HJR

25

CS FOR SPONSOR SUBSTITUTE FOR HOUSE JOINT RESOLUTION NO. 25(RES)

IN THE LEGISLATURE OF THE STATE OF ALASKA

NINETEENTH LEGISLATURE - FIRST SESSION

BY THE HOUSE RESOURCES COMMITTEE

Offered:
Referred:

Sponsor(s): REPRESENTATIVE GRUSSENDORF

A RESOLUTION

Relating to a ban on trawling in the eastern Gulf of Alaska east of 140 degrees west longitude.

BE IT RESOLVED BY THE LEGISLATURE OF THE STATE OF ALASKA:

WHEREAS the eastern Gulf of Alaska has been a significant hook and line fishing area for almost 100 years and most of the high value fisheries in the area are fully utilized by the hook and line fishing fleet; and

WHEREAS the level of trawl fishing effort in the eastern Gulf of Alaska is expected to exert undue fishing pressure on fish stocks in the area and displace traditional hook and line fisheries; and

WHEREAS foreign trawl fishing in the Gulf of Alaska resulted in depressed populations of several species of rockfish; and

WHEREAS the eastern Gulf of Alaska contains a unique assemblage of valuable rockfish species in amounts small enough that the rockfish stocks could be easily damaged by large vessel activity; and

WHEREAS, under federal fishing regulations, if any single species in the rockfish complex reaches its overfishing level, the entire rockfish complex and any other fishery that might take any of the overfished rockfish species are closed; and

WHEREAS the trawl fishery in the eastern Gulf of Alaska can significantly disrupt the traditional fisheries on which 3,000 Southeast Alaska hook and line fishermen depend; and

WHEREAS the narrowness of the continental shelf and continental slope in the eastern Gulf of Alaska concentrates trawl fishing effort in a small area and as a result prevents recovery of trawl fishing areas and may permanently impoverish the ecosystem of the eastern Gulf of Alaska; and

WHEREAS the Southeast Alaska area contains limited smooth bottom areas suitable for trawls, but many rocky areas that support an abundant, diverse, but fragile deep water habitat; and

WHEREAS the impact of trawl roller gear and trawl doors could significantly affect corals and associated hard bottom species; and

WHEREAS, only by closing the eastern Gulf of Alaska east of 140 degrees west longitude to trawl fishing, will the unique assemblage of local marine resources be protected;

BE IT RESOLVED by the Alaska State Legislature that the North Pacific Fishery Management Council through the United States Secretary of Commerce is respectfully requested to immediately implement permanent regulations closing the eastern Gulf of Alaska east of 140 degrees west longitude to pelagic and bottom trawling.

COPIES of this resolution shall be sent to the Honorable Ron Brown, Secretary, U.S. Department of Commerce; the Honorable Richard B. Lauber, chair of the North Pacific Fishery Management Council; and to the Honorable Ted Stevens and the Honorable Frank Murkowski, U.S. Senators, and the Honorable Don Young, U.S. Representative, members of the Alaska delegation in Congress.

F USE COMMITTEE REPOF

(9)
Date Referred: March 3, 1995

FURTHER REFERRALS:

Date of Committee Action: 3/15/95

The RESOURCES Committee considered: SSHJ 25

SPONSOR SUBSTITUTE FOR HOUSE JOINT RESOLUTION NO. 25
BAN TRAWLING IN EASTERN GULF OF ALASKA

Relating to a ban on trawling in the eastern Gulf of Alaska east of 140 degrees west longitude.

recommends it be replaced
with the following committee substitute CS SSHJR 25 (RES)

[X] the same title
[ ] a new title

[ ] additional referral to ____________ Committee
[ ] attached amendment(s)

ADOPTS: ____________ Letter of Intent

ATTACHES NEW FISCAL NOTE(s): (Dept)

[ ] fiscal note(s) ____________

[ ] zero fiscal note(s) ____________

APPROVES PREVIOUS: (Dept/Date)

[ ] fiscal note(s) ____________

[X] zero fiscal note(s) ADF&G

SIGNING WITH RECOMMENDATIONS		DP	DNP	NR	AM
[signature]	Davies	X			
[signature]	Maclean	X			
[signature]	Green	✓			
[signature]	Kott	✓			
[signature]	Ogan	✓			
[signature]	Williams	✓			
[signature]	Austerman			✓	
		(6)		(1)	

CHAIR'S SIGNATURE [signature]
Williams

REPRESENTATIVE
BEN GRUSSENDORF
1221 HALIBUT POINT ROAD
SITKA, ALASKA 99835
(907) 747-8458

FINANCE COMMITTEE

DISTRICT 2
KUPREANOF
PETERSBURG
SITKA
WRANGELL

Alaska State Legislature

WHILE IN JUNEAU
STATE CAPITOL
JUNEAU, ALASKA 99801-1182

(907) 465-3824

House of Representatives

TO: Representative Joe Green
Co-Chairman
House Resources Committee

Representative Bill Williams
Co-Chairman
House Resources Committee

FROM: Representative Ben Grussendorf

DATE: February 20, 1995

RE: SSHJR 25, "Relating to a ban on trawling in the eastern Gulf of Alaska east of 140 degrees west longitude.

I have introduced SSHJR 25 in response to concerns expressed by Southeast fishermen for the devastating impacts of trawl fisheries on the condition of the rockfish stock and on the delicate habitat on the bottom of Southeast Alaska waters. The level of trawl fishing effort in the eastern Gulf of Alaska is expected in increase, resulting in depressed populations of several species of rockfish and damage to the fragile deep water habitat in Southeast.

The sponsor substitute made the following changes from the original resolution:

page 1, lines 1 - 2 was amended as follows:

"Relating to a ban on trawling in the eastern Gulf of Alaska <u>east of 140 degrees west longitude</u>."

page 1, line 12 added a new whereas:

"Whereas the eastern Gulf of Alaska contains a unique assemblage of valuable rockfish species in amounts small enough that the rockfish stocks could be easily damaged by large vessel activity; and"

page 1, lines 15 - 16; page 2, line 1 reworded a whereas:

"Whereas, under federal fishing regulations, if any single species in the rockfish complex reaches its overfishing level, the entire rockfish complex and any other fishery that might take any of the overfishing rockfish species are closed; and"

page 2 lines 13 - 14 was amended as follows:

"Whereas, only by closing the eastern Gulf of Alaska east of 140 degrees west longitude to trawl fishing, will the unique assemblage of local marine resources be protected;"

page 2 line 16 was amended by deleting the reference to emergency regulations.

I appreciate your consideration in scheduling a hearing for this resolution in your committee at your earliest convenience.

Thank you.

AMENDMENT #1
SSHJR 25

Austerman

Page 2 Line 15 INSERT After the second occurrence of the word "The"

NPFMC through the

Page 2 Line 19 INSERT After the word "The"

NPFMC; the

Alaska State Legislature

REPRESENTATIVE
BEN GRUSSENDORF
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SITKA, ALASKA 99835
(907) 747-6458

FINANCE COMMITTEE

DISTRICT 2
KUPREANOF
PETERSBURG
SITKA
WRANGELL

WHILE IN JUNEAU
STATE CAPITOL
JUNEAU, ALASKA 99801-1182

(907) 465-3024

House of Representatives
SPONSOR STATEMENT

SPONSOR SUBSTITUTE FOR HOUSE JOINT RESOLUTION 25

"Relating to a ban on trawling in the eastern Gulf of Alaska east of 140 degrees west longitude."

Southeast Alaska has a unique marine environment. The delicate marine environment differs from northern areas. It is extremely vulnerable to long term damage to the habitat of the bottom. Southeast Alaska also has a long history of longline fishing offshore. This economy is threatened by the activities of the factory trawlers. The species affected by the trawlers are fully allocated.

Southeast's marine environment has provided longline fishers the opportunity to make a living for over a century. Targeted species of halibut, sablefish, shelf rockfish and cod are caught on longlines with little damage, if any, to the bottom of the Pacific shelf. Most of the longline vessels are small. In many small towns commercial fishing is the only commercial opportunity.

I have introduced this resolution at the request of the Alaska Longline Fisherman's Association. I believe it is a good compromise with the trawl fleet and protects a generously productive marine environment from harm. It also will protect an industry that is for the most part locally owned and operated and which provides great returns to the communities and the economies of those communities.

I respectfully request your support.

FISCAL NOTE

STATE OF ALASKA
1995 LEGISLATIVE SESSION

BILL NO. SSHJR 25

Revision Date:
Title: Ban trawling in eastern Gulf of Alaska
Sponsor: Rep. Grussendorf
Requester: House Fisheries

Dept. Affected: Fish and Game
BRU: CFMD
Component: Fisheries Management
Component Serial No. 1941

Expenditures/Revenues (Thousands of Dollars)

OPERATING EXPENDITURES	FY 96	FY 97	FY 98	FY 99	FY 00	FY 01
PERSONAL SERVICES	0.0	0.0	0.0	0.0	0.0	0.0
TRAVEL	0.0	0.0	0.0	0.0	0.0	0.0
CONTRACTUAL	0.0	0.0	0.0	0.0	0.0	0.0
SUPPLIES	0.0	0.0	0.0	0.0	0.0	0.0
EQUIPMENT	0.0	0.0	0.0	0.0	0.0	0.0
LAND & STRUCTURES	0.0	0.0	0.0	0.0	0.0	0.0
GRANTS, CLAIMS	0.0	0.0	0.0	0.0	0.0	0.0
MISCELLANEOUS	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL OPERATING	0.0	0.0	0.0	0.0	0.0	0.0

CAPITAL EXPENDITURES						

CHANGE IN REVENUES ( )						

FUND SOURCE (Thousands of Dollars)

1002 Federal Receipts						
1003 GF Match						
1004 GF						
1005 GF/Program Receipts						
1008 GF/MHTIA						
Other						
TOTAL	0.0	0.0	0.0	0.0	0.0	0.0

Estimate of any current year (FY95) cost: $ 0.0

POSITIONS

FULL-TIME						
PART-TIME						
TEMPORARY						

ANALYSIS: (Attach a separate page if necessary)

Prepared by: Geron Bruce *Geron*
Division: Commissioner's Office
Approved by Commissioner: *[signature]*
Agency:

Phone: 465-6143
Date: 2/28/95
Date: *2/28/95*

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H˜USE COMMITTEE REPOR˜

(5)
Date Referred: February 20, 1995 FURTHER REFERRALS: Resources

Date of Committee Action: 3/1/95

The HOUSE SPECIAL COMMITTEE ON FISHERIES Committee considered: SSHJR 25

SPONSOR SUBSTITUTE FOR HOUSE JOINT RESOLUTION NO. 25
BAN TRAWLING IN EASTERN GULF OF ALASKA

Relating to a ban on trawling in the eastern Gulf of Alaska east of 140 degrees west longitude.

recommends it be replaced
with the following committee substitute ____________ [ ] the same title [ ] a new title

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ATTACHES NEW FISCAL NOTE(s): (Dept) APPROVES PREVIOUS: (Dept/Date)

[ ] fiscal note(s) ____________ [ ] fiscal note(s) ____________

[X] zero fiscal note(s) ADFG [ ] zero fiscal note(s) ____________

SIGNING WITH RECOMMENDATIONS	DP	DNP	NR	AM
[signature]	✓			
[signature]			✓	
[signature]			✓	
[signature]			✓	
[signature]	✓			

CHAIR'S SIGNATURE [signature] 3/1/95

KODIAK FISH COMPANY

F/V Alliance F/V Provider
P. O. Box 469
Kodiak, Alaska 99615-0469

March 6, 1995

The Honorable W. K Williams
Co Chairman
House Resources Committee
Alaska House of Representatives

VIA FAX: 907-465-3793

Re: A Resolution relating to a ban on trawling in the eastern Gulf of Alaska east of 140 degrees west longitude.

Dear Chairman Williams:

The resolution relating to a ban on trawling will have some repercussions on the scallop fishery which takes place in the eastern Gulf of Alaska. Significant commercial beds of scallops occur east of 140 degrees west longitude. Though the ban on trawling would not directly ban scalloping, the draft scallop FMP currently being written by the North Pacific Fishery Management Council incorporates all of the areas closed to bottom trawling so that they are all also closed to scalloping.

The scallop fleet is required to have 100% observer coverage and so has gathered a significant number of observations on bycatch and catch in this fishery in the eastern Gulf. The bycatch in this area is termed by the biologists as "minimus" - meaning that bycatch is insignificant. Our own vessel has never caught a rockfish nor have we fished in or caught any coral. In fact, the areas considered sensitive including those containing coral forests have already been closed to scalloping by the Board of Fish. We had no objection to closures of those areas as no commercially important scallop resources exist there and closure would prevent any novice scallopers who were not aware of this from entering an area and potentially causing problems.

We would request that this Resolution be amended to specifically exclude scalloping as the scallop fishery does not impact any rockfish stocks nor any other species other than weathervane scallops. Thank you for the opportunity to comment.

Sincerely,

Mark P Kandianis

Mark P. Kandianis

PHONE 907-486-6002
FAX 907-486-2617

FILE COPY

3741

Final Report

Research Unit #601

HABITAT REQUIREMENTS AND EXPECTED DISTRIBUTION OF ALASKA CORAL

Robert L. Cimberg
VTN Oregon, Inc.

Tim Gerrodette
Scripps Institution of Oceanography

Katherine Muzik
Harvard University

October 1, 1981

II. BACKGROUND REVIEW

The term "coral" is applied to several diverse orders within the Phylum Coelenterata (Table 1). This study covers those orders of Coelenterates having corals found in Alaska. These include the orders Alcyonacea (soft corals), Gorgonacea (sea fans or horny corals), and Scleractinia (cup corals, stony corals, or hard corals) in the class Anthozoa, and the order Stylasterina (hydrocorals) in the class Hydrozoa.

The morphology of corals varies. The living tissues are composed of polyps, each with a mouth surrounded by tentacles. Some species are composed of a single polyp, others are colonies of many polyps. Certain corals are upright and display varying degrees of branching, while others are low growing, encrusting forms. Corals vary in size from less than 1 cm to over 1 m. The skeletons of corals consist of spicules which are embedded within or are deposited outside the living tissues. The chemical composition (hardness) and size of the skeleton are important in determining the commercial value of each species.

Sexual reproduction usually takes place between individual polyps or colonies, since sexes in most corals are separate (Lacaze-Duthiers 1864; Bayer and Weinheimer 1974; Grigg 1977; Weinberg and Weinberg 1979). Female colonies harbor the eggs, which are fertilized by sperm from male colonies. Fertilized eggs develop within the female polyps into planula larvae.

The planula larva of many species has never been observed (Stimson 1978); those that have been studied are usually large (between 0.5 and 2.5 mm long), pink, ciliated, and slightly negatively buoyant (Sevens 1981). The larvae usually live between 2 and 10 days (Lacaze-Duthiers 1864; Gohar 1940; Kinzie 1973; Grigg 1977; Weinberg and Weinberg 1979) although some have been reported to survive up to 90 days in the laboratory (Vaughan and Wells 1943; Grigg 1979).

Table 1. Coelenterate Systematics. Orders covered in this study are asterisked (*).

Phylum Coelenterata	Common Name; Distribution
Class Anthozoa	
Subclass Octocorallia (Alcyonaria)	
* Order Alcyonacea	Soft corals, sea strawberries; found in Alaska.
Order Coenothecalia	Blue coral; found in tropical Pacific reefs.
* Order Gorgonacea	Sea fans, fan coral; found in Alaska.
Order Pennatulacea	Sea pens, sea pansies; found in Alaska.
Subclass Hexacorallia (Zoantharia)	
Order Actinaria	Sea anemones; found in Alaska.
Order Antipatharia	Thorny corals, black coral; found in tropics, subtropics.
Order Ceriantharia	Cerianthids; possibly in Alaska[1].
* Order Scleractinia (=Madreporaria)	Stony corals, cup corals; found in Alaska.
Order Zoanthidae	Zoanthids; not in Alaska.
Class Hydrozoa	
Order Hydroida	Hydroids and jelly fish; found in Alaska.
Order Milleporina	Fire coral, millepores; not found in Alaska.
Order Siphonophora	Jellyfish; found in Alaska.
* Order Stylasterina	Hydrocorals, hard corals; found in Alaska.
Order Trachylina	Jellyfish; found in Alaska.
Class Scyphozoa	Jellyfish; found in Alaska.

* Covered in this study
1 Dr. Bruce Wing, personal communication

Planula larvae either swim, crawl, sink and perhaps float after being released. Planula of most corals are not usually dispersed very far from parent colonies (Fritchman 1974; Gerrodette 1981). The larva of one species creeps down the parent colony and settles nearby (Kinzie 1973). Larvae of other species can crawl and settle up to 40 m away (Weinberg and Weinberg 1979). There is one report of planula larvae floating (Butler 1980), but this observation has not been substantiated.

The planulae settle, often on current-swept solid substrates, and undergo metamorphosis into the primary polyp stage. Only a very small fraction of the larvae reach this stage; many are lost by landing on unfavorable substrates, others are eaten by predators, while still others are abraded and smothered by sediment and algae. In colonial species, subsequent budding (asexual reproduction) of the primary polyp stage produces additional polyps, each with a mouth surrounded by tentacles; these polyps form and share a common skeleton. The colony continues to grow by budding more polyps and secreting additional skeletal material. Growth of most corals is believed to be slow and may require over 100 years to reach maximum size.

Causes of adult mortality include physical factors such as smothering by sand (Grigg 1977), toppling of large colonies by storm waves (Birkeland 1974), weakening of skeletons by boring organisms (Dr. Richard Grigg, personal communication), freshwater runoff, and exposure to air during extreme low tides. Biological factors include inter-specific competition with other coral species, and predation. Corals compete with each other for space and light by overgrowing one another and/or by digesting adjacent colonies. Coral predators include snails (Kinzie 1973, Birkeland 1974), fish (Randall 1967; Clarke 1965), polychaetes (Dr. R. Kinzie, personal communication), starfish and nudibranchs (Sebens, personal communication). Recently man has caused mortalities as a result of thermal and chemical pollution from power plants, sewage (Smith et al. 1973), and oil and gas exploration and development (Dept. of Commerce 1979; Loya and Rinkevich 1980).

Coral distribution and abundance is affected by substrate size, currents, depth, and temperature. Most coral species require a solid, rocky substrate to survive, however, a few can live on sandy and muddy bottoms. Currents bring food, reduce sedimentation, and may assist in larval dispersal. Depth is important because of its relationship with other factors such as light, temperature, salinity, oxygen, and wave action. Light is necessary to many tropical, reef-building corals harboring commensal algae, which produce the necessary food for the host coral. Temperature is known to control the distribution of reef forming corals and the reproductive activity of certain temperate species (Grigg 1979). Corals are often found in association with other species and can provide a habitat for fish and invertebrates that fish might feed on.

Coral Loss Could Deplete Fish Stocks

by Frank Saxton

An important nursery area for tarakihi and snapper is located in one of the two declining coral beds in Tasman Bay.

Frank Saxton is a Fisheries Officer based in Nelson.

In a recent study of the history of the beds, local fishermen were asked to compare conditions in the past with those prevailing today. The most important finding was that the Separation Point coral bed has been the site of a vast nursery of juvenile tarakihi and snapper. This nursery environment has all but disappeared, and there is cause for concern at the extent to which this will be detrimental to future stocks of these species.

The coral is a bryozoan. It usually occurs in large rock-like pieces, but is made up of the individual homes of very small, almost microscopic, animals, each living in a hard case into which it can withdraw for protection from predators. As each bryozoan dies new ones build their homes on top of the old, and so the colony grows — much like a true coral. The map shows the approximate area of Tasman Bay once covered with these coral colonies.

Foul Ground

Commercial trawling in Tasman Bay began in 1946, and it was soon discovered that large areas of the Bay were foul ground. Two coral areas were defined — the Torrent Bay and Separation Point beds, the Separation Point bed being the most dense.

The problem of trawling over coral was simply that the trawl net ripped whenever it encountered coral. If the net picked up coral blocks it became heavier and sank hard onto the bottom, increasing the likelihood of damage. Small pieces of coral in the cod end also caused a lot of damage to the catch.

These problems were considerable in the years before 1956, as all trawl nets were made from natural fibres (mostly cotton) and were easily torn. However, even before synthetic materials appeared trawlermen had devised techniques which allowed them to trawl over the Torrent Bay coral.

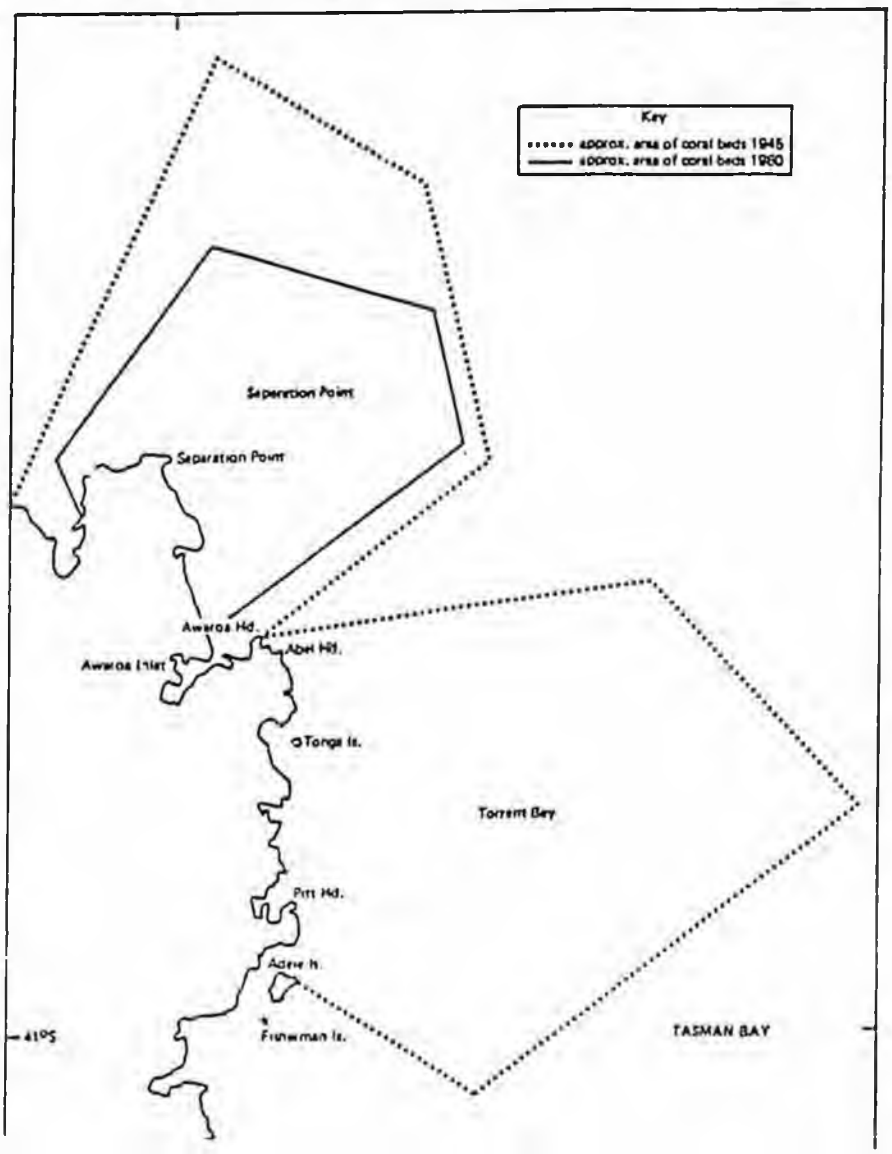
Some of the larger vessels attached cow hides under the cod end to protect the mesh, while other fishermen used extra floats on the net to keep it above the coral. Another widespread practice was the attachment of a sledge to the centre of the groundrope. The sledge slid along the bottom and raised the groundrope up to half a metre.

Tickler chains were also dispensed with when trawling on new coral beds. Once the coral became "broken in" a skilled trawlerman could use a tickler provided it was a short one that travelled well ahead of the groundrope so that any coral thrown up off the bottom by the tickler had time to fall to the sea bed before the groundrope could pass over it.

"Breaking In"

However, all the fishermen interviewed stressed that whatever technique was used, it was impossible for an otter trawl to fish over coral without causing damage. This was often referred to as "breaking in" a coral bed. The sweeps and bottom bridles usually rub along the bottom for part of their length. Together with the heavy otter boards these will al-

A sample of the coral from the beds in Tasman Bay.



ways tow long furrows of destruction over any coral bed even if the net itself is floating well clear of the bottom.

In the late 1940s and early 1950s the trawl fleet consisted only of a few low-powered trawlers using cotton nets. Even so, they slowly became more confident at trawling over the Torrent Bay coral bed. The Separation Point bed was never trawled as it was considered for too heavy. In 1956 the first synthetic twine (Nynack) came onto the market, and when the first buoyant synthetic (Drummolino) became available in 1964, it became possible to make an ideal "coral trawl". By the early 1960s however, the Torrent Bay coral was in an advanced state of decay after experiencing 15 years of trawling. Its final destruction was left to the scallop dredges of the 1960s, and although small patches still exist, they cause little concern to trawlermen.

The fish associated with the Torrent Bay coral were about the same size as those found in the rest of Tasman Bay. However, in the early days there were good quantities of John dory and blue cod, which are seldom seen today.

Separation Point

The Separation Point coral bed differs from the Torrent Bay bed in an important way: both fishermen and scientists consider it to be a home to big schools of small juvenile tarakihi and snapper. This is in addition to blue cod and two unmarketable species, red mullet and sea perch, which are fish not normally associated with trawl grounds.

The edges of the Separation Point bed slowly retreated inshore between 1946 and 1975. This was most noticeable in the northern boundary which retreated shorewards about two miles. The western boundary (known as the "smoke line") also shifted shorewards. These boundary retreats were caused by unintentional encroachments over the years as trawlermen attempted to fish near the coral.

Trawling did not begin its direct assault on this bed until the mid 1970s. By this time tough bouyant synthetic material was universally used in trawl nets, and forays began to be made onto the area over the coral.

In the winter of 1977 trawling on this coral bed became common with four boats consistently working the area. Huge bags of small unmarketable tarakihi and snapper were commonly taken and labouriously sorted through to find marketable-size fish; the rest were discarded overboard with little chance of survival. Often the nets would be seriously damaged, adding their toll to the profits of the operation.

With the serious decline in the scallop fishery in the 1978 and 1979 seasons, more boats spent time trawling in Tasman Bay, chasing a seemingly ever-decreasing fish population. In the winter of 1979 at least six trawlers worked the coral. None of these trawlers exceeded 15 metres in length, and most were under 12 metres. There is no evidence that large trawlers with big nets have ceased any significant effects. As the coral is broken in it becomes easier to work, and it is therefore easier for trawlermen with less experience to enter the fishery.

Patches of coral still exist off Separation Point, but they are decreasing in size and number. The large bags of juvenile fish of the past are seldom taken these days. Those that are taken are now sold for about 4 cents a kilogram and are used for rock lobster bait. The coral that afforded them so much protection for so long has been broken up and so made them vulnerable to the ubiquitous trawl net.

Closure?

Three or four years ago, when trawling began in the Separation Point nursery area, local fishermen expressed concern at this new practice, and there was a lot of local support for legally closing the area. There was a novel suggestion that fasteners be placed throughout the area to deter would-be illegal trawling. A fastener would probably consist of a heavy block of concrete. If a trawler passed over a fastener its net would come fast and be badly damaged. This was said to be the only sure way of effectively enforcing a closed area such as that over the Tasman Bay coral areas.

More on-the-spot survey work is needed to define the extent of this coral bed, followed by the formulation of a practical method of closing the area to trawling. Bryozoan species can be fast-growing and this important nursery area may be yet re-established.

There is an important lesson in fisheries management in this study of the Tasman Bay coral beds, both for MAF and fishermen. It might be said that MAF could or should have been aware of this problem much sooner, anticipating damage to the coral beds from trawling. However, it is not possible for MAF to be aware of all the problems which can or do arise in a fishery. The fishermen themselves are the most knowledgeable about their fishery because of their day-to-day participation and intimate contact with the fish and fishing grounds. They play a vital role as a source of information for MAF, and by relaying information to MAF, can encourage protection of their fishery.

MAF's responsibility is to ensure it can react to such information quickly, verify the problem, and take remedial action before damage is irreversible. The fact that Tasman Bay fishermen recognize the problem they are creating, yet are unable to stop the practice of fishing coral beds, suggests that they need the assistance of MAF to provide management protection.

— Rick Boyd,
Fisheries Management Division, Auckland.

Do you know that in granting a licence to a foreign fishing vessel to fish in New Zealand's EEZ the Minister of Fisheries may attach conditions relating to the use, transfer, transhipment, landing, and processing of fish taken?

Sail-Powered Longliner

With rapidly rising fuel costs sail-powered fishing vessels are becoming increasingly common around the world. A 29-metre sail-assisted longliner is described in a recent issue of *Canadian Fishing Report*.

The vessel is being designed by Massachusetts marine architect Fran Morey, and Mr Morey has estimated fuel savings of over 50 percent. Main particulars will be roughly as follows: Length overall, 29.2 metres. Waterline length, 24.4 metres. Beam, 7.3 metres. Draft, 2.7 metres. Displacement, 161.9 tonnes. Moulded depth, 2.7 metres. Fish hold volume, 100.5 m^3. Fuel oil capacity, 22 730 litres. Lube oil capacity, 909 litres. Hydraulic oil capacity, 1 818 litres. Fresh water capacity, 8 183 litres. Accommodation for 9-10 men.

The vessel will use a single Cummins KT 1150M, 365 hp. Using the engine alone, the vessel will cruise at 11 knots, using about 54 litres per hour. With sails alone, the vessel will cruise at 11 knots, given a wind of 18-20 knots. Mr Morey predicts savings of fuel, compared with a conventional hard-chined vessel, of 50 to 70 percent.

Mr Morey said that the vessel should cost within 10-15 percent of a conventional vessel: perhaps US$800,000 to $1,000,000. A big saving comes from using a smaller engine. The most economical size for a sail vessel looks to be 20 metres to 30 metres.

"Smaller vessels wouldn't be that much more economical. And on vessels over 30 metres, to get good savings you'd almost have to jump to 60 metres".

Mr Morey, who has experience in designing yachts, said a good hull could cut fuel costs by 30 percent. The hull efficiency depends on a combination of shape and amounts of surface.

Hedgepeth, J. W. 1968: The atyid shrimp of the genus *Syncaris* in California. *Internationale Revue der gesamten Hydrobiologie 53* : 511 – 524.

Hughes, D. A. 1969a: Responses to salinity change as a tidal transport mechanism of pink shrimp, *Penaeus duoarum*. *Biological bulletin 136* : 43 – 54.

——— 1969b: On the mechanisms underlying tide associated movements of *Penaeus duorarum* Burkenroad. *F.A.O. fisheries report 57* : 867 – 874.

Hunte, W. 1975: *Atya lanipes* Holthuis, 1963, in Jamaica, including taxonomic notes and description of the first larval stage (Decapoda: Atyidae). *Crustaceana 28* : 66 – 72.

——— 1976: The distribution of freshwater shrimps (Atyidae and Palaemonidae) in Jamaica. *Zoological Journal of the Linnean Society 64* : 135 – 150.

Ishikawa, C. 1885: The development of *Atyephira compressa*. *Quarterly journal of microscopical science 25* : 391 – 428.

Juberthie-Jupeau, L. 1969: Reproduction et mue chez les Decapodes souterrains due genre *Troglocaris* Dormitzer, 1853. *Fifth congres internationaler du speleologie, Stuttgart* : B32.1-B32.2.

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Coral-like bryozoan growths in Tasman Bay, and their protection to conserve commercial fish stocks

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Abstract Mounds of 'coral' off Separation Point, Tasman Bay, which have recently been protected to conserve ecologically associated commercial fish species, are predominantly growths of Bryozoa. Two species (*Celleporaria agglutinans*, *Hippomenella vellicata*) make up the bulk of these structures. Trawling through the 'coral' grounds has affected the fish populations to the extent that an area has been closed to trawling to conserve stocks.

Keywords *Celleporaria agglutinans*; *Hippomenella vellicata*; Bryozoa; fisheries; marine ecology; resource conservation

INTRODUCTION

Regular trawling off the northern coast of New Zealand's South Island began in 1946, and fishermen were quick to observe, in certain areas, the association of juveniles of important commercial fish with abundant clumps and mounds of 'coral'. The most valuable fish species were *Chrysophrys auratus* (Bloch & Schneider) (snapper), *Cheilodactylus macropterus* (Bloch & Schneider) (tarakihi), and *Zeus faber* (Linnaeus) (john dory).

The present study is based upon diving observations in the area known as the Separation Point coral bed (40°47'S,173°00'E), lying between Tasman and Golden Bays. This bed is about 40 square nautical miles in extent (Saxton 1980a) at depths of 10-35 m. There was formerly a similar bed immediately to the south, about 80 square nautical miles in area, known as the Torrent Bay coral bed (Saxton 1980b).

Similar coral beds of unknown extent are reported by commercial fishermen from the north-eastern side of Tasman Bay, and others occur in the outer Marlborough Sounds (pers. obs). The Separation Point coral bed, however, appears to be particularly significant as a nursery area for commercial fish

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CORALLINE GROWTHS

The water in the coral bed area is very turbid with very low light penetration and considerable current speeds (surface mean 0.72 kn and 0.4 kn at spring and neap tides respectively) (RNZN Hydrographic Office, Chart NZ 614).

The coralline growths are of 2 clearly distinguishable types, each of which comprises predominantly 1 of 2 species of gymnolaemate bryozoan. One, *Celleporaria agglutinans* (Hutton) (Fig. 1), grows in massive, heavy clumps attaining up to 50% cover and 0.5 m in height. There are 2 ways in which these growths may increase in size. *C. agglutinans* zooids have the capacity for frontal budding, enabling multiple layers of zooids to form upon one another. In this way, colonies of *C. agglutinans* can become quite rock-like, though minutely porous. Alternatively, growing edges can extend as prominent sheets, fans, or laminae around secondary components (other bryozoans, molluscs, and tube-dwelling polychaetes) of these coralline growths, firmly enclosing them within cavities. Most of the mass of these clumps is non-living skeletal material.

The other species, *Hippomenella vellicata* (Hutton) (Fig.2), is not so robust and rock-like. It may occur sparsely with *C. agglutinans* or form separate, coarse foliaceous 'honeycombs' to 0.3 m across and 0.15 m high, of bilaminar sheets of zooids.

The mounds and honeycombs provide attachment surfaces for other calcareous frame-building components, including any of 92 additional species (as in 1 locality in Tasman Bay) (Appendix) of mainly encrusting bryozoans, plus serpulid tubes, and a homotrematid foraminiferan, *Miniacina miniacea* (Pallas). Branching bryozoans of some significance

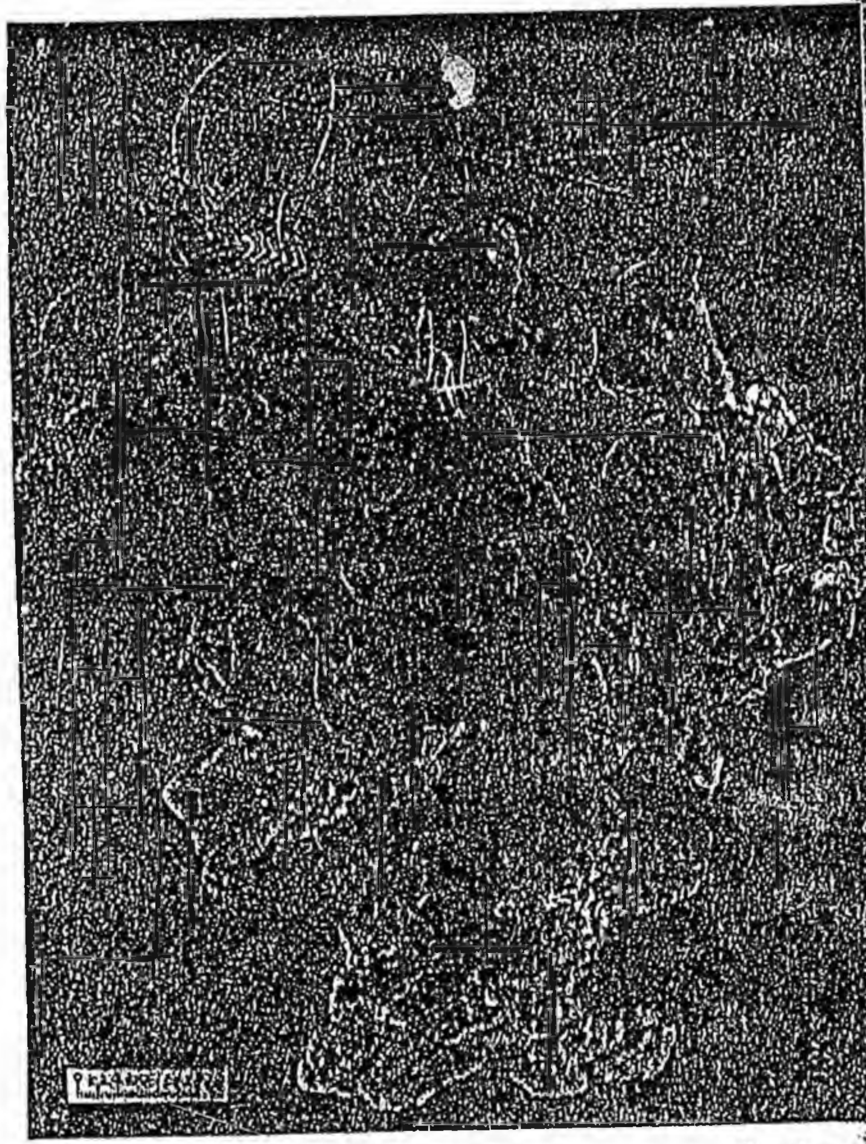


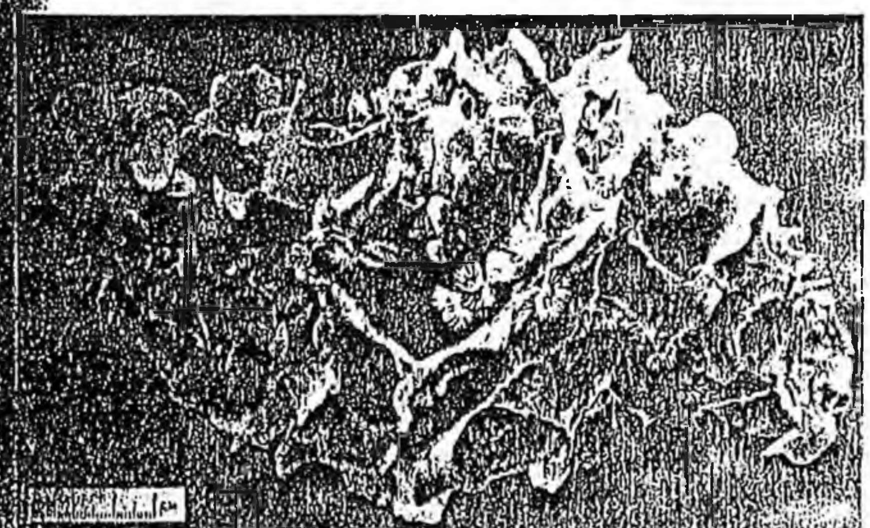
Fig. 1 A 0.22-m-high coralline mound, mainly comprising the bryozoan *Celleporaria agglutinans* (Hutton), from 33 m depth, 3.2 km off Anapai Bay, Abel Tasman National Park. (Photo: J. Whalan, Science Information Division, DSIR).

...econdary frame components include *Galeopsis ...idipora* (Waters), *Galeopsis polypora* (Brown), ... *Telopora digitata* (Busk). Comparable bryozoan ...wths are not well known, either geographically ...cologically, but where they occur an association ... additional calcareous species has been noted ...uffey 1977).

...hese growths are also characterised by an ...ed faunal diversity. By creating a vast surface ..., the interstices and exposed parts of the ...alline growths we have studied provide mic-...abitats for many epibionts including hydroids, ...nges, simple and compound ascidians, and ...alve molluscs. Polychaete worms are particularly ...ndant. Dissection of a 6.4 kg (wet weight) colony ... *C. agglutinans* (approximately 0.4 × 0.35 × 0.2 m ...h) yielded 51 polychaetes weighing 54 g. Of ..., 31 were tube-dwelling and 20 'errant' worms. ...y smaller, more delicate polychaetes were also ...n which could not be practically counted and ...ighed. Also found were 27 bivalve molluscs, 1 ...stropod, 3 amphineurans, 9 decapod crustaceans, ...olitary ascidians, and 1 small octopus. Ophiuroids ...e also been observed in bryozoan coral.

Some of these organisms are important in the diets of snapper and tarakihi (Godfriaux 1974). The coralline grounds are particularly favoured by 3-year-old tarakihi (20–27 cm long) and the snapper taken there are also commonly around 20–25 cm long (Vooren 1975). Other associated demersal fish species include *Parika scaber* (Bloch & Schneider) (leatherjacket), *Parapercis colias* (Bloch and Schneider) (blue cod), *Upeneichthys porosus* (Cuvier & Valenciennes) (red mullet), and *Helicolenus papillosus* (Bloch & Schneider) (sea perch).

The Tasman Bay coralline growths are comparable with small submerged bryozoan reefs recently discovered in the Bahamas (Cuffey et al. 1977). In these, *Celleporaria albirostris* (Smitt) occurs as a major framebuilder, with hermatypic corals and other encrusting bryozoans as secondary components. Of the 7 commonest secondary bryozoan genera, 4 (*Parasmittina*, *Rhynchozoon*, *Stegisnoporella*, *Buffonellaria*) also occur in the New Zealand mounds. Serpulid tubes and the foraminiferan *Homotrema rubrum* (Lamarck), among others, contribute to the Bahamian bryozoan reefs which rise 0.3–3.0 m above the bottom in 2–5 m of water.



...g. 2 The major part of an originally larger colony of the bryozoan *Hippomenella vellicata* (Hutton) ('cornflakes coral' ...ishermen), from 33 m depth, 3.2 km off Anapai Bay, Abel Tasman National Park. The stellate colonies are those of ...lopora digitata (Busk). (Photo: J. Whalan, Science Information Division, DSIR).

EFFECTS OF TRAWLING

Two major coralline grounds have been fished in the area studied by us in the Tasman Bay-Golden Bay area. Especially before 1956, fishermen avoided these grounds, whose boundaries were determined by experience, as their nets of natural fibres were easily snagged and torn by the bryozoan 'coral'. One of the grounds, off Torrent bay (40°58'S,173°04'E) was subsequently able to be fished by specially designed nets, floating just clear of the seafloor, because the coral was dominated by the comparatively light and brittle *H. vellicata*. By contrast, the Separation Point coral ground, comprising the mainly heavy *C. agglutinans*, was not fished until strong, buoyant synthetic netmaking fibres became available after 1960. Trawl nets were designed expressly for fishing these grounds, using chains, sledges, and rolling bobbins. Along with the sweep wires and otter boards common to all trawl gear, these caused extensive destruction of the coralline growths. Their size and extent was progressively reduced until, by the late 1970s, the Torrent Bay ground was virtually destroyed. Diving observations in 1980 revealed that where the growths persisted in the study area, they were markedly reduced in size compared to those previously taken there by fishermen. Their density was also less than that seen in an otherwise comparable ground off Separation Point. Clumps were often several metres apart and none was observed to stand taller than 0.15 m above the mud bottom.

With loss of shelter and availability of food organisms there has been a reduction in numbers of juvenile tarakihi and snapper in these important nursery grounds (Saxton 1980b). Accordingly, in December 1980, an area of seabed off Separation Point delimiting a coralline ground was closed (Mace 1981) to the power-fishing methods—trawling, Danish seining, and dredging—which were likely to continue destroying the coralline growths. Restoration of the habitat is being monitored. To our knowledge this is the first time that bryozoans have become protected, in effect, to conserve a commercial fishery.

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APPENDIX Bryozoa associated with *Celleporaria agglutinans* (Hutton) and *Hippomenella vellicata* (Hutton) (at NZOI Stn D273, 40°45'S, 173°49'E, 75 m depth, north-eastern Tasman Bay off D'Urville Island).

GYMNOLAEMATA

Nolella parva Silén
Onychocella serrata (MacGillivray)
Ellisina sericea (MacGillivray)
Crassimarginatella corbula (Hincks)
Crassimarginatella cucullata (Waters)
Crassimarginatella fossa Uttley
Crassimarginatella pyrula (Hincks)
Crassimarginatella validemuniita (Hincks)
Micropora circumsaepta (Uttley)
Antropora sp.
Foveolaria cyclops (Busk)
Chaperiopsis boninensis (Silén)
Chaperiopsis cervicornis (Busk)
Chaperiopsis funda (Uttley & Bullivant)
Chaperiopsis spiculata (Uttley)
Aetea ?australis Jullien
Aetea truncata (Landsborough)
Beania decumbens (MacGillivray)
Beania discodermiae (Ortmann)
Beania magellanica (Busk)
Caberea rostrata (Busk)
Menipea mortenseni Livingstone
Manzonella lepida (Hincks)
Steginoporella magnifica Harmer
Macropora grandis (Hutton)
Figularia carinata (Waters)
Figularia mernae Uttley & Bullivant
Figularia spinea Brown
Orthoscuticella margaritacea (Busk)
Bryozomella foraminigera (Hincks)
Arachnopusia unicornis (Hutton)
Umbonula ?leuipis (Hincks)
Escharella conjuncta Brown
Escharella jellyae Brown
Escharella tricuspis (Hincks)
Hippoporina rostrata (MacGillivray)
Hippadenella margaritifera (Lamouroux)
Schizomavella mucronifera Powell
Schizomavella cf. *neptuni* Jullien
Schizomavella punctigera (MacGillivray)
Chorizopora circinata (MacGillivray)
Buffonellodes ridleyi (MacGillivray)
Chiastosella enigma Brown
Chiastosella gabrieli Stach
Chiastosella longaevitas Powell
Chiastosella sp.
Smittina purpurea (Hincks)
Smittina maorea Powell
Smittina torques Powell
Schizosmittina maplestonei (MacGillivray)
Smittoidea flexuosa (Hutton)
Parasmittina aotea (Brown)
Parasmittina delicatula (Busk)
Hemismittoidea hexaspinosa (Uttley & Bullivant)
Porella marsupium (MacGillivray)
Escharella spinosissima (Hincks)
Escharella sp.
Crepidacantha crinispina Levinsen
Crepidacantha kirkpatricki Brown
Microporella intermedia Livingstone
Microporella sp.
Calloporina angustipora (Hincks)
Fenestrulina disjuncta (Hincks)
Fenestrulina reticulata Powell
Fenestrulina sp.
Hippothoa flagellum Manzoni
Chorizopora brongniartii (Audouin)
Celleporina costazii (Audouin)
Celleporina sp.
*Buffonellaria biaviculari*s (Powell)
Buffonellaria regenerata (Powell)
Buffonellaria sp. 1
Buffonellaria sp. 2
Galeopsis granulipora (Waters)
Rhynchozoon larreyi (Audouin)
Rhynchozoon pao Uttley & Bullivant
Bracebridgia longispinata (Busk)

STENOLAEMATA

Stomatopora sp.
Microecia ?ridleyi Borg
Plagioecia sp.
Lichenopora lineata MacGillivray
Tubulipora sp
Entalophoroecia sp
Telopora digitata (Busk)
Cinctipora elegans Hutton
Crisia sp. 1
Crisia sp. 2
Hornera sp.
Lichenopora novaezelandiae (Busk)
Disporella buski (Harmer)
Disporella fimbriata Busk)
Disporella sp.

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Environmental impact of trawling on the seabed: a review

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Abstract Fishers have been complaining about the effects of bottom trawl gear on the marine environment since at least the 14th century. Trawl gear affects the environment in both direct and indirect ways. Direct effects include scraping and ploughing of the substrate, sediment resuspension, destruction of benthos, and dumping of processing waste. Indirect effects include post-fishing mortality and long-term trawl-induced changes to the benthos. There are few conclusive studies linking trawling to observed environmental changes since it is difficult to isolate the cause. However, permanent faunal changes brought about by trawling have been recorded. Research has established that the degree of environmental perturbation from bottom trawling activities is related to the weight of the gear on the seabed, the towing speed, the nature of the bottom sediments, and the strength of the tides and currents. The greater the frequency of gear impact on an area, the greater the likelihood of permanent change. In deeper water where the fauna is less adapted to changes in sediment regimes and disturbance from storm events, the effects of gear take longer to disappear. Studies indicate that in deep water (>1000 m), the recovery time is probably measured in decades.

Keywords New Zealand; trawling; environment; damage; impact; effects; benthos; sediment; mortality

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INTRODUCTION

There is growing public and political awarenes the environmental impact of fishing activities. Thi reflected in the U. N. Convention for the Conservat of Antarctic Marine Living Resources (CCAMI which requires (Article II) that signatory States har resources in such a way that the direct and indir effects on the marine ecosystem are minimised, a that changes which are not potentially reversible o 2 or 3 decades are prevented.

The long-established technique of bottom trawli is attracting increasing criticism over the percei environmental damage it may cause. This is particular concern in Australasia where commer fishers are developing new trawling grounds down 1200 m (Judd 1989) and will certainly fish deeper technology improves. Whether bottom trawling ca environmental damage which is not potential reversible over a few decades is the subject of t paper. For the purposes of this review, bottom trawli includes the use of beam trawls, dredges, otter traw and Danish seine-nets, but not hydraulic clam dredg A review of the effects of the latter can be found Meyer et al. (1981).

Historical overview

As early as 1376 the British Parliament was petition by fishers concerned over the damage done to th fisheries by bottom trawling. Early complai included the capture of undersize fish, t indiscriminate capture of non-target species, and perception that fishing was deteriorating. Trawli also destroyed "the living slym and underwater plant (March 1970; De Groot 1984). Gear used by saili beam trawlers was relatively light and was towed slow speed in shallow water. It was not until t advent of the steam trawler in the 1900s that the si and weight of the trawl gear began to increase, particular through the use of "tickler" chains (chai between the wings of the trawl scraping the seab ahead of the footrope). Following complaints fro fishers, one of the earliest studies on the effects such gear was carried out during 1938 on the plai hing grounds in the North Sea (Graham 1955). om that study, based on comparisons of catches om normally fished grounds and from areas where ommercial trawlers did not usually fish, Graham 955) concluded that trawling was having no long- rm effect on the macrobenthos.

By the end of World War II, the use of the sweral trawler towing an "otter" or "Granton" trawl ad become widespread. However, the beam trawl ad also persevered, with the introduction of heavy kler chains and chain chaffing mats. The weight of ese beam trawls increased steadily with the creasing power of the towing vessel. Beam trawls eighed up to 3.5 t total weight in the late 1960s ole 1971) but by the early 1980s had reached about t (Beek et al. 1990). The heavy tickler chains were own to dig up and displace large boulders which en damaged the lighter gear of other fishers. The ains made the gear more efficient at catching emersal fish and crustaceans (Anon. 1971; hittenden & van Engel 1972; Harden Jones & choles 1974) and their use persisted despite omplaints by other fishers (Anon. 1971).

In the early 1970s, the French "Institut Scientifique Technique des Pêches Maritimes", concerned at e changes to the bottom topography of fishing rounds around Corsica—which they attributed to eavy chain on trawls—obtained a ban on the use of is gear in the Mediterranean (De Groot 1984). They en sought a similar ban on Dutch beam trawlers orking along the French Atlantic coast. Fisheries boratories bordering the North Sea had not noticed ny significant changes to the benthos over time, and ther countries were even less convinced that a roblem existed (Anon. 1971; Cole 1971). The subject as raised at the 58th International Council for the xploration of the Sea (ICES) meeting in 1970 and sulted in an ongoing series of studies on the effects the benthos of all trawl gear types. Most of these udies are unpublished ICES working papers and are eferenced in Redant (1987, 1990). A 1988 ICES udy group concluded that changes in the benthic ommunity could be related to fishing. However, no rm conclusions could be reached because relevant formation on the physical effects of trawling was ot available, and the impact of other effects such as utrophication and pollution could not be estimated. n 1990, ICES established a working group to evaluate he effects of fishing on the marine ecosystem, ncluding the effects on marine mammals, birds, and enthos (Rijnsdorp et al. 1991).

Early studies (generally in shallow water and on and or mud) showed that benthic organisms were exposed to predators by the action of trawl gear (e.g., Arntz & Weber 1970; Caddy 1973), but it was concluded that this extra food source could only benefit the fishery. If there was a reduction in the invertebrate fauna, it was felt that this would be of no account as food availability was not usually limiting to fisheries (Cole 1971).

More recent studies have examined the effects of trawling on hard-bottom communities and assessment of the impact has varied. Following concerns that trawl gear might reduce the amount of productive fish habitat (Wenner 1983), Dolah et al. (1987) reported the results of a single research trawl tow (in 20 m depth) on a hard-bottom assemblage of sponges and corals. They concluded that, though damage was caused, the effects could not be detected after 12 months. This result contrasted with a 1979 study in Florida by Tilmant (cited in Dolah et al. 1987), who used a prawn trawl, and who was working in an area heavily fished by prawn trawlers.

As the concept of community ecology has become established and the realisation has grown that the associated fauna provide more than just a food source for the target fishery (Sainsbury 1988), the debate over the long-term chronic effects of observed seabed changes has continued. This debate is not confined to Europe as similar concerns over the effects of trawling have been voiced in Australia (Gibbs et al. 1980; Butcher et al. 1981; Hutchings 1990), New Zealand (Saxton 1980; Bradstock & Gordon 1983), Indonesia and Thailand (Chong et al. 1987), and in North America (Dolah et al. 1987; Goudey & Loverich 1987; McAllister 1991). Apollonio (1989) went as far as to question whether eliminating the otter trawl could be the key to better fisheries management. A similar view was put forward by Chong et al. (1987) following the 1980 Indonesian Government ban on trawling (trawling was primarily for prawns with pre-ban landings of 130 000–200 000 t). Chong et al. (1987) reported that the trawl ban caused no reduction in the total Indonesian marine landings but there was, however, a positive impact on fishing profitability. The reasons for this were complex, involving the recovery of overfished stocks, improved value of the catch, and the distribution of wealth derived from the fishery among the local communities rather than to offshore trawling companies. In New Zealand, Fenaughty & Bagley (1981) note that the Otago fishery was far more productive in tonnage landed in the early 1900s than it was in the 1970s, despite the introduction of large trawlers and modern trawl gear.

Allied with trawling activities is the problem of disposing unwanted catch, fish heads, and frames.

Dumping this waste at sea benefits predatory fish, marine mammals, and seabirds (an aspect outside the scope of this review). However, concern has been expressed at the effects on the seabed of discharging substantial quantities of such waste (Livingston & Rutherford 1988). Trials have shown that dissolved oxygen levels could be affected near the seabed but no studies have been made on the grounds.

OBSERVED EFFECTS

Trawl gear has a direct physical effect on the seabed wherever the ground rope, chains and bobbins, sweeps, doors, and any chaffing mats or parts of the net hug contact the bottom. Ways in which gear affects the seabed can be classified as: scraping and ploughing; sediment resuspension; and physical destruction, removal, or scattering of non-target benthos. The fishing operation further affects the seabed through waste dumped from the vessel. Indirect effects on the seabed are related to the stress imposed on the benthos. These effects include post-fishing mortality of damaged or disturbed organisms, and long-term changes to the benthos community structure.

Scraping and ploughing

Otter boards imprint distinct tracks on the seafloor, ploughing a groove which can vary from a few cm up to 0.3 m deep (Arntz & Weber 1970; Caddy & Iles 1972; Krost et al. 1990). Bobbins and chains can also leave recognisable tracks (Krost et al. 1990) and may skim off the surface sediment layers between the two grooves left by the otter boards. The depth of the otter board groove depends on the weight of the board (which can be several tonnes), the angle of attack (the board is towed at an angle to the direction of motion to generate the lift required to spread the net), and the nature of the substrate, being deepest in soft mud.

These trawl tracks remain visible for varying times depending on the nature of the substrate and on water movements over the bottom. The greater the water movement, the faster the tracks will be filled in. Bernhard (reported in Krost et al. 1990) found that the sandy mud of Eckernförde Bay held the same trawl track for almost 5 years. Churchill (1989) and Krost et al. (1990) reported an increase in the frequency of tracks attributed to trawl doors in deeper water, presumably where water movement is less pronounced.

Appreciable areas of the fishing grounds can be affected. Caddy (1973) calculated that c. 3% of the bottom area in Chaleur Bay (Gulf of St Lawrence was covered in what were presumed to be traw tracks. Studies by Caddy & Iles (1972) revealed high frequency of trawl tracks on parts of the George Bank area of the Northwest Atlantic. Churchill (1989 reported up to 20 tracks/100 m² at depths of 100 m o the southern New England shelf.

Each set of trawl tracks defines an area swept by trawl. Even if the footrope and net were clear of th bottom, the benthos between these tracks would st have been affected by turbulence. In a detailed surve of Kiel Bay (Baltic), Krost et al. (1990) found up t 19% of the study area, which was deeper than 20 m and in mud, bore trawl tracks. They calculated tha there was a "more or less complete" disturbance i those areas where trawl tracks were classified a "abundant" (10–35% of the survey area). In th Netherlands, where the spatial distribution of fishin effort is known for 30 × 30 mile squares, it has bee calculated that, in heavily fished squares, every squar metre of the seabed is trawled, on average, at least times a year (Rijnsdorp et al. 1991).

Sediment resuspension

The sediment cloud generated by turbulence fro trawl doors contributes to fish capture, especially i clear water (Main & Sangster 1979, 1981). Howeve these trawl sediment clouds can also contribute to th total suspended sediment load. Churchill (1989 modelled sediment resuspension by trawling an found that this may be a primary source of suspende sediment over the outer shelf (100–140 m) whe storm-related bottom stresses are weak. Th suspended sediment reduces light levels on th substrate, and when the sediment eventually settl out, the benthos can be smothered. Galtsoff (196 showed that as little as a 1 mm layer of silt over settlement surface could prevent spat settlement i *Ostrea virginica* and Stevens (1987) claimed th high levels of turbidity inhibited settlement of *Pecte novaezelandiae* veliger larvae, depressed growth rate of adults, and caused inefficient metabolism o glycogen stores through enforced anaerobi respiration.

Theil & Schriever (1990) studied sedimen resuspension in deep-ocean environments. They foun that an experimental plot at 4000 m, previous ploughed repeatedly with a rig resembling a tra bobbin gear and chains, had not recovered from th effects of sediment redeposition after 6 months. Ev the harpacticoid copepod fauna remained significan reduced (G. Schriever pers. comm.). Their assessme as that the substrate would take decades to recover.

As well as resuspending sediment, trawl gear can ring about vertical redistribution of sediment layers. layer et al. (1991) showed that heavy chain dredges ould mix surface organic material into subsurface ayers. This organic material was removed from the urface metazoan-microbial aerobic chain to an naerobic system. If the subsurface layers are already noxic, furthur problems can occur. Churning up the oft bottom can create anaerobic turbid conditions which are, for example, capable of killing scallop (*Platinopecten* sp.) larvae (Yamamoto 1960). The uestion whether the resuspended organic material mproved nutrient availability to filter feeders was tudied by Anderson & Meyer (1986) who found that ediment resuspended from clam dredges in a Maine stuary did not improve the food value of the uspended material available to filter feeders, and if xpressed as protein per unit weight of sediment ltered, actually decreased the food value since filter eeders had to filter more material to obtain nutrients.

estruction of non-target benthos

he large, heavy-shelled bivalve *Cyprina islandica* ormed a substantial part of the food of cod and atfish in Kiel Bay (Baltic) only after trawling began the area. Arntz & Weber (1970) concluded that the ish were feeding on bivalves crushed by the otter oards. Medcof & Caddy (1971) and Caddy (1973) onfirmed there was feeding on exposed and damaged enthic animals in trawl tracks. By contrast, bservations made using submersibles, reported in tevens (1990), found that trawling caused no bservable injuries to crabs whereas Butcher et al. 1981) found little or no damage to the Jervis Bay Australia) environment by scallop dredging. These ifferences in results may well be caused by the ifferent sites used since Creutzberg et al. (1987), for xample, found that the number of tickler chains on n experimental beam trawl had no effect on the atches of epibenthic animals over a mud substrate ut at sandy stations the number of chains used did orrelate to the catch. The effects of trawling can be uite subtle. Bull (1986) found that survival of *Pecten novaezelandiae* spat in Golden Bay (New Zealand) as better than 20% after 9 months in an area closed o trawling but was only 0.8% for an adjacent site which was open to trawling.

Wilson (1979) suggested that patches of the deep water coral *Lophelia* would be broken up by trawling and thus provide new settlement substrate, increasing the rate of colonisation. However, he also noted that the coral grows at only 6 mm per year at the depth studied (220–350 m) and that the coral dies when in contact with the substrate. Repeated trawling over the same patch would therefore be expected to eradicate the *Lophelia*—not spread it. Saxton (1980) and Bradstock & Gordon (1983) recorded the effects of the systematic destruction by trawlers of the bryozoan beds in Tasman Bay, New Zealand, which provided habitat for juvenile snapper (*Pagrus auratus*) and tarakihi (*Nemadactylus macropterus*). The surviving beds were closed to trawling to conserve fish stocks. Riesen & Reise (1982) describe the removal of *Sabellaria* reefs in the German Wadden Sea by shrimp fishers clearing trawling grounds of obstacles, and De Groot (1984) makes the point that recolonisation does not occur as the substrate has been changed (though not necessarily by trawling—see Rees & Eleftheriou (1989)). Trawling and dredging effects were also implicated in the spread of mussels through the Norderaney area of the Wadden Sea (Reise 1982; Reise & Schubert 1987).

Dumping of processing waste

The amounts dumped as "waste" can be substantial. Off India's north-east coast, some 100 000 t of bycatch is discarded yearly (Anon. 1991). Wassenberg & Hill (1990) estimated that Australian prawn trawlers, in catching about 500 t of prawns, discarded 3000 t of material, primarily crustaceans and echinoderms. This dumping can inject high levels of nutrient into the ecosystem providing additional food for birds and predatory fish, but most probably sinks to the seabed causing potential problems with oxygen depletion (Hill & Wassenberg 1990). By contrast, Berghahn (1990) after noting the rarity of recently discarded fish during bycatch studies in the North Friesian Wadden Sea, estimated that predators (birds, seals, and fish) were capable of clearing discards of moribund fish from the study area. Livingston & Rutherford (1988) calculated that the discarded waste from the New Zealand West Coast Hoki fishery could be as much as 47 800 t dumped in an area of 1000 km^2 over 60 days. Rutherford (1987) modelled the potential oxygen depletion such wastes would cause, calculating that oxygen concentrations at the seabed could be reduced to 4–5 g m^{-3} (45–55% saturation), but actual oxygen measurements have not been made and no studies have been done to establish if discarded material reaches the seabed.

Little published information is available on the effects of discarding fisheries wastes on the seabed

(Salla 1983) and no studies have been carried out on the compounding effects of exposure of anaerobic sediments by the ploughing effect of the gear. Most published studies have been on shallow water or estuarine sites polluted by onshore processing plants. In coastal waters, small-scale vertical oxygen gradients can be critical (Rosenberg 1977; Jørgensen 1980; Arntz 1981). In the south-east Baltic, Arntz & Rumohr (1982) recorded a poor benthic fauna in areas of oxygen stress but found that experimental containers of sediment suspended 30–40 cm above the bottom developed a more normal fauna. Changes to the catch per unit effort in the Norway lobster (*Nephrops norvegicus*) fishery in the Kattegat have been linked with low oxygen levels bringing the lobsters out of their burrows (Baggo & Munch-Petersen 1979; Rosenberg 1985). Following complaints from fishers that tailing *Nephrops* at sea "spoils" the grounds, Chapman (1981) presented evidence that the presence of "heads" appeared to temporarily inhibit *Nephrops* from emerging from their burrows.

Indirect effects

McLoughlin et al. (1991) review studies of natural mortality on scallop beds which showed that natural mortality and indirect fishing mortality rates were much higher on fished scallop beds than the natural mortality on unfished beds. They point out that post-fishing mortality is not just confined to shells damaged by dredges. Their study showed that 4–5 times as many scallops were crushed or damaged as were caught and landed by the scallop gear used in the Bass Strait (Australia) fishery. However, within 9 months of the start of the fishery "virtually the entire stock was lost", which McLoughlin et al. (1991) attributed to a suspected bacterial infection resulting from decomposing scallops on the seabed.

New Zealand commercial fishers and Ministry of Agriculture and Fisheries staff (including the author) have frequently seen a noticeable reduction in the invertebrate fauna brought up by trawls as new deep-water (> 800 m) grounds are developed. Amounts of non-crustacean invertebrate fauna caught are not recorded, so quantitative evidence is lacking. Saxton (1980) noted a decline in juvenile fish with the removal of bryozoan beds in Tasman Bay, New Zealand. Sainsbury (1988) found a significant reduction in sponge frequency on the Australian north-west shelf between 1967–73 and 1979. Loss of sponges, together with alcyonarians and gorgonians, lead to a change in the catch composition of the pair-trawl fishery on the Australian north-west shelf between those years. The fishes *Lethrinus* and *Lutjanus* were associated wi habitats containing large epibenthos and catches these fish species had significantly declined. T fishes *Nemipterus* and *Saurida* occurred mostly ov the open sand and had increased in biomass.

A general decrease in diversity can be predict as long-lived slow-growing species are removed killed by human activities. Reise (1982) noted disproportionate increase in polychaetes had occurr in the Wadden Sea over the previous 112 year Pearson et al. (1985) found a 20% reduction in depo feeders, a 19% increase in suspension feeders, and 25% increase in predators in the Kattegat betwee 1911–12 and 1984. Overall, they found an increa in ophiuroids and worms with a decrease in echinoi with the change most apparent in shallow wate Although trawl effects could not be eliminated, the authors suggested that eutrophication was the mai cause of the change. Evidence that such change occur in the absence of trawling was provided b Kröncke (1990) who detected a 30% decline in th macrofauna total biomass on the northern Dogge Bank between 1950–54 and 1987. Though the dro in biomass was caused by the lack of the bivalv *Spisula*, the presence of the echinoderm *Echinocardium* indicated that trawling was unlikely to b the cause. The area of the Dogger Bank in questio had not been heavily fished since the 1970s.

THEORETICAL CONSIDERATIONS

Apart from direct studies on trawl gear, there is a growing body of information on effects to seabed fauna of other potentially disruptive operations (fo example, spoil dumping and pollution). Such studies provide information on the resilience of the fauna to stress and particularly on recovery rates. Severa studies have focused on the ability of macrofauna t recolonise sediments (summarised in Boesch & Rosenberg 1981). These studies confirm that recovery rates on the continental shelf and deep sea are much slower than in shallow-water temperate communities (and are measured in years at depths over 1000 m). Subsequent work by Flint & Younk (1983) supports the hypothesis of Boesch & Rosenberg (1981) that communities in less constant environments are more resistant to disturbance and that colonists in shallow waters are usually species already dominant in the community, rather than short-lived opportunist species. The reverse is true in deeper-water, less disturbed habitats, where colonisers differ markedly from the long-lived equilibrium species.

SUMMARY AND CONCLUSIONS

From the work performed under the aegis of ICES, it would appear that beam trawls, otter trawls, and dredges are all basically similar in their effect. Generally, the heavier the gear in contact with the seabed, the greater the damage. The effects vary greatly depending on the amount of gear contact with the bottom, together with the depth, nature of the seabed, and the strength of the currents or tide.

In areas of tide and current, the resuspension of the sediments is of short duration and the effects of the sediment redeposition are not permanent on biota adapted to storm events and sediment transport by currents. However, in areas of little water movement such as in the deep ocean, where the benthos is not adapted to high sediment loads, the adverse effects of sediment resuspension by gear could persist for decades.

The removal of the macrobenthos also has variable effects. In shallow-water areas where the damage is intermittent, recolonisation soon occurs. However, where the macrobenthos is substantially removed and recovery is not permitted (such as the *Sabellaria* beds of the Wadden Sea and the bryozoan beds of Tasman Bay), the change is permanent.

The predicted changes in shallow-water communities, a relative increase in *r*-strategists such as polychaetes (where population size is determined by the intrinsic rate of population growth *r*) and a decrease in *K*-strategists such as molluscs and crustaceans (population size is determined by the carrying capacity of the environment *K*), have been observed in the Wadden Sea (Riesen & Reise 1982), the Kattegat (Pearson et al. 1985), and the English Channel (Holme 1983). There is, however, great difficulty in attributing such observed long-term changes in the benthos to the effects of trawl gear alone, since natural fluctuations and other changes such as chemical dumping and eutrophication have undoubtably occurred (Pearson & Barnett 1987; Rees & Eleftheriou 1989).

Most shallow coastal Northern Hemisphere grounds have been fished for centuries and have at the same time been affected by land use changes such as deforestation, pollution, and war. The marine environment was probably changing and adapting before modern "baseline" measurements began (about 100 years ago). The North Sea is not the best place for detecting environmental changes resulting from trawling, but this is where most of the studies have been done.

It is also noticeable in reviewing the literature that authors have underestimated the sampling problems inherent in trying to attribute observed changes to a single cause. Simple pre- versus post-treatment designs, or plot comparison designs (such as that of Graham (1955), do not allow for the separation of effects resulting from the treatment from those effects resulting from other causes (Walters et al. 1988). In addition, many types of impact do not change long-run mean abundances (Underwood 1991). Experimental designs suitable for assessing transient responses to environmental disturbances are becoming available and should be used (Walters et al. 1988; Faith et al. 1991; Underwood 1991).

The evidence is that bottom trawling has an impact on the environment, but that the extent and duration of that impact varies depending on local conditions. There is an urgent need to carry out trawling impact studies in deeper water (> 500 m) since this is where studies indicate that effects could be severe and that any recovery may be measured in decades. Changes to the seabed, by whatever cause (and bottom trawling gear is certainly involved), can affect the fisheries above the beds (Bradstock & Gordon 1983; Sainsbury 1988). To what extent this is a factor in observed "fishery declines" has seldom been addressed in the literature on fisheries management.

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Effects of a Research Trawl on a Hard-Bottom Assemblage of Sponges and Corals

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ABSTRACT

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The effects of a research trawl on several sponge and coral species was assessed in a shallow-water, hard-bottom area located southeast of Savannah, Georgia. The study entailed a census of the numerically dominant species in replicate 25-m² quadrats located along five transects established across a trawling alley. The density of undamaged sponges and corals was assessed in trawled and non-trawled (control) portions of each transect immediately before, immediately after, and 12 months after a 40/54 roller-rigged trawl was dragged through the alley once. Some damage to individuals of all target species was observed immediately after trawling, but only the density of barrel sponges (*Cliona* spp.) was significantly reduced. The extent of damage to the other sponges (*Ircinia campana*, *Haliclona oculata*), octocorals (*Leptogorgia virgulata*, *Lophogorgia hebes*, *Titanideum frauenfeldii*) and hard corals (*Oculina varicosa*) varied depending on the species, but changes in density were not statistically significant. Twelve months after trawling, the abundance of specimens counted in the trawled quadrats had increased to pre-trawl densities or greater, and damage to the sponges and corals could no longer be detected due to healing and growth. Trawl damage observed in this study was less severe than the damage reported for a similar habitat in a previous study. Differences between the two studies are attributed to (1) differences in the roller-rig design of the trawls used, and (2) differences in the number of times the same bottom was trawled.

INTRODUCTION

Hard-bottom reefs are a common topographic feature of the continental shelf off the southeastern United States. Parker et al. (1983) estimates that hard grounds cover approximately 30% of the shelf between Cape Fear, North Carolina, and Cape Canaveral, Florida. In shallow shelf waters, these areas are

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often characterized by low-relief rocky outcrops and extensive areas of hardpan with no emergent rock (Henry and Giles, 1979; South Carolina Wildlife and Marine Resources Department (SCWMRD), 1982). Because hard-bottom habitats support diverse communities of sessile reef invertebrates, they are attractive to many commercially and recreationally important fishes such as snapper, grouper, porgy and black sea bass. Traditionally, these fishes have been caught by hook and line and fish traps, but there is growing interest among some commercial fishermen in trawling hard-bottom areas for these fishes. Trawls have also been used extensively in several research programs to assess demersal fish communities associated with hard-bottom habitats (e.g. Ulrich et al., 1976; Miller and Richards, 1980; SCWMRD, 1981, 1982; Wenner, 1983).

Concern that trawl gear may cause long-term or irreversible damage to reef communities has been expressed by various fishing groups, researchers (Tilmant, 1979; Wenner, 1983) and management agencies. Previous studies on the effects of trawls on benthic communities generally have been restricted to sand-bottom areas (Graham, 1955; Bridger, 1970; Anon.,1971; Caddy, 1973; Gibbs et al., 1980). Thus far, only one study in Florida has documented damage to hard-bottom communities caused by roller-frame trawls (Tilmant, 1979), and that study evaluated the effects of commercial trawl gear which is not commonly used in the South Atlantic Bight.

This paper presents results from a second study which examines trawl effects in hard-bottom habitats. The primary objective of this study was to evaluate damage to sponge and coral assemblages resulting from research trawling practices used in a larger study examining hard-bottom resources in the South Atlantic Bight (SCWMRD, 1981, 1982). Sponges and corals represent the largest and most conspicuous sessile species in hard-bottom habitats of the region. As a result, they are extremely important components of the invertebrate community because they greatly enhance the structural complexity of the bottom, particularly in hardpan areas where sessile invertebrates provide the only topographic relief attractive to fishes. Thus, a better understanding of the effects of trawl gear on these taxa is needed.

STUDY AREA AND DOMINANT FAUNA

The study site was located approximately 32.5 km east of St. Catherines Island, Georgia (31°35.7′N, 80°47.9′W), at a depth of 20 m. This hard-bottom area was chosen for study because it was typical of low-relief hard-bottom habitat in the South Atlantic Bight and because it was easily relocated due to its proximity to an artificial reef (Georgia "Reef J").

Preliminary diver surveys characterized the study area as having a smooth rock bottom covered by a thin layer of sand. Although rock ledges were noted nearby, no emergent rock outcrops were observed in the area to be trawled. Sessile invertebrate growth was extensive throughout the area, with sponges

and corals being the largest growth forms. Ascidians, hydroids, bryozoans and algae were also common, but these taxa were generally represented by low or encrusting growth forms.

Three of the most abundant large sponges, *Haliclona oculata*, *Ircinia campana* and *Cliona* spp. (mostly *C. celata*), were selected for assessment. All of these species have been collected in roller-trawl samples taken at inner-shelf hard-bottom stations (SCWMRD, 1982). The finger sponge, *H. oculata*, is an upright ramous sponge which usually occurs as a single stalk with multiple branches. It has a spongy texture and the branches are quite flexible. The purple vase sponge, *I. campana*, is a keratose sponge which persistently occurs in a cup or vase shape. The texture of this sponge is firmer than *H. oculata*, but it is still quite pliable. Finally, the boring sponges, *Cliona* spp., are upright and cake or barrel shaped in the gamma stage. These sponges have a distinct dermis covered with tubercles and are hard or stiff in consistency. *Cliona* spp. are similar in shape and sometimes confused with the massive loggerhead sponge, *Spheciospongia vesparium*, which is also common in hard-bottom areas of the South Atlantic Bight (SCWMRD, 1982; Wenner et al., 1983).

The dominant octocorals in the area were the whip coral *Leptogorgia virgulata*, the false sea fan *Lophogorgia hebes*, and the stick coral *Titanideum frauenfeldii*. All of these species were more common than the sponges and generally grew tall enough to be collected in roller-trawl samples at inner-shelf hard-bottom sites (SCWMRD, 1982; Wenner et al., 1983).

The only hard coral found in the area was the branching tree coral *Oculina varicosa*. This species occurred only rarely, and the colonies were usually small. Even though *O. varicosa* was uncommon, it was assessed in this study due to its fragile composition and probable susceptibility to damage from trawling.

METHODS

Trawling alley

A trawling alley was established by placing two parallel series of five 90-kg concrete anchors on the bottom, running in an east–west direction (Fig. 1). The alley was approximately 105 m wide and the anchors served as points of attachment for transect lines which were stretched across the alley. All anchors were buoyed and secured with iron spikes driven into the substrate. Transects 1–3 were approximately 20 m apart and were located in an area of high sponge and coral density (Fig. 1). Transects 4 and 5 were located approximately 40 and 60 m, respectively, to the west of Transect 3 and were in an area of high octocoral density but low sponge density.

Transect lines, consisting of 3-mm galvanized cable, were shackled to each pair of anchors approximately 40 cm above the bottom and then drawn tight with a rachet hoist so that the lines were tautly suspended above the bottom

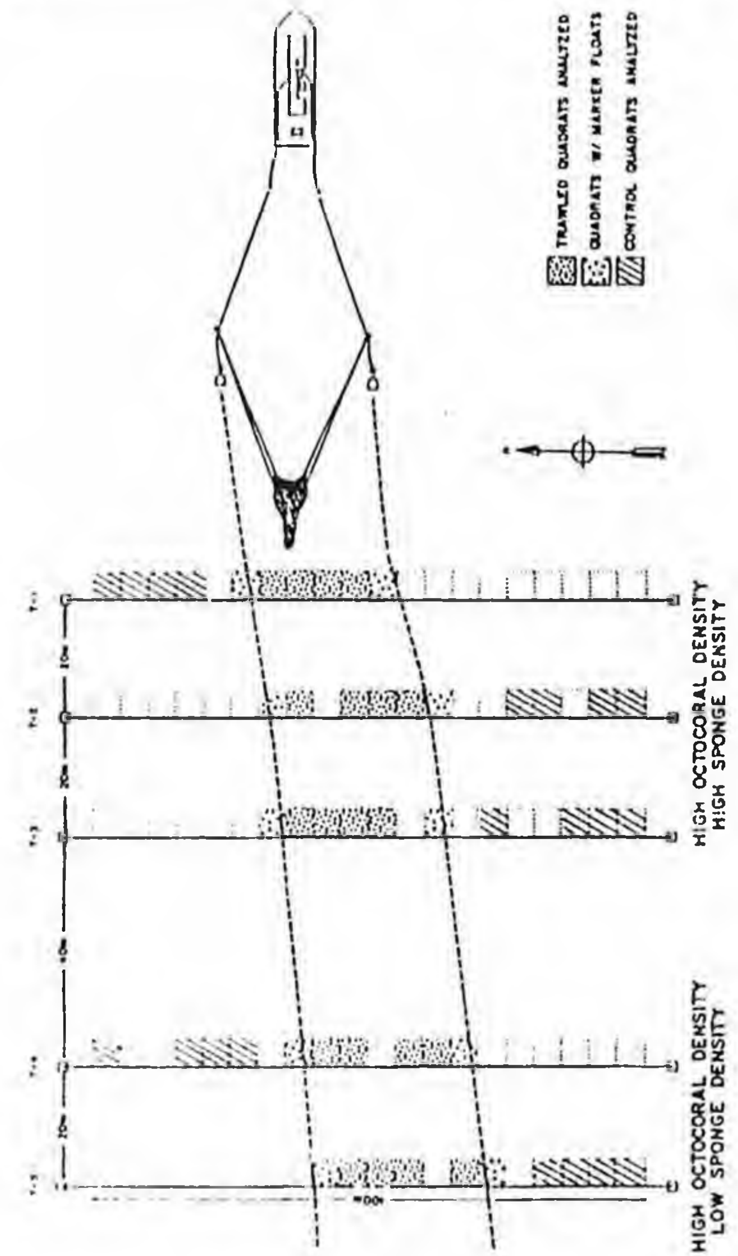

Fig. : Diagram of the trawling alley showing the path of the trawl through the alley and the quadrats analyzed for damage assessment. Vessel and trawl are drawn approximately to scale.

along their entire length. Each transect line was marked with numbered tags at 5-m intervals, starting 2 m from the southern anchor. To further assist in placing quadrat frames in the same position during each assessment, 100-cm² colored plexiglas plates were spiked to the bottom under all numbered tags.

Pre-trawl assessment

For the initial survey (August 1982), divers assessed 20 quadrats along each transect line because the exact path of the trawl through the alley could not be anticipated. Quadrat boundaries were defined by placing a square PVC frame (5×5 m) on the bottom along the east side of the line (Fig. 1). The sponges *Haliclona oculata*, *Ircinia campana* and *Cliona* spp., and the corals *Leptogorgia virgulata*, *Lophogorgia hebes* and *Oculina varicosa* were then counted in the entire 25-m² area of each quadrat. Because the octocoral *Titanideum frauenfeldii* was so abundant, it was counted only in a 1-m² sub-quadrat set up in the northwest corner of each 25-m² quadrat area. Organisms present under the sides or northern edge of the PVC frames were included in the quadrat count. Organisms occurring under the southern edge of the frame were only counted in the first quadrat of each transect line. Sponges and octocorals smaller than 10 cm in height were not counted, but the hard coral *O. varicosa* was counted regardless of size. After the pre-trawl assessment was completed, all transect lines were removed from the area in preparation for trawling.

Trawling operations

The roller trawl used in this study was a 40/54 fly net with a 12.2-m headrope and a 16.5-m footrope equipped with six 30-cm rubber rollers separated by numerous 15-cm diameter rubber discs along most of its length. The net had a 12.8-m vertical mouth opening and stretch-mesh dimensions of 20.3 cm in the wings, 10.2 cm in the body, 4.1 cm in the codend and 0.6 cm in the codend liner. The net was attached to 1.8 × 1.2-m China-V doors using 30.5-m leg lines. This net has been used extensively in previous research trawling in the South Atlantic Bight (Waltz et al., 1982; SCWMRD, 1982; Wenner et al., 1983; Sedberry and Van Dolah, 1984). Larger versions of this net are currently being used by some commercial fishermen in the area.

The trawl was towed once through the trawling alley (26 August 1982) from the 30.8-m R/V "Oregon" at an approximate speed of 6.0 km h⁻¹ using a 3:1 scope in the trawl warps. Under these conditions, the spread of the trawl rig from door to door was approximately 30-35 m. The trawl was deployed well in advance of the alley entrance to ensure that it was fishing properly, and was hauled immediately after passing through the alley. To mark the trawl path, two small chase boats followed buoys attached to each trawl door (Fig. 1), and deployed small sub-surface markers approximately every 5 m along the path.

These markers consisted of grouped fishing weights attached to small balsam floats on 3-m sections of line.

Contents of the trawl were sorted, weighed and then preserved in a 10% formalin-seawater solution for identification in the laboratory.

Post-trawl assessment

After trawling operations were completed, divers replaced all transect lines in their original positions. Quadrats with sub-surface markers denoted the trawl path. Eight quadrats from each transect were then randomly selected for re-assessment. Four were selected from quadrats in the trawl path; the other four from those outside the trawl path to serve as control areas (Fig. 1). Quadrats with markers were not considered in this selection since unequal portions of those quadrats were affected by the trawl, and selection of control quadrats was limited to one randomly selected side of the trawl path to minimize diver swimming time. This sampling design provided a total of 20 trawled quadrats and 20 control quadrats for analysis.

Counting techniques used in the post-trawl assessment (August-September 1982) were similar to those used in the pre-trawl census except that the number of damaged specimens of each species was also noted. Additionally, the degree of damage was subjectively categorized as none, slight, moderate or heavy. Damaged organisms were counted regardless of size. Twelve months later (August 1983), the same 40 quadrats were re-assessed in the control and trawled areas. Counting techniques were the same as before, except that organisms were not categorized by degree of damage since that was no longer evident.

Data analysis

The species selected for assessment of trawl damage were compared with respect to densities of undamaged specimens in the trawled quadrats before, immediately after, and 12 months after trawling. Damaged specimens were not included in the analyses since some organisms were completely removed from the area, thereby precluding accurate counts. Control (non-trawled) areas were also compared before and after trawling to evaluate accuracy of the counting technique, and to monitor natural changes in the density of each species with time. Comparisons between treatment groups (before, after, 12 months after) were made using 1-way ANOVA tests on log $(x+1)$ transformed data. When differences were significant, the a posteriori Student-Newman-Keuls test was used to determine separation of treatment groups.

The distribution of octocorals and hard corals appeared to be fairly uniform throughout the study area. Therefore, quadrats from all 5 transects were treated as replicates in control and trawled groups. Sponge density, on the other hand, was noticeably lower along Transects 4 and 5 than along Transects 1-3. As a result, separate analyses were performed for each sponge species in the high density (T_1-T_3) and low density (T_4-T_5) areas since quadrats from these two portions of the alley could not be considered to be replicates. This provided 8 and 12 replicate sponge counts per treatment group in the high- and low-density areas, respectively.

RESULTS

Pre-trawl sponge density was much higher along Transects 1-3 than along Transects 4-5 (Fig. 2). The most abundant sponges counted in both areas were the barrel sponges *Cliona* spp., which were more than twice as numerous as the finger sponges, *Haliclona oculata*, and the vase sponges, *Ircinia campana*. The latter species was the least abundant sponge found along all 5 transects. Octocorals were more numerous than sponges, with the stick coral *Titanideum frauenfeldii* being the most abundant species (Fig. 3). An accurate estimate of the density of *T. frauenfeldii* could not be made because counts were based on the number of emergent stalks which sometimes grew from the same basal disc. Even so, *T. frauenfeldii* stalks were so numerous that colony density of this species was undoubtedly higher than that of the other octocorals, *Leptogorgia virgulata* and *Lophogorgia hebes*, which were also abundant throughout the alley. The stony coral *Oculina varicosa* was the least abundant coral counted in the quadrats (Fig. 4). In contrast to the sponges, no consistent differences in density were noted between transects for any of the coral species.

Immediately after trawling, divers surveyed the area and noted that the sub-surface markers accurately defined the path of the trawl doors based on damage to surrounding sponges and corals. At least some specimens of all species counted in the pre-trawl assessment were found damaged in the area between the door marker-floats, with more destruction noted among sponges than corals. Damage to sponges ranged from slight tears and nicks to major portions being torn off, or the entire sponge being knocked down. Grooves resulting from rubbing by the trawl leg lines were also observed in the sides of several sponges, especially *Cliona* spp. Damaged octocorals and stony corals were most often completely severed at their base.

Histograms of undamaged sponge density before versus immediately after trawling (Fig. 2) illustrate a significant decrease in the number of undamaged sponges present in the trawled quadrats of Transects 1-3 ($P<0.05$, ANOVA). A similar decline was also noted in trawled quadrats of Transects 4-5, but this decrease was not statistically significant at the 95% confidence level. Of the 208 sponges remaining in the 20 trawled quadrats, 31.7% were damaged. In contrast, no sponge damage was detected in the control quadrats of any transect and total sponge abundance had not changed significantly in either the high- or low-density areas ($P>0.75$).

Most of the damaged sponges were *Cliona* spp. (Fig. 2). In the high- and

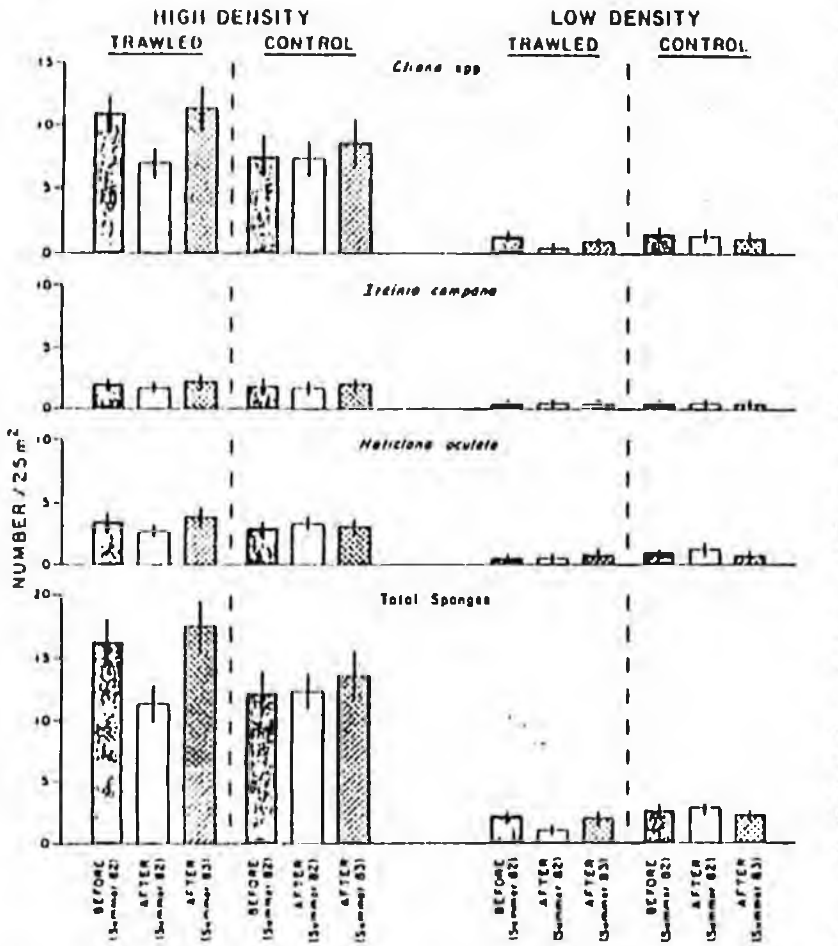

Fig. 2 Mean density (±SE) of undamaged sponges counted in trawled and control quadrats during the three census periods. High-density histograms represent quadrats from Transects 1-3 and low-density hsitograms represent quadrats from Transects 4-5.

low-density areas, respectively, there were 35.3 and 76.9% fewer undamaged clionid sponges present in the trawled quadrats. Both of these decreases were statistically significant ($P < 0.05$, ANOVA), whereas in the control quadrats no significant decreases were noted in sponge density after trawling ($P > 0.75$). Although trawl damage to *Cliona* was significant, it should be noted that only 7 of the 149 clionid sponges initially counted were missing from the quadrats after the trawl had passed through the area. Furthermore, of the 49 specimens found damaged, only 29 were considered to be heavily damaged (i.e. > 50% damage or loss of the specimen).

Twelve months after the trawl had passed through the alley, divers could not confidently relocate any of the damaged *Cliona* spp., and the abundance of

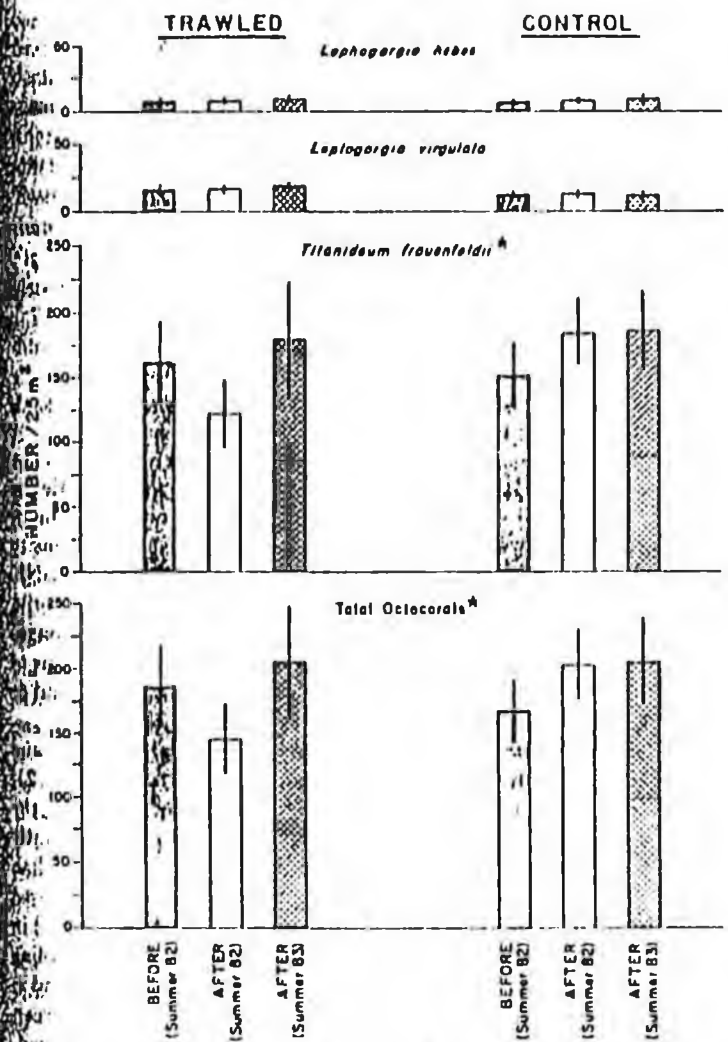

Fig. 3. Mean density (±SE) of undamaged octocorals counted in trawled and control quadrats during the three census periods. Values are based on quadrats from all transects and (*) indicates estimates based on counts of *T. frauenfeldii* in 1-m² quadrats.

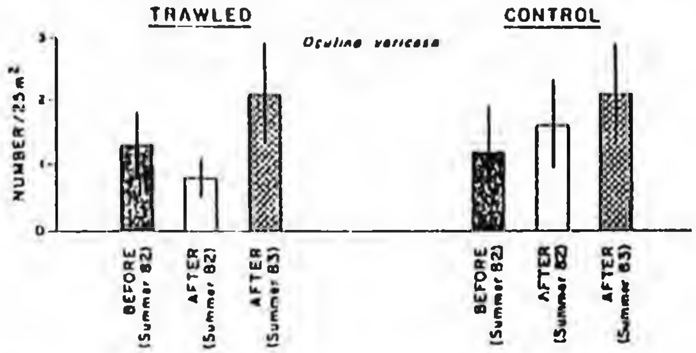

Fig. 4. Mean density of undamaged stony corals counted in trawled and control quadrats during the three census periods.

specimens counted in trawled quadrats had increased to pre-trawl densities or greater (Fig. 2). No significant differences were detected, in either the high or the low-density areas, between pre-trawl and 12-month post-trawl density estimates of either *Cliona* spp. alone or all sponges as a group ($P > 0.05$, SNK tests). Regeneration of tissue among the damaged *Cliona* during the interim period was sufficient to have rounded off the tops of partially severed sponges and to have closed wounds on other sponges. Thus, while some specimens of *Cliona* were obviously shorter than before, none appeared to be moribund or even damaged.

Effects of the trawl gear on the other large sponges, *Haliclona oculata* and *Ircinia campana*, were not as severe as those noted for *Cliona* sp. (Fig. 2). Although 16 damaged finger sponges were found in the trawled quadrats, the mean density of undamaged *H. oculata* in those quadrats was not significantly different between census periods ($P > 0.5$, ANOVA). Additionally, fewer than 8 of those 16 sponges were considered heavily damaged. Vase sponges appeared to be least affected by the trawl, with only one damaged *I. campana* found in the alley. As with finger sponges, no significant differences between sampling periods were noted in the mean abundance of undamaged *I. campana* found in trawled quadrats ($P > 0.05$), nor were there any significant differences between sampling periods with respect to the density of either species in control quadrats ($P > 0.75$).

Total octocoral abundance declined in the alley after trawling (Fig. 3), and a few damaged specimens of all species were found in the trawled quadrats. However, effects of the trawl on the three octocoral species appeared to be minimal in comparison with the sponges, since there were no significant differences between pre-trawl and post-trawl density estimates for any of the three species ($P > 0.5$, ANOVA). In fact, mean densities of the fan and whip corals, *Lophogorgia hebes* and *Leptogorgia virgulata*, remained constant in the first post-trawl assessment, and only the stick coral *Titanideum frauenfeldii* declined in mean abundance immediately after trawling (Fig. 3). The constant mean densities observed for fan and whip corals before and after trawling were unexpected, since divers counted 9 damaged *L. hebes* and 6 damaged *L. virgulata* in trawled quadrats. This discrepancy was probably due to counting errors. Twelve months after trawling, the densities of all octocoral species were higher than pre-trawl densities, although differences were not significant ($P > 0.5$, Fig. 3). Octocoral densities in the control quadrats also remained fairly consistent throughout the study period ($P > 0.5$).

Divers counted 30% fewer undamaged stony corals in the trawled quadrats during the immediate post-trawl assessment (Fig. 4). Of the seven colonies affected by the trawl, four were moderately to heavily damaged and three were damaged only slightly. Twelve months after trawling, the mean density of *Oculina varicosa* was greater than the pre-trawl estimate (Fig.4), and damage could not be detected on any of the colonies. Differences in the density of stony corals between sampling periods were not statistically significant in either the trawled or control areas ($P > 0.25$, ANOVA).

All of the species examined in this study were collected in the trawl net, with the exception of the vase sponge *Ircinia campana* and the stony coral *Oculina varicosa* (Table 1). Biomass of the invertebrates collected in the trawl was within the range of biomass estimates from previous trawl collections at inner-shelf stations where trawling distances were longer (SCWMRD, 1982). Relatively few fish were collected in comparison with previous catches using this gear (SCWMRD, 1982; Sedberry and Van Dolah, 1984). However, the distance trawled was much shorter than in the previous studies. In general, the catch and all observations made during trawling operations indicate that the trawl was fishing properly when it passed through the alley.

DISCUSSION

Data generated from this trawling study support the hypothesis that roller trawls damage sponges and corals found in hard-bottom habitats of the South Atlantic Bight. However, the damage observed in this study was not as severe as that noted in the only other study of trawling effects on this type of bottom (Tilmant, 1979). In that study, the effects of commercial shrimping with roller-frame trawls were evaluated in a shallow-water area of Biscayne Bay, Florida. Tilmant observed severe damage (specimens crushed or torn loose) to more than 80% of the stony corals, 50% of the sponges and 38% of the soft corals along the trawl path. In contrast, significant damage in our study was limited to sponges, of which 31.7% were found damaged immediately after trawling. Damage to octocorals was much lower, with only 3.9% of the colonies affected in trawled quadrats. A higher percentage of stony corals was affected in our

TABLE I

List of taxa captured in the trawl net during its pass through the trawling alley

Species	Number caught	Biomass (kg)
Phylum Porifera		
Cliona spp.	3	22.80
Haliclona oculata	1	1.00
Ircinia ramosa	1	0.38
Porifera (undet. fragments)	-	0.90
Phylum Cnidaria		
Leptogorgia virgulata	6	0.54
Lophogorgia hebes	3	0.26
Telesto sp.	-	0.26
Titanideum frauenfeldii	-	0.14
Phylum Mollusca		
Teuthoidea (undet.)	1	0.52
Phylum Echinodermata		
Arbacia punctulata	1	0.05
Holothuroidea (undet.)	1	0.01
Phylum Chordata		
Subphylum Urochordata	-	
Ascidiacea (undet.)		0.58
Subphylum Vertebrata		
Acanthostracion quadricornis	1	0.27
Aleuterus schoepfi	5	0.46
Monocanthus hispidus	2	0.05
Other (misc. invertebrate fragments)	-	0.19

study (30.4%), but the initial density of those corals was very low in the traw ing alley.

Two factors may account for the differences observed between Tilmant (1979) study and this one. First, the roller-frame trawls used by Florida shri pers are considerably different in design from the roller trawl used in our stud The shrimp trawl frame generally has non-flexible roller assemblies consisti of steel pipes welded around a central axle to form slatted roller-cylinde approximately 13 cm in diameter (Tabb and Kenny, 1967). The roller assem bly used on our trawl, on the other hand, is more flexible because it consists several short rubber rollers spaced along a chain with smaller rubber dis

separating them. Additionally, these rollers are larger in diameter (30 cm) than the steel-slatted rollers used on the shrimp trawls. The relatively large size and flexibility of this roller assembly undoubtedly accounted for the less severe damage to the large sessile fauna in our study as compared to that produced by the smaller, less flexible rollers used in Tilmant's study.

The second factor which may explain differences between the two studies is related to the number of times the same area of hard bottom was trawled. Although much of the damage Tilmant (1979) described was attributed to a single tow, he noted that his post-trawl assessment followed ". . . 44 nights of fishing by an average of 10 shrimp boats (440 boat nights) working in the area". Thus, some of the severe damage he observed may have been caused by previous trawling over the same bottom. In contrast, the trawl damage noted in our study purposely reflects the effects of one tow through the alley, since this study was designed to evaluate the effects of our research trawl which typically does not cross the same bottom area more than once (SCWMRD, 1982; Sedberry and Van Dolah, 1984). Multiple tows through the alley would probably have caused much greater damage to sponge and coral populations.

Commercial trawlers often drag over the same area more than once to minimize gear damage and loss due to hangs on unfamiliar rocky bottom. Thus, their effect on hard-bottom communities would probably be much greater than that noted for our research trawling. Commercial trawling without roller rigs would have even more serious adverse impacts on bottom communities. For example, C.A. Wenner (unpublished data) collected approximately 477 kg ha^{-1} of invertebrates (mostly sponges and corals) in a single tow over hard bottom using paired 40/60, 4-seam semi-balloon trawl nets without rollers. On a sand bottom, Bridger (1970) found that tickler chains on trawls could dislodge rocks partially buried in the sand, thereby changing the bottom environment.

In our study, the barrel sponges, *Cliona* spp., were the most severely affected organisms in the trawl path. As noted previously, these sponges are relatively inflexible and thus would be more easily torn or knocked down than sponges such as *Ircinia campana* and *Haliclona oculata*, which are less rigid. Colony flexibility may also account for the comparatively insignificant damage observed among the three octocoral species *Lophogorgia hebes*, *Leptogorgia virgulata* and *Titanideum frauenfeldii*. *Oculina varicosa*, on the other hand, is very brittle and the fact that most of the stony corals in the trawl path were not crushed or broken was probably due to the small size of the *O. varicosa* colonies in this area. This would have allowed many coral heads to escape damage as the trawl bounced over larger organisms. Additionally, the relatively small size of both stony corals and many octocorals would have minimized damage from the trawl leg lines, which apparently drag above the bottom based on evidence of leg-line damage on the sides of larger *Cliona* spp.

The location of the trawl door markers in the alley indicated that the path of the trawl rig was approximately 30–35 m wide. Since the width of the trawl net and rollers was only about 6 in at the towing speed used (unpublished data), most of the bottom area affected by this trawl rig was damaged by the lower leg lines which connect the net footrope to the trawl doors. Fauna damaged by these leg lines would generally not be captured in the net, as evidenced by the low numbers of sponges and corals collected in our trawl relative to the number found damaged. Thus, it is important to consider gear design in any evaluation of trawl damage to bottom invertebrates. Trawls with doors attached directly to the nets would greatly reduce the bottom area damaged by trawling activities, as would any modifications to the net roller rig that would raise the lower leg lines even further off the bottom.

Sponges and corals damaged in this study appeared to have recovered, at least partially, within 1 year following the trawling operation, since divers could not distinguish damaged from undamaged organisms during the last post-trawl survey. While this capacity for regeneration reduces the likelihood of serious long-term impacts from limited research trawling over hard-bottom communities, the small amount of growth rate information obtained during this study (Van Dolah et al., 1983) suggests that it may take several years for some damaged sponges and corals to attain their original size. Other studies also suggest that sponges and corals in general may be slow growing. For example, Nicol and Reisman (1976) measured *Cliona celata* in New York waters and reported growth data which indicate that it may take several years for *Cliona* to reach sizes equivalent to those present in our study area. Similarly, Grigg (1974) examined two gorgonian corals (*Muricea* spp.) in California waters and noted that it takes approximately 40 years for those corals to reach a height of 50 cm. More extensive data on the recruitment and growth rates of sponges and corals is needed to fully evaluate impacts from roller trawling, particularly since the size and density of these organisms directly influence the structural complexity of hard-bottom habitats and, consequently, the attractiveness of these areas to fishes.

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Recruitment Characteristics of the Commercially Harvested Red Sea Urchin *Strongylocentrotus franciscanus* in Southern British Columbia, Canada

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ABSTRACT

Sloan, N.A., Lauridsen, C.P. and Harbo, R.M., 1987. Recruitment characteristics of the commercially harvested red sea urchin *Strongylocentrotus franciscanus* in southern British Columbia, Canada. *Fish. Res.*, 5: 65-69.

The test size frequencies of red sea urchin, *Strongylocentrotus franciscanus* (Agassiz), populations from British Columbia revealed low recruitment overall (≈9.5%) compared with populations from lower latitudes. Juvenile urchins tended to shelter under adult conspecifics. On a fine scale, i.e. over 0.5-8.0 km, high variability in recruitment was evident. Possible effects of commercial harvesting are discussed. Site-specific harvest controls based on local habitat and urchin population (size-frequency) data are desirable as a fishery management tool, but would be too costly to gather over such an extensive coastal area.

INTRODUCTION

Populations of red sea urchin, *Strongylocentrotus franciscanus* (Agassiz), in southern British Columbia are experiencing increased harvesting by diving fishermen (Fig. 1). A special biological concern with this fishery is that harvesting of adult urchins not only reduces brood stock, but may also affect recruitment by decreasing the amount of spine-canopy shelter provided by adults for young conspecifics (Tegner and Dayton, 1977). Recruitment is defined by Ebert (1983) as being the addition of new individuals, which are just large enough to be collected in proportion to their true abundance, to a population by reproduction or immigration. Estimates of recruitment in British Columbia populations are generally lower than those in southern California

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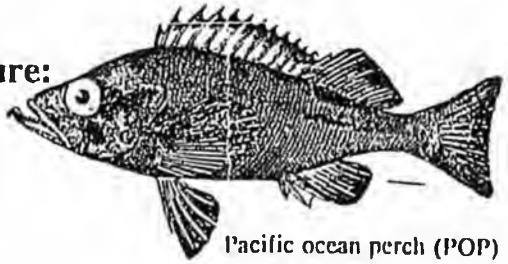
Southeast Alaska trawl closure: A case study in risk-averse management



Pacific ocean perch (POP)

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INTRODUCTION

In February 1991, the fishers of Sitka, Alaska launched a campaign to protect the waters off Southeast Alaska from the effects of trawling. Over the following year and a half, fishers, seafood processors, environmental organisations, towns and communities, the Alaska State Legislature and the Governor's office joined Sitka's effort. Letters, resolutions, and petitions were sent to the North Pacific Fishery Management Council, the federally-appointed management body requesting protection for Southeast's marine resources and coastal communities. The Alaska Department of Fish and Game compiled an Environmental Assessment (EA) emphasizing the importance of precautionary management in Southeast's unique environment. And yet, despite this enormous effort, in September, 1992, the North Pacific Fishery Management Council voted 7 to 4 against closing Southeast to trawling, dismissing the EA and the public testimony documenting trawl impacts as either "unquantified" or "anecdotal."

The Councils's decision highlights a flaw in U.S. fisheries management policy: despite a Congressional mandate in the Magnuson Fishery Conservation and Management Act to err on the side of conservation, managers too often place the burden of the proof for "quantifying" habitat or ecosystem damage on concerned fishers and environmentalists. Since information on the deepsea environment is limited, and quantifying damage occurring at 260 metres (140 fathoms) is difficult at best, the suspected offenders, in this case the factory trawlers, have an easy upper hand. Until risk-adverse management becomes integral to fisheries policy, the marine environment will continue to pay the price for unquantified or unquantifiable effects. With the Magnuson Act scheduled for reauthorization in 1993, policy-makers have a responsibility to evaluate the effectiveness of U.S. fishery management policy. As a case study, the Southeast trawl closure provides insight into the current interpretation and application of the Act.

HISTORY

Trawling off Southeast began in the 1960s when foreign factory trawlers first prosecuted slope rockfish stocks in the waters of the Eastern gulf of Alaska (the Eastern Gulf includes both the Southeast and the Yakutat regulatory areas). Catches peaked in 1965, then dropped off precipitously. Species in the slope rockfish complex are long-lived (95-140 years), have a late age of reproduction and limited movement patterns. These characteristics make the complex highly vulnerable to over-exploitation. By the late 1960s, stocks of Pacific ocean perch (POP) (*Sebastes alutus*), the dominant and most targeted species within the slope complex, had been reduced to 10-16% of historic levels. In 1982 the North Pacific Fishery Management Council

significantly reduced slope rockfish quotas in the Eastern Gulf and initiated a rebuilding program for Pacific ocean perch. In the same year, the council prohibited foreign trawlers from fishing off Southeast Alaska.

In 1985, the domestic factory trawl fleet first appeared in the Southeast area. Local hook-and-line fishers, called longliners, watched with concern. As was the case with the foreign trawlers operating off Southeast, the domestic trawlers targeted POP and other slope rockfish species. Although little or no stock recovery had yet occurred, slope rockfish quotas were raised in response to lobbying pressure from domestic trawlers and the rebuilding program was abandoned. Between 1985 and 1991, factory trawl landings increased from 423 metric tonnes (mt) to 1,402 mt in the Southeast area, and from 807 mt to 5,108 mt in the Yakutat area. Although only five to seven factory trawlers fished off Southeast in any one year, the impact was noticeable. Slope rockfish live on or near the ocean floor, hence are targeted with hard-on-bottom trawls. After the arrival of trawlers on traditional fishing grounds, local longliners pulled up empty hooks from once productive areas. Their concern deepened.

In February 1991, representatives from a factory trawl company visited Sitka to investigate crew transportation and emergency docking facilities. The representatives mentioned that their company intended to send three factory trawlers into Southeast to fish its "virgin grounds" for Pacific cod (*Gadus macrocephalus*), a traditional longline species. As is the case with most factory vessels, all supplies, gear, crew, etc. were to be obtained outside of Alaska, and all fish would be processed on board the vessels. The intent of this company sparked the smouldering fire: Sitka fishers drafted a proposal to prohibit trawling off Southeast Alaska.

The fishing grounds that appeared "virgin" to the trawlers have been fished by shore-based longline fishers for close to a century. Over the years the grounds have remained productive, evidence that longline fishing is a sustainable harvest technique appropriate to the area. Southeast longliners target Pacific halibut (*Hippoglossus stenolepis*), sablefish (*Anoplopoma fimbria*), demersal shelf rockfish (*Sebastes* spp.) and the Pacific cod. The local longline fleet is composed of relatively small vessels (less than 20 metres (60 feet) in length) that deliver to processors in the Southeast coastal communities. Many of the vessels are family-owned and operated, part of a fishing tradition that stretches back through two or three generations. In many of these communities commercial fishing is the sole source of employment and revenue. Consequently, local fishers and processors have supported conservative management of marine fish species. Longliners had already seen the destructive force of the foreign trawlers; how they feared that history was repeating itself. The grass-roots effort to protect communities and the resources they depend on grew from that fear.

CONSERVATION CONCERNS

Pacific ocean perch are the dominant species harvested with domestic trawl gear in the Southeast area. POP recruit into the trawl fishery (i.e. start to be caught by trawlers) between the age of five and seven, but do not become sexually mature until age nine or eleven. Prior to exploitation, the POP population consisted of a wide distribution of age classes from juveniles to 95 year old adults. According to 1987 data now only 12% of the population is over age 15, which is an indication of the severely reduced reproductive potential of the stock (Heifetz and Clausen, 1991). The POP biomass reached minimum levels during the late 1970s and early 1980s, showed signs of slight recovery following the Council's rebuilding effort, then, according to triennial trawl research surveys, declined by 43% between 1984 and 1990. Recent verification of the trawl survey data by submersibles suggests that stock depletion may be more severe than previously assumed; observations indicate that the biomass figures currently used to evaluate quotas may over-estimate POP abundance by a factor of two (Krieger, 1992).

The rockfish conservation problem is further exacerbated in the waters off Southeast by the narrowness of Southeast's continental shelf/slope and the abundance of rocky, high-relief terrain. The Southeast trawl closure EA emphasizes that the Southeast area contains very little smooth bottom suitable for trawls, which serves to concentrate trawl effort. Submersible observations recorded row after row of trawl furrows in this limited smooth bottom habitat, some estimated to be almost 2 metres (5 feet) deep (Krieger, video footage, 1992). Since rockfish are widely recognized as being non-migratory and area-specific, concentrating trawl effort in the few smooth bottom areas may result in localized depletion of rockfish species (Bracken and Bibb, 1992).

The smooth-bottom habitat off Southeast is interrupted by deep-water canyons and boulder fields. Although adult POP are found in the smooth bottom areas, rougheye rockfish (*Sebastes aleutianus*) and shortraker rockfish (*Sebastes borealis*) slope rockfish species of secondary importance to the factory trawl fleet, are commonly associated with this rocky, high-relief terrain. Using rolling gear (similar to over-sized tires filled with cement) along the lower edge of the net, some rockfish trawlers have recently developed techniques that allow them to fish the rocky areas. These rocky areas support a high abundance and diversity of fragile deep-water corals, including octocorals, hydrocorals and hexacorals. These corals are presumed to be long-lived and slow-growing. During public testimony, rockfish trawlers claimed to avoid contact with corals, stating that corals tear and damage nets, a claim supported by the lack of corals in the fish-catch observer data. However, submersible observations recorded pieces of broken coral along trawl tracks and attributed to trawl impact the displacement of boulders 1.5-3.0 metres (5-10 feet) in diameter. This suggests that, although trawl nets may not come in contact with corals and associated hard-bottom species, the impact of roller gear and trawl doors could be significant (trawl doors, used to spread the net mouth, weigh several tons apiece).

The canyons and other isolated rocky areas are often uncharted, hence are difficult for large vessels with heavy gear to avoid. In recent years three trawl vessels brought into Sitka for emergency repairs have all had significant amounts of *Primnoa*, or red tree coral, piled on deck. (Pictures of these vessels with coral on deck were submitted to the Council by local fishers). Although research vessels conducting the triennial trawl surveys tried to avoid rough-bottom terrain, in 1990 eight Southeast survey crews reported the occurrence of substantial amounts of coral: one tow reported 925 kg (2,039 pounds) of *Primnoa* (Derrah, 1990). *Primnoa* is predicted to have a growth rate of 1 cm/year (0.4 inches/year) and to require 100 years to reach full size. After reviewing a 1987 trawl impact study conducted in near-shore, South Atlantic waters, the South Atlantic Fishery Management Council (SAFMC) concluded that repeated trawling in live-bottom, coral areas could result in significant habitat loss (SAFMC, 1988). Cold water corals are presumed to be slower growing and have a lower rate of production than warm water corals (Cimberg, *et al.*, 1981). A recent study concluded that the effect of trawling on the seabed environment in deeper water (greater than 500 m (1,600 feet) could be severe and that any recovery may be measured in decades (Jones, 1992). The rockfish trawlers fishing off Southeast operate in cold water at depths of 200-600 m (650-2000 feet). Although information on the deepsea environment and the coral/trawl interactions occurring off Southeast are limited, the best available information indicates that the impacts on habitat could be long-term and significant.

MANAGEMENT ISSUES

There are several documented management problems associated with trawl effort in the Southeast area. The quotas for many fish species are relatively small. The trawl fisheries are fast-paced and high-volume, and have a history of exceeding the small Southeast quotas. In recent years actual catches have been as high as 185% of the area quota. Many of the rockfish species in the Eastern Gulf are managed close to biological threshold levels (i.e., estimated maximum sustainable harvest levels). Exceeding quotas and these threshold levels may pose severe conservation problems.

In some cases quotas are also set close to the "overfishing" definition.[1] In 1991, one trawl vessel's misreporting of its demersal shelf rockfish (DSR) bycatch almost triggered the overfishing definition for DSR. Along with creating a potential conservation problem, triggering the overfishing definition would have preempted the traditional longline halibut and directed DSR fisheries in the Southeast area. This demonstrates the potential for a single trawl vessel to affect the traditional fisheries of the entire area. Even after reclassifying most of the misreported DSR bycatch, the National Marine Fisheries Service (NMFS) closed by emergency rule the Southeast area to trawl gear to prevent overfishing of DSR and to ensure that the fall halibut longline fishery was not preempted (emergency rules can be implemented for a maximum of 180 days). Although the emergency rule prevented a disaster, such crisis management can not be expected to function effectively in every situation.

The ability of high-volume trawl fisheries to quickly harvest small quotas has also caused many species in the Southeast area to be listed early in the year as "bycatch" or "prohibited." When a species is listed as "bycatch," it may only be harvested in limited amounts incidental to other target fisheries. If this limited amount is exceeded, the species must be discarded. When

[1] When the overfishing definition for a species is reached, any fishery that may affect the species is closed.

a species is listed as "prohibited," any amount harvested must be discarded. For example, during the 1990-1992 fall halibut fisheries, rougheye and shortraker rockfish were listed as "prohibited" and had to be discarded by longline halibut fishers. Factory trawlers also discarded rougheye and shortraker during the 1992 POP fishery. Since the mortality of discarded rockfish is 100%, such listings mandate waste. Eliminating the directed rougheye and shortraker trawl fishery would ensure that small quotas were adequate to meet the bycatch needs of traditional fisheries, preventing waste and minimizing the risk of exceeding quotas.

SOCIAL CONSIDERATIONS

The continental slope is significantly closer to the shore off Southeast Alaska than it is off central or western Alaska. This proximity enables Southeast's small boat longline fleet to safely access the off-shore sablefish and halibut grounds. Most of the over 3,000 longliners fish only in the Southeast area, being limited by vessel size to the near-shore fisheries. The Southeast longline fleet is shore-based, delivering 75% of its harvest to Southeast processing plants. These landings are taxed by the State of Alaska at 3%, with half of the revenue generated by the tax accruing to the Southeast coastal communities. The seafood industry is the largest private, basic industry employer in the State; in many of the small Southeast communities, it is the only employer. Both Southeast fishers and the communities in which they live depend on the long term productivity of their traditional fisheries.

In 1991, a total of eleven trawl vessels fished off Southeast. These factory vessels are highly mobile and currently participate in fisheries throughout the Gulf of Alaska and Bering Sea. Fishing off Southeast contributes to, but does not fully constitute the fleet's annual income. None of these factory vessels deliver to Southeast processing plants nor pay any seafood tax to the communities or State of Alaska. However, as was demonstrated by the rockfish trawler in 1991, any one of these eleven vessels could significantly disrupt the traditional fisheries on which the 3,000 Southeast longliners depend. Such disruption would impose severe social and economic costs on Southeast fishers and coastal communities. As North Pacific Council member Lary Cotter stated, "This region is scared to death for the future if trawling is allowed to continue."

ECONOMIC CONSIDERATIONS

The Environmental Assessment (EA) separates the economic effects of the proposed trawl closure into three categories: losses to trawl vessels, gains to hook-and-line vessels, and net benefits to the nation. The EA estimates that gross revenue losses to the trawl fleet would range from $3 million to $3.6 million. These losses would be mitigated to some extent by the ability of the affected trawl vessels to fish in other areas. Estimated economic gains to the hook-and-line fleet and the coastal communities ranged from $1.9 million to $2.3 million. Additional gains identified in the EA arise from: protecting rockfish stocks from overfishing, preventing curtailment of other groundfish and halibut fisheries, and ensuring that "increased trawl effort in the future will not erode the economic base of the [Southeast] coastal communities" (Bracken and Bibb, 1992).

Closing the Southeast area to trawling would result in an estimated net loss to the nation of $1.1 to $1.3 million. Virtually all of this loss is attributed to the forgone harvest of POP in the Southeast area (estimated value of POP in the Southeast area is $1.2 to $1.4 million). The analysis states that this loss would occur only if the POP quota constitutes a "truly harvestable surplus." Given the current depleted status of POP and the conservation concerns associated with the rockfish trawl fishery, it is difficult to consider the POP quota a "truly harvestable surplus."

Prohibiting trawling off Southeast would benefit the resource and the nation through habitat protection, decreased waste, and the conservation of depleted rockfish stocks. Southeast coastal communities would benefit through increased economic and social stability. The Council weighed these "unquantified" benefits against the trawler's economic loss and found them insufficient. To the dismay of a region united in its concern, the trawl closure was denied.[7]

SUMMARY

At the recent United Nations Conference on Environment and Development (UNCED), participating nations agreed that: "States should commit themselves to the conservation and sustainable use of living marine resources...promote the development and use of selective fishing gear...[and] preserve rare or fragile ecosystems as well as habitats and other ecologically sensitive areas." Southeast Alaska's nearly century-long tradition as a productive, hook-and-line area indicates that longline fishing is an appropriate, sustainable means of harvesting Southeast's marine resources. Southeast fishers fear that factory trawlers could destroy that tradition. The United Nations have urged managers to promote sustainable, selective gear and to protect critical habitat. Through the Southeast trawl closure, local fishers sought to follow this directive.

The Magnuson Fishery Conservation and Management Act directs regional Councils to base decisions on the "best scientific information available." (Section 301 (a) (2). The Act defines the terms "conservation and management" as: "all the rules, regulations, conditions, methods and other measures which are required to rebuild, restore and maintain...any fishery resource and the marine environment; and which are designed to assure that...irreversible or long-term adverse effects on fishery resources and the marine environment are avoided" (Section 3 (2). Proponents of the Southeast trawl closure sought to apply these directives. Gathering the best scientific information available, proponents asked the Council to rebuild depleted slope rockfish stocks and to prevent long-term adverse effects on the marine environment off Southeast. Although quantifiable information specific to the Southeast was limited, in the words of Council member Ron Hegge: "It does not do much good after the fact to know for sure that the damage has been done." Given the complexity and inaccessibility of the marine resource, information on marine fish species and the ecological sensitivity of deep-sea habitat is likely to

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[7] Four of the six Alaskan council members voted in favor of prohibiting trawling off Southeast; Council members from Oregon, Washington and the National Marine Fisheries Service voted against the trawl closure.

remain limited. Only risk-adverse policy will protect the diversity and productivity of the marine environment. The UNCED Resolutions mandate conservative management in the face of uncertainty; the Magnuson Act provides a similar directive. Application of the Act should reflect these directives.

The State of Alaska, Southeast coastal communities, fishing organizations, seafood processors, environmentalists, and several thousand Southeast residents asked the Council to protect local marine resources by prohibiting trawling off Southeast. The request was denied. Southeast fishers are now working to compile additional information, hoping to someday "quantify" trawl damage to the satisfaction of the Council. As Congress begins the process of reauthorizing the Magnuson Act, those same individuals and organizations will be looking for opportunities to strengthen the conservation standards within the Act.

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A sweep towards change in Nova Scotia!

The Moosehead-Clean Nova Scotia Beach Sweep and Litter Survey.

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INTRODUCTION

Starting in 1989, The Clean Nova Scotia Foundation has helped volunteers organize local beach clean-ups throughout the province of Nova Scotia at hundreds of locations. The first Beach Sweep attracted 119 volunteers in April 1989. In September of the same year, 708 volunteers participated. Since that time, thousands of Nova Scotians have shown their concern for our coastal environment by participating in the Beach Sweep and Litter Survey Programmes. The June 1992 Sweep involved close to 10,000 participants making it one of the largest per capita coastal clean-up projects in North America.

In 1992, during Spring and Fall Beach Sweep programmes, volunteers across the province recorded over 4,075 bags of plastic trash from approximately 260 kilometres of Nova Scotian coastline. Collection results indicate an estimated 20 tonnes of marine debris and beach litter were gathered from our beaches in 1992.

Now sponsored by Moosehead Breweries Limited, the Beach Sweep programme provides volunteer groups with the practical materials to organize a fun and rewarding shoreline clean-up. In 1992, organizational guides, sample media releases, posters, garbage bags, data collection cards, pencils and rubber gloves were provided to participants at 214 clean-up locations. Over the years, the Foundation has modified and enhanced materials to reflect our Nova Scotian coastal environment and address specific environment concerns. For instance, the Beach Sweep organizational guide now lists all beach areas which are home to the Piping Plover, an endangered bird species which nests each spring on Nova Scotia's shoreline.

Beach Sweep volunteers not only collect garbage but record their findings as well. Specially designed data collection cards enable participants to efficiently document the debris they are collecting. The data cards are available in either French or English. These data collection cards are modelled on cards created by the Center for Marine Conservation in Washington, D.C. for their Coastal Clean-up Project. The debris survey results from the Fall Beach Sweep are forwarded to Washington to be included in the International Clean-up Project numbers each year. The International Project now compiles statistics from 26 countries around the world. The results from the data cards provide researchers with pertinent information about the numbers and sources of marine debris. Common sources include commercial and recreational fishing activity, galley wastes and beach-goer garbage, illegal shoreline dumping and antiquated sewage systems.

SEAFOOD PRODUCERS COOPERATIVE

PRODUCERS, PROCESSORS & MARKETERS OF PREMIUM QUALITY SEAFOODS

March 14, 1995

Representative Ben Grussendorf
House of Representatives
Room 415
State Capitol
Juneau, AK 99801-1182

Dear Representative Grussendorf:

The 350 member fishermen of Seafood Producers Cooperative enthusiastically support HJR 25, which would ban trawling in the waters east of 140 degrees west longitude.

The oceanography, ecology, and socioeconomic structure of Southeast Alaska make the area unique, and uniquely vulnerable to the impact of trawl fishing. Factory trawlers in Southeast Alaska will displace the local small boat fleet with a handful of large vessels who buy supplies, hire crews, process, and deliver product outside Alaska. Factory trawlers contribute nothing to the economy of Southeast, yet could damage sensitive habitat, deplete locally important fish stocks, and cause extreme economic harm to local Southeast residents and communities.

Economic changes in Southeast Alaska during the past few years have served to heighten the regional dependence on local commercial fisheries. Southeast residents hold over 4300 commercial fishing licenses, with over 6000 people employed as crew members. Another 1400 people work in the shore based processing sector, which has a total annual impact on the Southeast economy of $547 million. The Southeast commercial fisheries pay over $5.3 million in raw fish taxes each year, and support a host of service industries in the region.

We feel the future of Southeast will be determined by the future of the local fisheries. Our concern for the long term ecological and socioeconomic stability in Southeast Alaska mandates that factory trawling be eliminated east of 140 degrees west longitude.

Thank you for your consideration.

SEAFOOD PRODUCERS COOPERATIVE

Barry S. Lester
General Manager/C.E.O.

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March 28, 1991

Anchorage Daily News
Box 149001
Anchorage, AK 99514-9001

Dear Editor:

I noted with great interest the lead article in your March 27 issue on the plight of the threatened sea lion. It was certainly adequate insofar as it went. One thing puzzles me. Would you please explain how you could presume to address this issue and yet be totally silent on what many knowledgeable persons believe to be the most likely cause of the beast's decline? I'm referring to mortality caused by their being caught in the nets of the drag fleet -- especially the huge trawls of the offshore factory processors which in recent years have been scooping up virtually everything in their paths.

Your article pointed out the decline in numbers of sea lions westward from mid-Gulf well out to the end of the Aleutian chain. What most of your readers do not know is that this corresponds closely with the area of operations of this trawl fleet. And that sea lion populations in Southeast Alaska, which has yet to be hit heavily by the drag fleet, remain numerically healthy. And that massive catches of sea lions in these trawls have been officially documented!

Let me refer you to the publication Marine Mammal Science for January, 1986. In the article Incidental Mortality of Northern Sea Lions in Shelikof Straits, Alaska, the authors, Thomas R. Loughlin and Russell Nelson, Jr. state that U. S. observers in the joint-venture fishery for pollock during February, March and April, 1982 actually observed a catch of 528 sea lions. The total estimated catch for this period was extrapolated at 958. A footnote states, in part, that "....trawls with as many as one hundred dead sea lions caught in the nets were reported by U. S. fishery observers..." The authors, incidentally, were at the time and still are employees of the National Marine Fisheries Service.

I'm enclosing a photo which may be of interest to you and your readers. It shows five crewmen sitting on the carcass of a bull walrus on the deck of a dragger in the Bering Sea.The faces of the crew have been blocked out by me to protect them from reprisals. The photo was given to me by one of the men in the picture. He stated that he didn't have any sea lion photos because their occurrence in the catch was common. The walrus, however, was unusual so they took a picture of it.

You are to be complemented for focusing on this problem. May I be excused for suggesting that perhaps the subject deserves your further attention?

Dean Paddock

BRISTOL BAY DRIFTNETTER'S ASSN.

Dean Paddock, Executive Director

Alaska State Legislature

Please enter into the record my testimony to the House Special Common Fisheries Econ
committee name

committee on HJR 25, dated 3/15/95.
bill/subject

I am in favor of HJR 25 for all the obvious reasons as stated in the whereas's

all we have to do is look east to the Atlantic and the present condition of their fishery. Their problems were brought on by Trawling.

When do we learn?

Signed: Royce F. Ranney
Testifier

Ktn Gillnetter Ass chapter of USAG
Representing (Optional)

P.O. Box 702 Ward Cove 99928
Address

225-5700 W 247-2606 H
Phone No.

9/88 Legislative Information Office

Alaska State Legislature

Please enter into the record my testimony to the Fisheries
committee name

committee on #HB 25, dated 15 March 95.
bill/subject

I am in favor of this Bill because of The Damage that is caused by the Trawl fisheries. Any fish caught in a Trawl is gone while Hook & Line can release unwanted caught. I am against the Trawl fisheries because of Damage I have seen done in other areas of the U.S. (East coast & Gulf) until the Trawl fleet can make their equipment so they can separate the fish by species. At present Trawl fisheries is killing our fisheries in the Bering Sea we have to protect something.

Signed: STEPHEN T ALDRICH SR
Testifier

Self / Sport Fishing.
Representing (Optional)

P.O. Box 3275 Ketchikan AK 99901
Address

907-225-3280 907-225-9800
Phone No.