture of sea turtles was permitted, fishermen report that removal of sea turtles from the trapping area virtually stopped their trap damage.

RSMAS marine mammologist, Dr. Dan Odell, was asked to review our photographs of trap damage for clues that might suggest predation by other than sea turtles. He stated, in effect, that porpoises are possible contributors to trap damage. They do, on occasion, eat shellfish and have the jaw shape to grasp trap laths, but without evidence of teeth marks on laths it was unlikely that the damage shown in these photographs was caused by marine mammals.

We questioned responsible lobster fishermen about the possibility of gear damage caused by marine mammals. Several had observed, but infrequently, atypical trap damage that might have been caused by a marine mammal. The frequency of this was not a problem.

In summary, we believe there is ample strong evidence of sea turtle damage to lobster traps:

a) fishermen assert that this has been observed;

b) the crushed appearance of lath s and tops without teeth marks;

c) appearance of apparent flipper markings in encrusted growths on the top of traps;

d) the damage to wire-sided traps and;

e) the cessation of trap damage when sea turtles have been removed from the lobster trapping area.

Fishermen state that turtles damage their traps in an attempt to feed on the trapped lobster and that they more frequently attack traps with many lobster than empty traps or ones containing only one or two lobsters. They support this by citing the condition of the inside of the damaged traps and the proximity of damaged traps to other traps which contain many lobsters.

Trapped lobsters brush the inside of the trap with their antennae. When several lobsters are in a trap, brushing removes mud and marine growth from the inside of the trap. The general consensus among fishermen was that it took at least four lobsters to make a trap very clean inside. Fishermen report that the number of lobsters previously in a recently damaged trap can be estimated by the "cleanness" of the trap.

The relation between cleanness of a trap and the number of lobsters it contained was observed by the investigators on trips with the fishermen. We also observed that most damaged traps were clean inside and saw some correlation between damaged traps and close proximity to other traps with higher than average catch rates.

The attempt to find a significant relation between trap damage and catch rate or soaktime was unsuccessful. These two factors are probably important to the determination of a rate of damage. Our lack of success might be attributed to variables not measured or the measures of soak time

and catch per trap might have been inaccurate or inappropriate.

Daily mean catch per trap pulled may poorly reflect the relation between catch in a particular trap and the probability of damage to it, if the turtles are more likely to attack traps which are full of lobster. The timing with which the lobsters enter the trap can affect the relation of soaktime and damage rate. Lobsters often move in large groups called "runs" by the fishermen. Herrnkind (1969) has reported these mass migrations from the Florida Keys and elsewhere. After August, the majority of the catch of fishermen is obtained from these runs. If the trap is empty for most of the soak period and a number of lobster enter the trap shortly before it is pulled, total soak time does not accurately reflect the actual time in which the trap is likely to be attacked by predatory turtles.

Many other factors may affect the rate of damage to traps. Fishermen have observed that damage decreases in time of poor water visibility. They also report sighting more turtles and finding more damage following severe cold weather. They believe that turtles move from Florida Bay onto the reef to avoid reduced water temperature.

In attempts to estimate loss of lobster from damaged traps, it was initially postulated that the mean daily catch per trap pulled ($\overline{CPTP}$) would be a reasonably accurate estimator. However, $\overline{CPTP}$ appears to be an underestimate. The available evidence strongly supports the fishermens contention that damaged traps contain more than the average catch. Based on personal observation and discussion with the fishermen from all parts of the Florida Keys, a loss rate of twice the $\overline{CPTP}$ was accepted as a more reasonable estimate. If this is the case, lobster escape as a consequence of turtle damage is a significant loss of income to the fisherman. An example of costs and returns very similar to that given above was presented

by Prochaska and Williams (1976). They report the average landings for lobster vessels 24-28 feet in length as 12,203 pounds. At a loss rate of 2 ($\overline{CPTP}$), 1029 pounds of lobster were lost by the fisherman we analyzed. This would have represented a 8% increase in average annual (total) landings. The average net return above total costs from lobster fishing estimated by Prochaska and Williams (1976) was $5,975 at a price of $1.11/pound. At this price the dollar loss from turtles to the Florida Key's fisherman was approximately $1142.00. Had this loss been eliminated, his net profit would have increased by 19%.

Estimates of gear damage and lobster loss (Table 3) and total dollars lost (Table 4) were discussed with fishermen in all areas of the Keys. The extent to which they agreed with these estimates varies by fishing area. Comments on the degree of damage and economic loss by fishing area follow closely the pattern of damage we described in the results section. In Key West, fishermen confirmed that gear damage from turtles was not significant this year (1977). In the area from Cudjoe Key to Marathon, fishermen generally agreed with our estimates. This was the area from which the data used to make the loss estimates were obtained. In the Marathon area, most fishermen did not fish in the damage zone. Some of those that did stated that their losses were much greater than our estimates. In the Upper Keys, Long Key to Key Largo, the fishermen's consensus was that turtle damage was much more costly to them than our estimates. It is not unusual for fishermen in Key Largo to spend $800 to $1,000 per year or more on wire. In addition, trap damage and loss of lobsters was greater.

RECOMMENDATIONS

Under the proposed EIS, section IV.5.b. exception to taking of sea turtles is proposed for cases of economic hardship (NMFS, not dated). Requirements regarding hardship exemptions are also provided for under the Endangered Species Act of 1973. We believe that our data demonstrate the basis for recognizing economic hardship due to turtle damage to spiny lcbster gear in certain limited areas of the Florida Keys of Monroe County. We therefore strongly recommend that upon due qualification, exemption be given for the removal of loggerhead or green turtles from the affected spiny lobster trapping area. It is further urged that extension service or advisory service personnel be assigned to assist spiny lobster fishermen to obtain such permits before the opening of the spiny lobster season, using damage data for the previous season.

In lieu of this option, which enables fishermen to help themselves, we recommend that the NMFS, using the fishermen as consultants, remove sea turtles from the Keys areas sustaining heaviest damage during the 1977-78 season, i.e., Key Largo and Cudjoe-Summerland Keys. This recommendation would be vastly more expensive and less effective than allowing the fishery to care for itself.

Additionally, we believe funding should be used to investigate methods of reducing sea turtle damage to lobster gear similar to that proposed to Sea Grant by University of Florida scientists. In that proposal, physical, acoustic, and electrical deterrants were proposed, along with basic behavioral studies.

ACKNOWLEDGEMENTS

Many members of the spiny lobster fishing industry aided this project, but we would like to especially thank: Tom Thomas of Cudjoe Key, Thomas Barrett and Henry Renier of Key Largo for taking us on lobster trips and allowing us to slow their work while we gathered data; Don and Gwen Hess of E. Fish Co.; and Bubba Felton of A&B Fish Co. for their help and hospitality.

We especially appreciate the assistance given to us in contacting fishermen and fishing companies by Douglas Gregory, Jr. and Christopher Combs of the Spiny Lobster Research Program of the University of Florida in Key West.

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Appendix Table A. Spiny lobster gear damage reports by fishermen and by Interview (September - December, 1977).

Date of Damage	Traps or Buoys Lost	Traps Damaged	Average Catch per trap (lb)	Type Damage	Area
9/10		3	0.75	slats, one side	Marquesas Key
9/12		1	1.75	slats, one side	Looe Key
9/14		1	1.75	slats, one side	Looe Key-American Shoal
9/15		8	0.80	slats/frame	Key Largo Reefs
9/15		3	1.00	slats/lid	Looe Key
9/16		4	2.00	14 buoys/slats, one side	NE Dry Rocks
9/19		3	0.80	slats, one side	Looe Key
9/20		2	0.50	slats, one side	Looe Key-American Shoal
9/21	3 traps, buoys, line	17	1.00	frame/lid/funnel	Looe Key
9/22		12	1.00	slats/frame	Hawk Channel
9/22		5	0.75	slats	Florida Bay
9/22		2	0.80	---	Atlantic
9/23	100 traps*	--	--	Total loss	West Key West
9/25	1 buoy	6	1.50	3 buoys, one side	Bahia Honda
9/29	50 traps, buoys, line	400-300	5.00	one side/one end	Hawk Channel
9/29	40 traps, 4 buoys 2400 ft. line	150	0.50	top/funnel	Coffin Patch
9/30		15	0.50	side/lids/funnel	Looe Key
Sept.	20 traps, buoys, line	30	5.00	3 sides, frame	Loggerhead & Looe Keys
10/3		6	0.50	slats, side	American Shoal
10/6		18	0.78		? Hawk Channel (?)
10/6		1	0.50	slats, one side	Atlantic
10/?		--	--	Divers	Florida Bay & Atlantic
10/		4	1.0	slats/end	Florida Bay
10/		--	--	major repairs	Molasses-Alligator Reefs
10/10		14	2.0	slats, one side	American Shoal
10/11		19	2.5	slats, one side	Looe Key
10/12		7	2.0	slats, one side	Hawk Channel
10/13		12-13	0.50	slats, one or two sides	American Shoal
10/17		55	2.17	lids/slats, one side	Molasses Reef
10/17		6	1.50	slats, sides	American Shoal
10/18		9	2.00	slats, sides	Looe Key
10/18		8	7.00	lids	Off Tavernier
10/21		12-14	4.00	side slats	Grecian Rocks
10/25		2	1.00	side slats	Looe Key-American Shoal
10/26		11	1.00	side slats	Looe Key-American Shoal
10/28		13	0.70	one & two sides and ends	Key Largo Reefs

Date of Damage	Traps or Buoys Lost	Traps Damaged	Average Catch per trap (lb)	Type Damage	Area
11/6		12	1.00	side slats/lids	Hawk Channel
11/15		6	1.00	side slats	Hawk Channel
11/16		8	2.50	side slats	Hawk Channel
11/17		5	2.00	side slats	American Shoal
12/2		8	1.80	side slats	Looe Key-Hawk Channel
12/3		8	2.00	side slats/frames	American Shoal
12/3		6	1.50	side slats	American Shoal
12/15		15	1.00+	side slats	Hawk Channel
12/15		3	1.80	side slats wire damage not counted	Hawk Channel

*This loss to commercial net boats mackerel fishing.

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