Analysis of Coral Bycatch by SIODFA Vessels Operating in the Southern Indian Ocean, 2006- 2007[1]

Summary

An analysis of coral bycatch by four deepwater trawlers operated by members of the Southern Indian Ocean Deepwater Fishers' Association showed that average coral bycatch was 111.1 grams for each bottom tow and 28.2 grams a tow when averaged over all tows, both bottom and mid-water, for vessels fishing in the study area for the data set that was examined. These results were based on the bycatch records of 678 bottom tows and 2002 mid-water trawls. No distinction is made in the analysis between coral rubble and living coral in the trawl bycatch. Coral bycatch was recorded from up to 10.7% of the estimated number of sea floor features that were fished. Depending on the vessel, period of the data record, and the seafloor feature, the percentage of tows with coral bycatch ranged from <0.01% to 2.27%.

Based on the fishing period for which coral bycatch data were available (a total of 706 days), the estimated annual bycatch of cold-water corals per vessel is 39.0 kg/vessel. With the current maximum fleet size of four SIODFA vessels, this implies a current total removal by this fishery of 156 kg of combined coral and coral rubble a year though only three vessels are fishing at present. Based on estimates derived from projections in UNEP documentation of the areas where vulnerable benthos occurs and where the bottom environment may be exposed to deepwater fishing activity in the area covered by the Southern Indian Ocean Fisheries Agreement, removal of cold-water coral per square kilometer of vulnerable habitat is estimated to be between 1.42 and 90.8 gm/km^2 depending on the assumptions as to the average area of a seamount in the SIOFA area and the vulnerability weighting (see Clark *et al.* 2006). This estimate is based on an assumption of 283 seamounts in the SIOFA area and the vulnerability of these areas. The actual rate of areal live cold-water coral removal by the current SIODFA fleet may be much lower than this.

It is conjectured that this negligible rate of coral bycatch may be the result of (a) improved instrumentation of bottom trawls that reduces the incidence of trawl contact with the sea floor, (b) departure from the fishery of inexperienced skippers who would be more likely to make contact with the seafloor with the trawl, (c) increased avoidance of cold-water coral habitats through greater awareness of areas of cold-water corals, (d) the creation of benthic protected areas where corals are known to occur and where no trawling is now undertaken and (e), clearing of benthos by repetitive towing on restricted tow lanes on seafloor features.

The SIODFA believes that this analysis shows that bycatch of cold-water corals is not a major issue of conservation or protection of biodiversity in the Southern Indian Ocean Fisheries Agreement area at current levels of fishing effort. However, the SIODFA are aware that catches of unacceptably large amounts of coral by deepwater trawlers fishing in the area have occurred prior to the start of the bycatch monitoring programme reported here and the introduction of the benthic protected areas that have been implemented in various areas. For this reason, SIODFA vessels will continue to monitor the bycatch of coldwater corals and other benthos to identify areas of vulnerable benthos.

[1] Recommended citation for this report: SIODFA 2007. Analysis of Coral Bycatch by SIODFA Vessels in the Southern Indian Ocean, 2006- 2007. Southern Indian Ocean Deepsea Fishers' Association Tech. Rep. 07/01. 14 pp.

1. INTRODUCTION

Considerable concern has been expressed about the catch of cold-water corals by bottom trawling (Koslow, Gowlett-Holmes, Lowry, O'Hara, Poore & Williams 2001, Anderson & Clark 2003, Clark & O'Driscoll 2003), and the environmental effects of bottom trawling in general. However, the number of studies to directly determine the effects of deepwater bottom trawling have been few and the most detailed have been restricted to the areas around New Zealand, the southwest of Tasmania and in the Northeastern Atlantic. Observation of deepwater trawling operations have, in some instances, shown that large quantities of cold-water coral bycatch can occur, and no doubt these examples of destructive fishing have been a, perhaps major, reason for calls for a moratorium on deepwater fishing on the high seas. However, the area that contains large areas that may provide suitable habitat for cold-water corals is enormous (Clark, Tittensor, Rogers, Brewin, Schlacher, Rowden, Stocks & Consalvey 2006) and the nature of the seafloor, not least bottom features that attract fishing effort, will variably considerably in their physical and biological characteristics and the vulnerability of their benthos to deepwater trawling.

Members of SIODFA have reported that in the early years of the deepwater fishery in the Southern Indian Ocean, tows in deepwaters have, at times, resulted in large catches of cold-water corals. Then, as now, the great majority of hauls took no catch of coral at all. More importantly, no systematic record of coral bycatch was taken across the fleet to provide data that could authoritatively inform the discourse on the effects of deepwater trawling in the Southern Indian Ocean on this particular component of the benthos.

SIODFA members know of the existence of many areas of cold-water corals in the Southern Indian Ocean as they are detectable using the acoustic systems used to fish the deep waters of these areas. This knowledge has prompted the creation of a number benthic protected areas (SIODFA & IUCN 2006, Shotton 2006) – see Figure 1 - in which SIODFA members agreed not fish to ensure the conservation of this component of deepwater biodiversity (An example of one of these benthic protected areas is shown in Fig. 4). To provide a factual basis for discussions regarding the current impact of deepwater trawls in the benthic ecosystems, and cold-water corals in particular, SIODFA members decided to record the amounts of cold-water corals taken as trawl bycatch and, to the extent possible, record the type of coral bycatch. This report presents the results of this programme to date.

2. METHODS

2.1 Estimation of Coral Bycatch Removal by the SIODFA Operators

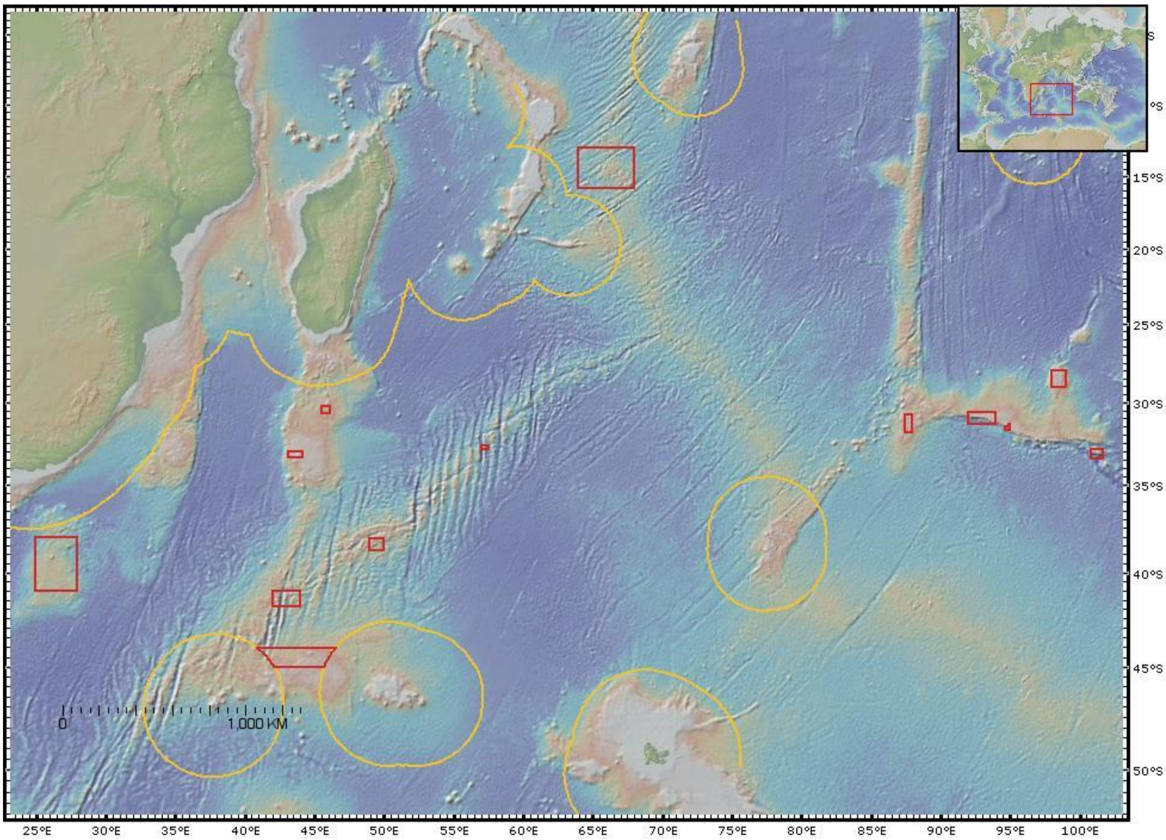
Vessels skippers were instructed by the operators to record the total quantities of coral bycatch that were caught by their vessels and the type of corals in the coral bycatch using the form shown in Appendix I. The possible types of coral that might be encountered were expected to include:

- brain corals (*Lobophyllia* spp.)
- black corals (Antipatharia)
- white corals (Scleractinia)
- stony and Cup corals (Caryophyllidae)
- bubblegum corals (Paragorgiidae)
- bamboo corals (Isididae)
- sea Fans (Gorgonidae)
- sea pens (Pennatulacea) and
- other invertebrates.

Vessel skippers reported that invariably the coral bycatch is generally white, broken up and often of a dead, loose-type branched 'brain coral', i.e. coral rubble. Occasionally, black coral may be retrieved when fishing new grounds. Examples of benthic bycatch are shown in Figures 2 and 3.

Recording of coral bycatch is usually done by the factory manager, or under his supervision, as he is present when the net is emptied. Many of these personnel are experienced in recording bycatch data and know the species involved from previously working on vessels in Australian and New Zealand deepwater fisheries where such information is commonly collected. Skippers were provided with sections of the document "A guide to common deep-sea invertebrates in New Zealand

Figure 1
Southwestern Indian Ocean showing bottom features and locations of SIODFA high-seas benthic protected areas (SIODFA & IUCN 2006)



waters ((Tracey, Anderson, Clark & Oliver 2005) with the objective of improving identification of the types of invertebrates taken as bycatch, though it is clear that further work is required to improve the ability to provide accurate taxonomic identifications.

Skippers were instructed to record the following information together with coral bycatch data:

i. date
ii. tow number
iii. a feature code (bottom-directed fishing is inevitably associated with particular sea floor features)
iv. time of day and length of time of the tow
v. depth range of the tow (start and end depths when the net is on the feature or fish aggregation)
vi. coral bycatch in kilograms identified to coral type as far as is possible and
vii. appropriate comments if any, e.g. if the net became fast during the fishing operation.

Initially four vessels were involved in this data collection programme. This was subsequently reduced to three when one of the vessels transferred its operations from the South Indian Ocean region (a further vessel has had little activity in the area during the last year). An example of the catch record form is given in Appendix I: an illustrated spread sheet now exists that can be used for direct data entry. In recording the coral bycatch no distinction was made between living coral and coral rubble. This has avoided any contention in distinguishing living from dead material in the data record.

Figure 2

Figure 3

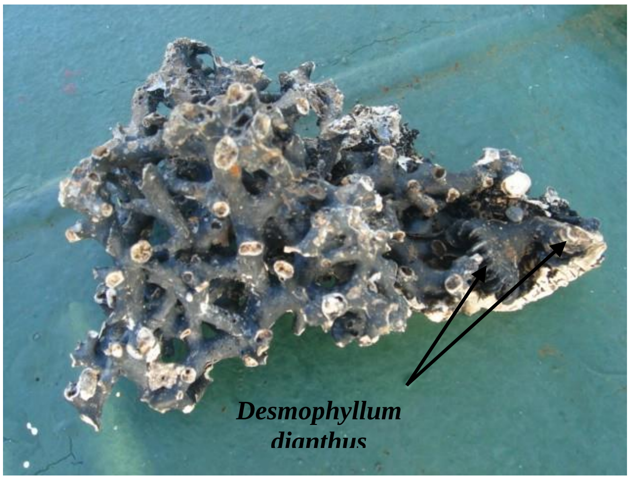


Photo credits: Paul Smith, Skipper, *F.V. Will Watch*.

Figure 2: The material on the left of this figure appears to be a piece of haxactinellid glass sponge. The centre piece appears to be a mixture of dead and alive octocoral material with some live calyces, (cups, polyps) present and dead remains. The dark colour could be caused by a manganese deposition, thus this piece may have been dead for a long time. The white elongated material on the right remains unidentified.
Figure 3: A large piece of– probably - *Solenosmilia variabilis*, a Scleractinian not unlike *Goniocorella spp*. found in New Zealand waters. This piece may have been dead for a long time (>1000 years) and has become covered with a manganese deposit. Growing on the piece of Solenosmilia are some *Desmophyllum dianthus*, an octocoral.

We thank A. Rogers, Zoological Society of London and Ms Di Tracey, NIWA, Wellington for their tentative ‘photo-only’ identifications.

Figure 4
Rusky Knoll

Tows on this feature must ‘fly’ over the top and ‘land’ below the ledge at 690 m that surrounds the knoll. The top of the feature is too steep for fishing: red lines show past tow positions. This is now a SIODFA high-seas benthic protected area.

The knoll is 1.54 miles across the base (indicated by the light blue edge). If no tows covered the same area, which is unlikely, then with an approximately 50 m wide footrope bottom contact, an estimated area of 0.78 km^2 would have been covered of the knoll’s area of 15.5 km^2 or 5.0% of the knoll area. Note that the gear must clear a ledge without touching the bottom to avoid gear damage or loss.

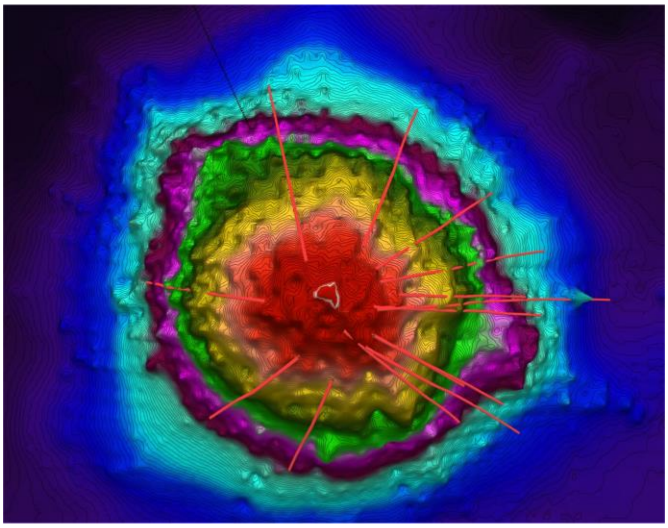


Image credit: G. Patchell, Sealord Group, Nelson; and Piscatus™ (bottom-imaging software).

2.2 Estimation of Annual Areal Coral Bycatch Removal

The data that may permit estimation of the areal impact of the current deepwater fishing activity on cold-water corals are few, but as they represent what are the ‘best available scientific information’ they have been used here to provide an indication of the possible impact of SIODFA vessels on coral production in the southern Indian Ocean. Clark *et al.* (2006) have examined the issue of coral habitat suitability and in their Figure 5.3 illustrate the predicted habitat suitability for seamount stony corals from 750 – 1250 m in the Southern Indian Ocean. These authors have classified these habitats by their ‘suitability, ranging from 0 – 10%, in 10% increments, to 90 – 100%. The criteria used in making these classifications were:

[species] marginality
alkalinity
aragonite saturation
surface chlorophyll
depth
dissolved O_2
primary productivity
export productivity
salinity
total CO_2/DIC
temperature and
regional current and
velocity.

3. RESULTS

3.1 Coral Removal by the SIODFA Operators

Table 1 indicates the period of data collection and the number of tows that were involved in this data analysis. Table 2 lists the number of seafloor features that were fished. Table 3 provides the data on tows recording coral bycatch. These data are summarized in Table 4. The data presented in these tables can be used to estimate the annualized removal of coral by these vessels assuming that there is no significant change in fishing tactics or the areas of fishing. The date to which these data apply are summarized in Table 5.

The number of days listed in Table 1 will underestimate the number of days related to fishing activity because the number is calculated from the date of vessel departure for the period of concern until the date of vessel return. Depending on the vessel and period in its operating schedule, an additional 10 – 20 days could be added to the number of days of the data record shown in Table 1 to cover the additional time the vessel will spend in port e.g., for vessel turnaround activities, refitting, etc. as the data records do not yet cover an exact annual cycle.

For a total vessel activity of 706 days, 75.35 kg of coral was recorded as bycatch. This implies a total of 39.0 kg/vessel/yr. With a current SIODFA fleet size of four vessels; this implies an estimated removal of 156 kg of coral a year at this time.

Table 1

Data Collection Period, Number of Days and Tows in Data Record

Vessel	Date			No. of tows		
	Begin	End	No. of days	Bottom	Mid-water	Total
1	1/08/2006	12/4/2007	255	352	519	871
2	7/10/2006	20/11/207	45	103	72	175
3	11/7/2006	1/9/2006	52	186	34	220
4	21/1/2006	9/1/2007	354	37	1377	1414
Totals			706	678	2002	2680

Table 2
Number of tows on features with coral bycatch

Vessel	No. of separate seafloor features fished	No. of seafloor features where coral bycatch was recorded	No. of tows with coral bycatch
1	56	6 (10.7%)	9 (1.03 %)
2	35	1 (2.9%)	2 (1.14 %)
3	18	1 (5.6%)	6 (2.27 %)
4	19	1 (5.3%)	1 (<0.01 %)

The actual number of seafloor features that are fished is significantly less that the total of the second column in Table 2 as the SIODFA vessels often target the same seafloor features.

Table 3
Data on Tows Recording Coral Bycatch

Feature	No. of tows		Bycatch (kg)				
	On feature	With coral bycatch	Brain	White	Orange Fan	Other	Total
1A	132	3 (2.3%)	22	2			24
1B	11	2 (18.2%)	9	4			13
1C	48	1 (2.1%)	5	1			6
1D	24	1 (4.2%)	1	6	0.5		7.5
1E	40	1 (2.5%)				0.5	0.5
1F	4	1 (25%)				1.1	1.1
2E	-	2	5				5
3F	-	6	12			3	15
4G	161	1 (0.6%)	3.25				3.25
Totals		16	57.25	13	0.5	4.6	
Total coral bycatch							75.35 kg
Average coral bycatch *all tows* (grams) – *all tows*							28.1 gm
Average coral bycatch per *bottom tow* (grams)							111.1 gm

3.2 Annual Areal Coral Bycatch Removal

The number of seamounts in the area covered by the Southern Indian Ocean Fisheries Agreement was taken from the *Sea Around Us Database* and together with qualitative information in Figure 5.7 of Clark *et al.* (2006) (partially shown in Figure 5 here), was used to determine the area of potential coral habitat. Because of the difficulty and low accuracy possible from visual extrapolation from Figure 5.7 of Clark *et al* (2006), the category types are aggregated as in Table 5. It has been stressed (Pers. comm., D. Tittensor, Dalhousie University) that these values are for seamount summits, and the habitat suitability on seamount flanks may be different.

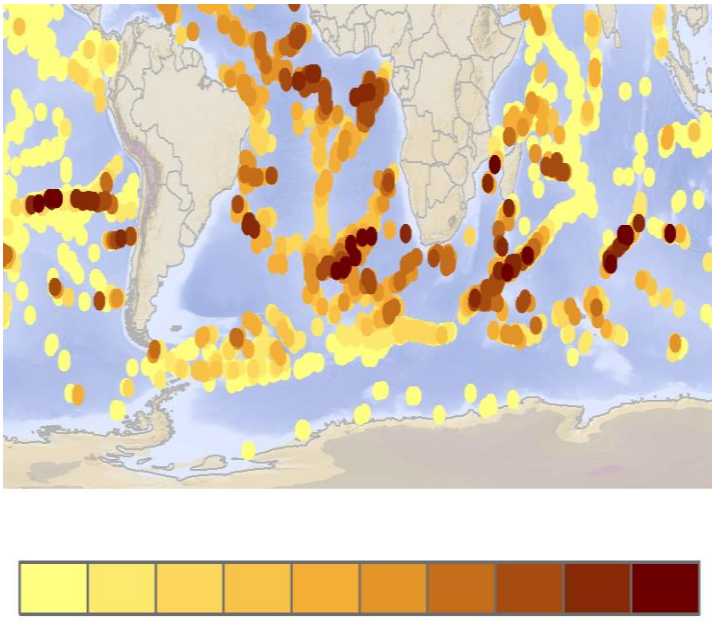
Table 4
Summary Data on Coral Bycatch for SIODFA Vessels

Type of Coral	Average catch of coral /tow (grams)	
	Bottom tows	All tows
Brain coral	84.4	21.4
White coral	19.2	4.9
Orange fan coral	0.7	0.2
Unidentified	6.8	1.7
Total	111.1	28.2

Table 5
Habitat Vulnerability Aggregation Assumptions

Suitability Clark *et al*. (2006) (%)	Aggregated Category - this text -
0 – 10	Low - 0.15 of area
10 – 20	
20 – 30	
30 – 40	Medium - 0.45 of area
40 – 50	
50 – 60	
60 – 70	High - 0.8 of area
70 – 80	
80 – 90	
90 – 100	

Figure 5



Results of combining predicted habitat suitability with summit depth and location of large seamounts (Clark *et al*. 2006.). Colour intensity of indicates increasing habitat suitability

Clark *et al* (2006) provide no quantitative estimates of the areas indicated in their Figure 5.7 so two assumptions have been used here: first that the perimeter of a seamount is 4 km on the square, i.e. a projected area of 16 km^2. If the seamount area was assumed to be circular, this would imply a diameter of the feature of 4.5 km. The second assumption used here is that a feature has an area of 20 km on the square, i.e. an area of 400 km^2. In this case, the implied diameter would be 22.6 km. Based on these assumptions, estimated base areas are given in Table 6. Note here, that few of the features that are fished are circular and in many cases the areas consist of elongated ridge areas or areas that are irregular and exist in a wide variety of plane (two dimensional) forms. These areas will be underestimated in size here as they have three-dimensional forms and thus greater areas than is assumed here.

Areal coral removals could be estimated using the areas listed in Table 7 but a more conservative and realistic estimate would be given by weighting the areas in terms of their vulnerability. This has been done using the mid-points for the low, medium and high categories, i.e., 0.15, 0.45 and 0.8 as multipliers of the estimated vulnerable areas (see Table 5). This would result in estimated areas as given in Table 6. An estimate of the annual removal of cold-water corals by SIODFA operators is given in Section 2 as 117 kg/yr. Based on these values, and the above assumptions, estimates of the annual areal removal of cold water coral from the SIOFA area are given in Table 8.

Table 6
Estimated Areas of Habitat Vulnerability
SIOFA area outside of EEZs provisionally estimated at 15 400 000 km^2

Category from Table 6	No. of Sea-mounts	Areas based on assumption of 16 km^2	% of SIOFA area	Areas based on assumption of 400 km^2	% of SIOFA area
Low	135	2160	0.014	54 000	0.35
Medium	69	1104	0.007	27 600	0.18
High	70	1120	0.007	28 000	0.18
Total	274	4384	0.028	109 600	0.71

Table 7
Weighted Estimated Areas of Habitat Vulnerability
I.e. areas of column three in Table 6 weighted by the habitat vulnerability

Category from Table 6	Areas based on assumption of 16 km^2	Areas based on assump-tion of 400 km^2
Low	324	8 100
Medium	497	12 420
High	896	22 400
Total	1717	42 920

Table 8
Estimated Areal Removal of Cold-water Coral from Vulnerable Habitat in the SIOFA Area

Category from Table 6	Area based on assumption of feature area of 16 km^2		Area based on assumption of feature area of 400 km^2	
Weighted area (km^2)	1717		42 920	
Coral removal (kg)	156		156	
Areal coral removal gm/km^2	Unadjusted	Weighted	Unadjusted	Weighted
	35.5	90.8	1.42	3.60

4. DISCUSSION

To the extent that the amount of coral bycatch is an accurate indication of the affect of deepwater trawling on the coralline benthos of the area, then it is difficult to conceive that the estimated removal of 156 kg of coral a year by the SIODFA fleet constitutes a threat to this faunal group in this area. A better evaluation of the possible impact may be possible by considering the size of the area considered to be vulnerable to trawl damage. Clark *et al.* (2006) provide illustrations that show areas that these authors predict as habitat suitable for stony corals in the depth range of 250 – 750 and 750 - 1250 m. Clark *et al*. also illustrate areas they predict as having habitats suitable for stony corals on seamounts. No quantitative data are provided as to the size of these vulnerable areas.

It is known that at least one vessel (not included in this analysis) had two hauls with a large amount of coral bycatch (1000 and 700 kg respectively) in the earlier stages of the fishery (2003?), though the great majority of this vessel's catches had no coral bycatch.

Two authors of Koslow *et al.* (2001) report that they "have observed tonnes of coralline material brought to the surface in a single trawl haul when a new area is fished." However, it is not always clear if researchers referring to coral bycatch are confounding live coral with coral detritus or rubble. In this 2001 paper the authors note that large amounts of coral rubble have been observed on, and at the base of seamounts and they note that such material may result from natural causes, i.e. causes other than trawl impacts. However, Koslow *et al*. do state that they believe from their comparative observations that trawling is responsible for stripping coral from the bottom. In this context it should be noted that orange roughy on the South Tasman Rise aggregate on mounds of coral rubble. In such cases where skippers did not have the experience to avoid the bottom with their nets, large amounts of coral rubble would be retained by the net.

Clark & O'Driscoll (2003) report that their camera sled scattered coral fragments widely when it collided with coral: they also note that extensive patches of broken and fragmented coral occurred on both the fished and unfished seamounts they examined and concluded that it is possible that damage to coral outcrops occurs naturally as well as from the affect of trawling.

There are a number of possible reasons as to why the SIODFA vessels catch so little cold-water coral given the well-described catches of cold-water corals by the deepwater fisheries in the southwest Pacific Ocean and southwestern Tasman Sea.

• *Clearing of towing lanes*

The minor amounts of coral at present being taken by SIODFA vessels may be the result of removal of previously existing coral from tow paths that are often imposed on the skippers by the rough bottom terrain that can restrict fishing to as little as five percent of the area of a bottom feature. Further, vessel skippers report that fewer than 5% of tows in a year are now made along tow paths that have not been previously fished.

If clearing of benthos from tow lanes were the case, it might reflect experience elsewhere. For example, Clark & O'Driscoll (2003), in their analysis of four seamounts of the east coast of New Zealand found evidence of a 'natural "trawl corridor"' though on other features, fishing appeared to be of a 'shot-gun coverage. On Richie Hill seamount, a feature they found to be moderately heavily affected (ranked 12th out of 23 features examined), they report that 'it appears about 50% has been impacted" though details of how this was determined are not given in their paper. On the Graveyard and Morgue seafloor features respectively, 71% and 83% of their benthic photos showed no signs of impact. Two lightly-fished features, examined for comparison (Diabolical and Gothic), showed 95% and 99% respectively of their photos with no sign of trawl impact. Past fish catches on the Graveyard and Morgan had been high and Clark & O'Driscoll report that subsequent catches of invertebrates from these features have been small.

Anderson & Clark (2003) also provide an account of the change in coral bycatch in a deepwater trawl fishery, in this case for the South Tasman Rise area, which experienced an intense, if short lived, fishery primarily for orange roughy over the period 1997 – 2001. Their account notes that 'many' trawls had large bycatches of corals ranging from one to 15 tonnes and the data they provide appears[2] to indicate that bycatch per tow was 10.6 t in the 1997/98 fishing year, 3.78 t/tow in the next and 0.754 t/tow by the 1999/2000, clearly an unacceptable average level, even at the end of this period. They note that a large amount of corals were taken in the early stages of the fishery, i.e. 1762 t from 165 tows during the 1997/98 fishery; 529 t from 140 tows during the 1998/99 fishery and 181 t of coral from 240 tows for the 1999/2000 fishery. Thus, by the third year of the fishery, coral bycatch per tow was 7.1% that at the beginning of the fishery. Again, it is not clear what fraction of coral was taken as 'rubble' and what part was alive. In any event, it seems clear that this deepwater fishery was particularly destructive to cold-water corals on these features. And, again, there may be several reasons for the decline in the rate of cold-water coral removals.

• *Improved instrumentation of bottom trawls and skippers' skills*

The aimed trawling techniques used by deepwater fishing operators in the Southern Indian Ocean depend on accurate positioning of the net in relation to the fish aggregations and the seafloor. A skipper unable to accurately position a net, which will be as much as 2 km behind his vessel and up to 1200 m in depth, will catch few fish and rapidly be out of the fishery. Likewise, a skipper unable to consistently keep his net from coming fast on the bottom will, sooner rather than later, loose his trawl: with a replacement value in excess of $100 000 together with the lost fishing time such skippers and their vessels are similarly soon out of the fishery.

Trawlers in the deepwater SIO fishery use a variety of methods of net mensuration. These include the *Furuno CN24 net monitor*, a model introduced in 1996 that transmits at a rate of 165 min^{-1} from the net to the vessel. This system uses a pressure sensor to determine water depth. It is fastened to the headline and sends information on echoes received from the ground-rope and sea bed to the ship. Echo information is displayed using relative motion, i.e. constant headline position (Figure 6), and true motion, i.e. the net moves up and down on the display screen (Figure 7). Echoes between the

[2] It is not entirely clear from their paper if the number of tows refers to their sample size or the number of tows in the fishery during the season when the coral bycatch was estimated.

headline and ground-rope usually indicate fish passing under the monitor and into the net. This provides a real-time two-dimensional image of what is happening to the trawl. More specialized equipment may be installed, e.g. one vessel has used the *Netview NV24 3D*, which has two receiving transducers in the ship's hull, each a known distance from the centerline of the keel. By timing the arrival of the echo at each transducer, the position of the net is determined by triangulation and the information displayed on a *Seaplot* navigational plotter. Simrad produce a similar system - the *ITI Trawleye* - but its trans-mission frequency is much less that the system that has been used and so has lower positional accuracy. Another option is the *Furuno TS 834*, which also sonifies a vertical scanned volume.

SIODFA vessels all use the acoustic-link style of net monitor and the Furuno CN 24, which is the industry standard. While a cable link monitor produces much higher definition information and the net sonars are now multidirectional, they cannot be used in this type of fishery for when there is cable damage and loss, the vessel is left with no control over its net, in addition to making them prohibitively expensive when lost. The acoustic monitors provide adequate information to enable accurate target fishing and this enables the time the net is on the bottom to be minimised.

- *Skipper skills and experience*

Deepwater bottom trawling is a highly skilled type of demersal fishing – as many entrants found to their cost when they joined the 'orange roughy bonanza' in 1999/2000 (Anon 2000, 2001) and obtained little, if any, catch (fishing in the region by SIODFA vessels began in 1997). It is, perhaps, no coincidence that most of the skippers involved in this fishery, almost on a global basis, come from a single port in New Zealand (Nelson) or live there, given the clustering of 'excellence' that has developed. With 'gearing up costs' in the order of half a million dollars to simply put a vessel into the fishery, there are intense selection pressures on skippers –those lacking the necessary skills are rapidly out of the fishery. Indeed, it is the view of SIODFA members that this is the reason the number of vessels in the fishery has declined from 42 in 2000 and 43 in 2001 to four in 2007. Of relevance is that of the four remaining (SIODFA) operators in fishery, two were the first into the fishery in 1999 while the other two companies started fishing in the area in 2000.

Figure 6
Sonar image with relative headline and fish aggregation position

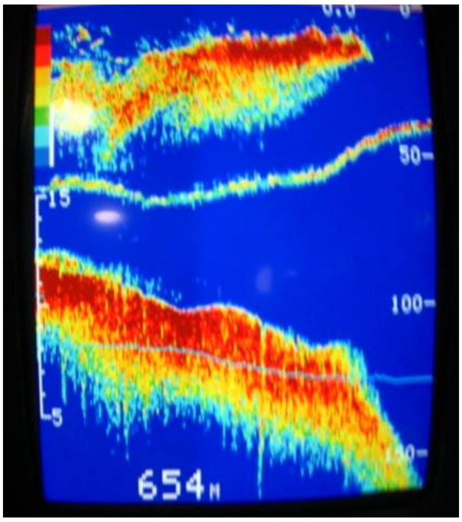


Figure 7
Sonar image showing actual headline, footrope and relative fish aggregation position

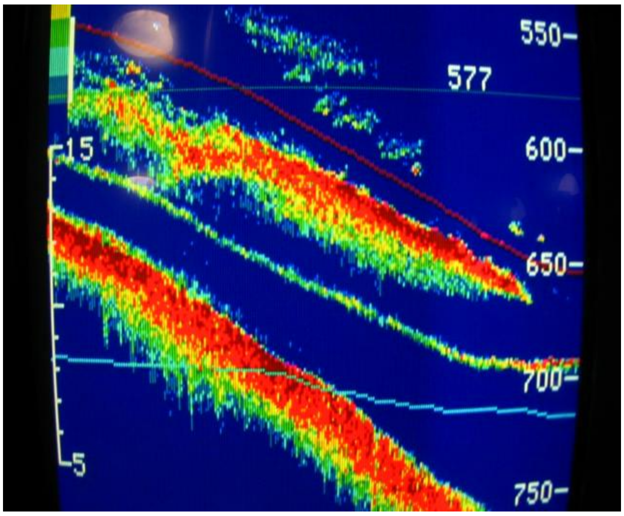


Image credits: Halli Stefansson, Skipper, *F.V. Nikko Maru1*

• *Closure of Known Areas of Coral Occurrence*

Since the early days of the fishery, SIODFA has voluntarily undertaken to observe eleven high-seas marine protected areas where their vessels are committed to refrain from trawling. Stands of tall coral have been detected in several of these benthic protected areas and cold-water corals would be expected to be present in every one of these zones. Cessation of trawling in these areas would contribute further to the decline in bycatch of benthos, including that of coldwater corals.

• *Total Removals of Coral by the SIODFA Fleet*

There is good reason to believe that the quantities of areal coral removals given in Table 9 are overestimates. The statistics provided in Table 9 are based on the known list of 283 'seamounts' in the SIOFA area as indicated by the *The Sea Around Us Programme* data base; SIODFA operators themselves report catches from no less than 56 seabed features.[3] Clark *et al*. (2006) predict that 1658 seamounts occur in the Indian Ocean, though the SIOFA area of 15 400 000 km^2 is probably only slightly more that half the size of the Indian Ocean. And, Romanov (2003) alone, in reviewing Soviet work in the southern Indian Ocean, shows seamounts on the Mid-Indian Ridge numbered up to 990, though this number may include sea-floor features in the area of competence of the Commission for Conservation of Antarctic Living Marine Resources and the extended economic zones of the Kerguelen and Crozet Islands. Thus, it may be reasonable to expect that the estimates of coral habitat areas in Tables 6 - 8 are at least three fold higher that the actual values. If the weighting based on Clark *et al*.'s (2006) estimates is ignored, then these areal estimates would be reduced by a further factor of 2.5.

• *Relative Area Affected*

As yet, no estimate has been made of the area that has been fished though this should be possible as SIODFA operators' vessel keep detailed positional information of their tows. However, using such data will produced a biased estimate of potentially affected area as when a trawl is on the 'bottom' it is not necessarily physically dragging down feature slopes. For mid-water trawls in contrast, although they are fished in the 'mid-water', there is no physical reason why they cannot collide with the bottom – though skippers have every incentive to avoid doing so.

Koslow *et al.* (2006) have attempted some quantitative estimates of the area of a seamount. They note that trawls on the seamounts are typically on the bottom for 1 to 10 min. Based on a mean speed of 6 ms^{-1} and a wing spread of 20 m, they estimate that a tow 'impacts' an area of 7200 to 72 000 m^2 and that a trawl tow would impact between 0.1 and 2% of the area of a seamount. However, these authors appear to have confused the steaming speed of a trawler, characteristically ≈ 12 knots (i.e. 6.2 ms^{-1}) with its towing speed, characteristically around 3 knots (i.e. 1.5 ms^{-1}). On this basis the estimates of Koslow *et al.* should be reduced by a factor of four.

SIODFA data (Shotton 2006) indicate that fishing has occurred on over 80 knolls, with base diameters at least 1.8 km and over 70 seamounts whose areas range in size from 100 km^2 to 500 km^2. In addition, enormous areas of elevated ridges occur that provide fish habitat but are not amenable to classification as seamounts, knolls or hills.

• *Live Coral or Coral Rubble?*

In measuring coral bycatch, SIODFA data recorders have made no distinction between living coral and dead coral or coral rubble. This practice removes all potential uncertainty in the estimates as to whether the distinction between dead and live was done accurately. However, as reports of the coral observations show, much of the coral that is brought to the surface in trawls is dead and its retrieval as bycatch would be expected to have little, if any, impact on the biodiversity in the area of fishing operations.

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[3] Operators fish many of the same features but refer to them with different names: the inter-company comparison of which targeted features are fished remains to be done.

• *Damaged but Unretrieved Corals*

Not all corals, or all of each coral, in the path of a trawl would be retained in the cod end – a large fraction of corals in the path of the trawl would be expected to pass under the footrope. Indeed, depending in the vertical profile of the particular coral, few may be retained in the net. This phenomenon would be greatest for corals with a height that was less than the height of the ground rope of the trawl or the diameter of ground-rope bobbins. Clearly, such corals may exist in areas fished by the trawlers in the deep waters of the Indian Ocean, but it is impossible at present to quantify the extent of such benthos. What is known from acoustic observations is that tall stands of cold-water corals do occur in areas that have been declared as benthic protected areas by SIODFA (SIODFA & IUCN 2006) and thus would be expected to be recovered from trawls if they were in the tow path. That this is not the case implies that there are few or no such stands of tall cold-water corals in the paths of trawl tows by SIODFA vessels.

- *Conclusions*

SIODFA members are aware that incidences of large coral catches have occurred in the past, e.g. one member has a record of a bycatch of 3.5 t from a single tow on Broken Ridge in 1997 and 1.5 t in 2006, again from a single tow. Other anecdotal accounts of significant cold-water coral bycatches exist, for example, one account describes a feature in the western part of the Southern Indian Ocean, which shoals to 740 m (known to skippers as “Suicide Drive”). This feature was heavily fished during the ‘false Klondike’ years of 2000/2001 by vessels and flag operators no longer in the fishery and resulted in high bycatches of coldwater corals. This area is no longer fished and remains the only area where many large catches of coldwater corals are believed to have been caught in the Southern Indian Ocean.

It is stressed that this analysis applies to the SIOFA area and current trawl fisheries only. To the extent that coral bycatch provides a useful indicator of the effects of bottom trawls on benthos in the Southern Indian Ocean, then it does imply that the issue of vulnerability of cold-water corals to fishing practices of SIODFA members is, not at present, a major concern, nor are the impacts of their fishing on the conservation of their biodiversity. However, SIODFA members recognize that, given the wide range of fisheries prosecuted in the Southern Indian Ocean, there are issues of faunal conservation and biodiversity to be addressed in the Southern Indian Ocean. But, not withstanding the area of 309 000 km^2 of benthic protected areas declared by SIODFA (SIODFA & IUCN 2006), cold-water corals do not appear to be an ongoing problem. Despite this, it is agreed that the affect of fishing on coldwater corals, especially in previously unfished areas, requires ongoing monitoring.

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B & S International Ltd, Cook Islands
Sealord Group, New Zealand and
TransNamibia Fishing Pty Ltd, Namibia.

Vessel: ________________________ *Captain's Signature* _______________ *Factory Manager or Observer's Signature* ____________________

Date	**Tow No.**	**Feature Code**	**Time net**		**Depth (m)**		**Coral Bycatch (kgs)**					**Comments on corals** Tree-like, branching, spiral, whip-like, cup-like. Indicate colour, especially for octocorals.
			On bottom	**Off bottom**	**Start**	**Finish**	**Black**	**Stony (branching & cup)**	**Sea Fan (Octocorals e.g.bubblegum, bamboo)**	**Soft / Sea Pen / anemones**	**Other invertebrates**[4]	

[4] Sponges, sea firs, crabs/lobsters, snails, clams, sea stars, sea urchins, sea cucumbers. Indicate if stony corals are branching reef-building corals or solitary cup corals; include sea pens with the soft corals.