Maximising yield and reducing discards in the South East Trawl Fishery

Workshop 30-31 July 1998

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FISHERIES RESEARCH & DEVELOPMENT CORPORATION

MARINE & FRESHWATER RESOURCES INSTITUTE

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The Commonwealth Policy on Fisheries Bycatch

Forward

Bycatch - the unwanted catch of fishing operations - is an issue of concern to a lot of people. Discarding unwanted catch is a wasteful practice and a threat to the marine environment.

There are a number of different avenues through which the management of bycatch can be pursued.

This policy paves the way for industry through the Australian Fisheries Management Authority (AFMA) to meet, and where appropriate, exceed the Government's international and national obligations for managing our oceans. The policy will complement existing initiatives and provide further protection for species such as albatross, dugongs and turtles.

A key feature of the policy is the partnership approach to developing practical solutions and management measures with industry and other stakeholders. This document sets out the Commonwealth's Policy on Bycatch and provides the framework for developing fishery bycatch action plans for each Commonwealth fishery. Whatever measures are adopted, all require close cooperation between stakeholders if they are to be effective.

The Commonwealth Bycatch Policy was drafted by a taskforce convened by AFMA and made up of representatives of the commercial fishing industry, the Department of Primary Industries and Energy, Environment Australia, the Bureau of Resource Sciences and CSIRO.

It is pleasing to note that this policy is only the first step in bycatch reduction as it will now become the basis for a national bycatch policy.

Warwick Parer
Minister for Resources and Energy

Robert Hill
Minister for the Environment

March 1998

The Commonwealth Policy on Fisheries Bycatch

The Commonwealth is committed to developing a strategic approach to addressing bycatch to ensure fisheries in Australian waters are ecologically sustainable. The Commonwealth, through AFMA and stakeholders will address bycatch by developing and implementing fishery specific bycatch action plans. Action Plans for major Commonwealth fisheries will be completed within twelve months of the launch of this policy. They will be integrated into fishery management regimes and reviewed regularly.

Introduction

Bycatch in fisheries (both commercial and recreational) has long been recognised as an issue requiring attention. Increasingly, international treaties and conventions are placing obligations on signatories to address bycatch. For example the United Nations Food and Agricultural Organisation has developed a "Code of Conduct for Responsible Fishing" which addresses the issue of bycatch and provides a useful blueprint for responsible fisheries management.

The United Nations Agreement for the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks contains a number of obligations regarding the conservation and management of these stocks. Among these obligations are provisions related to the impact of fishing on non-target species, and the application of the precautionary approach to the management of fisheries.

The entry into force of the United Nations Convention on the Law of the Sea, to which Australia is a party, means that this Government now has responsibility under international law for "dependent and associated species" within our exclusive economic zone.

The Commonwealth acknowledges that there is a need to develop a broad, more strategic approach in addressing the bycatch issue if fisheries in Australian waters are to be ecologically sustainable. However, it is also important to recognise that there will be some environmental cost in supplying the demand for seafood and that closing down or unnecessarily restricting Australian fisheries may not in itself lead to an overall reduction in bycatch. For example, if domestic fisheries are unnecessarily restricted, consumer demand may lead to the importation of seafood from poorly managed fisheries and an increase in the level of bycatch in those countries.

The Commonwealth also recognises that there are a number of different avenues through which the management of bycatch can be pursued to ensure ecologically sustainable fisheries. All require close cooperation between stakeholders if they are to be effective.

What does bycatch mean?

Although fishers use their skills and experience to take the highest value catch they can (target catch), in most forms of fishing some species which are not targeted will be caught. Some part of this unintended catch may be kept or sold by the fisher (by-product) and some may be returned to the sea (discards). Over time species may change from being discarded to being by-product or targeted, and vice versa, depending upon, among other things, consumer demand, markets and technology.

The definitions of fisheries bycatch, at its broadest, includes all material, living or non-living, which is caught while fishing, except for the target species. The objectives of the *Fisheries Management Act 1991* provide for the need to have regard to the impact of fishing activities on non-target species and the long term sustainability of the marine environment. A range of mechanisms exist to manage fisheries.

While the term bycatch may refer to all non-targeted catch including by-product, discards and other interactions with gear, this policy will deal specifically with those aspects of bycatch that are not currently subject to commercial management provisions, namely;

i) *that part of a fishers catch which is returned to the sea either because it has no commercial value or because regulations preclude it being retained, and*
ii) *that part of the "catch" that does not reach the deck of the fishing vessel but is killed as a result of interaction with the fishing gear.*

Target and by-product species are managed through formal arrangements such as fishery-specific Management Plans. By-product species in one fishery are commonly targeted in another fishery and as such may be managed under a fishery-specific Management Plan with complementary arrangements to limit their take in other fisheries. Such arrangements are generally based upon historical interactions between those fisheries. Offshore Constitutional Settlement Agreements between the Commonwealth and the States and Northern Territory facilitate these arrangements. Sustainability of target, by-product and increasingly bycatch species in Commonwealth fisheries are essentially dealt with through the Fishery Assessment Groups, established by AFMA for stock assessment purposes.

The combination of existing commercial management arrangements and this policy will ensure that resource users and other interested parties work towards the sustainability of all marine life that comes into contact with fishing, including species that interact with fishing gear but are not landed.

Why address bycatch? and why have a Commonwealth Bycatch Policy?

Discarding unwanted catch is a wasteful practice that may pose a threat to marine systems over time. Bycatch also poses a direct threat to the survival of some species or populations of marine animals such as turtles and dugong, seabirds and others that may be unable to sustain additional mortality from fishing.

The primary reason for a Commonwealth Bycatch Policy is to ensure that direct and indirect impacts on marine systems are taken into account and managed accordingly. There must be recognition given to the requirement under the Commonwealth *Fisheries Management Act 1991* to "ensure that the exploitation of fisheries resources and the carrying on of any related activities are conducted in a manner consistent with the principles of ecologically sustainable development and the exercise of the precautionary principle, in particular the need to have regard to the impact of fishing activities on non-target species and the long term sustainability of the marine environment". By reducing unused catch, particularly non-target catch and juveniles of commercially or recreationally valuable species, we can enhance the productivity of our fisheries and maintain the integrity of our marine ecosystems.

The Government's National Policy on Ecologically Sustainable Development and the National Strategy for the Conservation of Australia's Biological Diversity place an expectation on fisheries managers to address bycatch. Some species of marine animals (including some fish) are not managed under Commonwealth fisheries legislation, but under Commonwealth nature conservation legislation or by the States or Territories. As some of these species are taken as bycatch, a cooperative approach is needed to satisfy the requirements of both forms of legislation and to develop complementary management arrangements with the States and Territories.

By taking action to address bycatch, the fishing industry will benefit through maintaining marine ecosystems and ensuring sustainable catch levels, reduced damage to target catch, shorter sorting times, less gear damage and lower fuel consumption. These benefits will intrinsically flow to the whole community as well as fishers. A Commonwealth Bycatch Policy is needed because bycatch is a resource, environmental, educational, engineering and economic issue and needs to be addressed strategically and in a focused, coordinated manner.

It is also important that stakeholders have a common understanding and agreement on the need for the type of action that could work. By achieving a common understanding, support for addressing bycatch at the level of the individual fishery can follow. Stakeholders will have a role in ensuring that bycatch action plans will have meaningful and achievable objectives, and can be implemented in reasonable time frames.

The Policy recognises that there will be different ways of addressing the bycatch issue in different fisheries so fishery specific bycatch action plans will be needed. Action plans for Commonwealth fisheries will be prepared in consultation with stakeholders and the wider community, through the Fisheries Management Advisory and Consultative Committees (MACs and CCs, respectively). Action Plans for Commonwealth fisheries will be completed within the first twelve months of the launch of the Policy and integrated into fishery management regimes. The Policy provides a framework for the development of these fishery action plans.

Guiding principles of the policy

These guiding principles provide the philosophy which underpins the policy. They capture the spirit in which the policy will be developed and implemented.

Decisions and actions to address bycatch will:

- Foster stewardship of Australia's marine resources to maintain and improve the quality, diversity and availability of fisheries resources and the integrity of the marine ecosystem into the future.

- Promote cooperative and transparent approaches involving all stakeholders to ensure effective stewardship of our marine resources.

- Manage marine resources so that short-term considerations are consistent with long-term goals and apply the precautionary principle in the management of fisheries resources.

- Recognise the unique biological, ecological, economic and social nature of individual fisheries by developing fishery specific action plans to address bycatch issues.

- Encourage cooperation in the development of complementary arrangements between relevant authorities to ensure that, where stocks overlap or are split between jurisdictions or are migratory, effective management strategies are applied across jurisdictions. These include State and Territory agencies, other fisheries management agencies, and international bodies.

- Use robust and practical biological reference points relating to bycatch, where possible, to make decisions on bycatch management. Develop biological reference points in consultation with stakeholders, recognising that in many cases there are limitations to the costs of determining these reference points. Where the use of biological reference points is not feasible, the precautionary principle will be used as a basis for decision making.

Core objectives of the policy

An overarching objective of the policy is to ensure that bycatch species and populations are maintained. Within this are the following sub-objectives:

1. **To reduce bycatch. This could be by:**
   - developing, adopting, monitoring, reviewing and improving mitigation measures (eg Bycatch Reduction Devices (including Trawl Efficiency Devices), Bird Scaring Lines, appropriate area and seasonal closures, changing ways of fishing);
   - reviewing the management of fisheries so that management measures incorporate bycatch reduction strategies and do not encourage discarding;
   - increasing understanding of the reasons for bycatch in a particular fishery (eg monitoring changes in the level and composition of bycatch over time);
   - ensuring that as markets develop for by-product, those species are managed formally as commercial species;
   - incentive programs for fisheries;
   - applying target species management arrangements and other measures to bycatch species where deemed necessary.

2. **To improve protection for vulnerable species by:**
   - gathering data on the impact of fishing (and other sources of mortality or impact) on populations which may be vulnerable to fishing (or other) pressures;
   - developing, implementing, monitoring and improving appropriate mitigation measures;
   - education / awareness programs;
   - improved liaison, collaboration and development of cooperative arrangements with other agencies and stakeholders.

3. **To arrive at decisions on the acceptable extent of ecological impacts by:**
   - using the best available knowledge within the framework of a precautionary approach;
   - using appropriate biological reference areas (eg marine protected areas / multiple use zones);
   - using biological reference points or the precautionary principle for management of bycatch species;
   - identifying gaps in knowledge and, where feasible, collecting the appropriate data to reduce uncertainty in the management decision process;
   - monitoring the impacts of fishing pressure on bycatch species;
   - emphasising the need for appropriate solutions (eg educational, economic incentives and engineering solutions) to the bycatch issue.

Who are the stakeholders ?

All Australians, including future generations, are stakeholders. Specific interest groups include:

- Commercial fishing sector

- Recreational fishing sector
- Environment and conservation groups (non-government organisations)
- Indigenous people
- Consumers
- Tourism sector
- Seafood processors, marketers and retailers
- Research agencies
- Fishery management and conservation agencies

AFMA's approach

AFMA is responsible for the management of fisheries under Commonwealth jurisdiction. AFMA is the lead agency in addressing the bycatch issue for Commonwealth managed fisheries. AFMA will review the extent and nature of bycatch in all Commonwealth managed fisheries and identify priorities for action. In consultation with stakeholders, its MACs and CCs, AFMA will develop fishery specific action plans to address bycatch in those fisheries identified as a priority. The action plans will identify bycatch issues, data requirements, options and possible solutions.

Provisions identified in the action plans can be either incorporated in fishing permit conditions or, where they exist, become part of a statutory fishing right as defined under the *Fisheries Management Act 1991*. Provisions may also, where appropriate, be incorporated into fisheries directions, regulations or Management Plans. Refinement and review of the bycatch action plans will be ongoing and will be considered annually in conjunction with the Five Year Strategic Plan and Five Strategic Research Plan for each major fishery.

AFMA will use the Five Year Strategic and Research Plans created by MACs and CCs to identify knowledge gaps and facilitate the development of the bycatch action plans in the twelve month period from the launch of this Policy. AFMA recognises that there are technical experts in the field of bycatch reduction who would be able to add considerable expertise to the development of bycatch action plans, particularly through identifying relevant areas of research and possible management actions.

AFMA will work cooperatively with other relevant agencies to identify those fisheries requiring bycatch action plans and to ensure that the development and implementation of the action plans are in harmony with related legislation, international obligations and national policy directions. Ongoing consultation with all stakeholders will be undertaken throughout the development and implementation of bycatch action plans.

There are a range of strategies that could be adopted in developing bycatch action plans. Some are suggested below. For any given fishery a particular combination of strategies may be necessary, but not all strategies will be applicable to all fisheries. Further strategies will emerge through the consultative process. The standards and criteria by which these are developed should always refer to the principles on which this policy is based and to which AFMA is obligated.

Examples of strategies include:

- codes of practice to minimise bycatch;
- management plans which address bycatch in both existing and developing fisheries;
- education and training programs aimed at reducing bycatch;
- where appropriate, economic incentives may be applied to reduce bycatch;
- develop cooperative bycatch management arrangements for fisheries within more than one jurisdiction;
- enhance the quality and quantity of fisheries data and ensure that data on by-product and other species impacted by fishing is also collected;
- encourage research funding organisations and the fishing industry to fund and/or facilitate further work into the identification of the impacts of fishing on bycatch, and other species, mitigation techniques and use of bycatch species where appropriate;
- ensure the widest adoption of bycatch mitigation measures through collaboration between the fishing industry, research and research funding organisations, environment and nature conservation agencies and fisheries management agencies;
- ensure a thorough and efficient use of existing data sets to assist in achieving ESD management measures in a timely and cost effective manner;
- raise awareness and encourage participation of stakeholders in the management of fisheries bycatch.

Check list for developing a fisheries specific action plan

The following checklist has been designed to assist those involved in the preparation of bycatch action plans in defining the specific bycatch issues and identifying appropriate actions.

1. What is the issue (for example: threat to an endangered species, unsustainable bycatch, public perception of waste, lack of good quality data, benthic habitat impact, contamination, market forces, type of fishing operation, lack of community and fisher awareness)? What is the order of priority?
2. Is the issue species specific, fishery specific, fishing method based or regional in nature? Does it relate to a change in the management status of the region in which the fishery operates (eg the declaration of a marine protected area)?
3. Is the issue primarily due to the nature of the fishery (eg prawn trawling where there is a high bycatch) or the management regime under which that fishery operates (where a quota system may result in the discarding of some of the landed catch)?
4. What information and/or analyses are available on:

- the status of fish stocks concerned (both target and bycatch) (by fishery / area);
- the economic benefits of reducing discards;
- the status and the vulnerability of other populations interacting with the fishery/method concerned, and the impacts of that fishery;
- the survival of discards (including those that are not actually hauled on board, but escape during fishing activities);
- the conservation significance of the issue and its:
    - ↦ impact on biodiversity (ecosystem, species or genetic);
    - ↦ impact on foodwebs;
    - ↦ impact on interacting fisheries (recreational and commercial), stock and biological community structure;.
    - ↦ impact on trade and the economy
    - ↦ impact on the environment

5. Are there specific strategies already in place in other areas which minimise the possibility of taking vulnerable species (for example turtles, seabirds and others) and how effective are these strategies in minimising fisheries interactions?
6. Which groups are affected by the issue - who needs to be involved in addressing the issue and implementing the suggestions?
7. Are there engineering solutions (mitigation measures) for the bycatch issues? Are they being implemented? Are they effective? If not, why not?
8. Are there international obligations (treaties and conventions) or trade issues which must be considered? How should they be considered?
9. Are there any existing State/Territory policies and/or initiatives to address the issue and, if so, are they effective? Could they be extended to other jurisdictions?
10. Are there legislative obligations (Commonwealth or State)? Have these been satisfied?
11. Are there existing industry codes of practice? Are they being applied? Are they working? Are they effective?
12. Are current management or industry practices, or other factors, leading to increased bycatch or lower-value by-product species which are then discarded (for example the inability to store bulky, low-value bycatch aboard vessels)? Can more appropriate practices be identified and implemented, or solutions found to other causative factors?
13. What management options are available and what would be the impact of each of these on the seafood industry, consumers and other groups? Will raising awareness and conducting education programs need to be considered and can

these fit into existing frameworks such as Coastcare and the Fisheries Action Program?

14. Who should pay?

In summary, the most important thing in the development of fishery action plans is that these should be developed in a consistent and transparent way and that they are implemented effectively. The basic steps are:

- to determine the availability of data and its usefulness;
- to decide what the bycatch issue is; then
- to look at all the options (utilise, avoid or reduce) that are available; and
- decide how to address the problem (strategies) and determine whether new ways to address the issue need to be developed;
- to outline actions required that are practical and effective to achieve the objectives of the policy; and to
- review progress or evaluate the effectiveness of the program.

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Key components of Bycatch Action Plans

Presented by

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Key components of Bycatch Action Plans

Based on the draft Commonwealth Bycatch Policy, AFMA has developed some guidelines to Management Advisory Committees (MACs) on the key components of a Bycatch Action Plan. Fishery specific Bycatch Action Plans are intended to be used to develop a strategic approach to addressing bycatch issues to ensure fisheries in Australian waters are ecologically sustainable.

Each Bycatch Action Plan will have two major components:

- a background paper which will provide a lot of detail about the nature of the fishery, species targeted, gear employed, area fished, bycatch species, management arrangements, issues, available data and management action to address bycatch issues;
  - this paper will be targeted at a wide, public audience, ie, for those who are not familiar with the fishery and its issues;
- the Action Plan itself, this will be less detailed than the background paper and will outline the objectives of the Plan, the issues to be resolved and the aims, strategies or actions to be taken to address bycatch issues;
  - this paper will be targeted at those stakeholder groups involved in the management of the fishery.

The draft Commonwealth Bycatch Policy states that fishery specific Bycatch Action Plans for major Commonwealth fisheries will be completed within twelve months of the launch of the policy and they will be integrated into fishery management regimes and reviewed regularly.

Scope of a South East Trawl Fishery Bycatch Action Plan

At the time of writing, the following options developed by AFMA have been submitted to SETMAC for discussion at its meeting of 28-29 July 1998.

General issues

Based on information already known about the SETF a number of general bycatch issues are readily apparent and have been discussed by industry, scientists and managers in various forums over the last few years:

- discarding:
  - of quota species (highgrading, quota availability, size restrictions, juveniles, etc); and
  - of non-quota species (non-commercial, high grading, juveniles, etc);
- impacts of trawling on habitat and ecosystem, including ecologically related species;
- public perception:
  - of waste; and
  - of trawling as a method and its impacts.

Through meetings of stakeholder groups over the last few years, the issue of discarding has been consistently raised as the highest priority bycatch issue to be addressed in the SETF.

Possible objectives of a Bycatch Action Plan

AFMA's 1996-97 Annual Report states that a SETF Bycatch Action Plan will be developed that:

- assesses the impacts of trawl fishing and gear impacts on SEF species; and
- investigates opportunities for alternative management strategies, including possible gear modifications; and
- implements measures to minimise adverse effects of fishing on the environment.

More specific objectives of a SETF Bycatch Action Plan could include:

- reduce discarding of SETF caught species; and
- maximise yield of target species and key non-target species; and
- increase awareness in the community about how the industry and stakeholder groups are actively seeking to address bycatch issues in the fishery.

Possible strategies

The Bycatch Action Plan should encompass a range of different strategies aimed at addressing bycatch issues in the SETF in a holistic way, including:

- the five year Strategic Research Plan;
- alternative management strategies;
- a commitment to the industry code of conduct developed by SETFIA (attached to the SETF Management Plan);
- maintenance and improvement of the quality and coverage of data collection programmes;
- industry investigation of the potential for increased marketing and utilisation of those 'non-commercial' species which are currently discarded;
- development of a communication, public awareness strategy for the SETF.

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AFMA and the Commonwealth Bycatch Policy

Presented by

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AFMA and the Commonwealth Bycatch Policy

The Fisheries Management Act was developed in a peak period of international concern over the environment. At a conference in Rio in 1992 two major themes were Ecologically Sustainable Development (ESD) Conservation of Biological Diversity. In reflection of these global discussions Australia developed National Strategies for ESD and the Conservation of Biological Diversity and implemented the Commonwealth Endangered Species Protection Act 1992. The 1991 Fisheries Management (FM) Act 1991 objectives also include reference to the need for AFMA to pursue ESD, minimise the impact on non-target species and exercise the precautionary principle. In addition, the FM Act was recently amended to require fisheries management plans to contain provisions which limit the take of non-target commercial species to a minimum. The recently endorsed South East Trawl Management Plan includes such a provision.

As community concern over bycatch increased and to meet our legislative, national and international obligations AFMA established a working group in 1996 to develop a Bycatch Policy. Over time it was agreed that the policy should be a Commonwealth Policy with endorsement from environmental and fisheries agencies. The draft policy was circulated for public comment in mid 1997 and is currently awaiting approval and release from the Ministers for Environment and Primary Industries. The policy was developed to recognise that there are a range of different bycatch issues in each fishery by setting an overall approach to the development of bycatch action plans for individual fisheries. Following much discussion the definition of bycatch in the draft Commonwealth Bycatch Policy is as follows;

> *While the term bycatch may refer to all non-targeted catch including by-product, discards and other interactions with gear, this policy will deal specifically with those aspects of bycatch that are not currently subject to commercial management provisions, namely;*
>
> i) *that part of a fishers catch which is returned to the sea either because it has no commercial value or because regulations preclude it being retained, and*
> ii) *that part of the "catch" that does not reach the deck of the fishing vessel but is killed as a result of interaction with the fishing gear.*

While there can and have been many hours of debate over the definition of bycatch, the Commonwealth Bycatch Policy has adopted the above definition. Significant concern has been expressed by a range of individuals and organisations over the need to manage the take of all species by fishers. AFMA has acknowledged that the sustainability of the marine environment is the underlying objective of fisheries management and that a range of measures exist to pursue that objective. The Commonwealth Bycatch Policy is one such measure.

Maximising yield and reducing discards in the South East Trawl Fishery

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Characteristics of fleet and trawl gear in the South East Trawl Fishery

Presented by

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Characteristics of fleet and trawl gear in the South East Trawl Fishery

Introduction

This paper provides background information on the trawl fleet and gear presently operating in the SE Trawl Fishery. Data were not collected for orange roughy gear, and the Victorian Danish seine fleet and gear were not included in the study.

Data were sourced from AFMA, NSW Fisheries, and from discussions with fishers, net makers and gear suppliers during port visits. Logistic and time constraints meant that information collected referred mainly to NSW, Lakes Entrance and some Portland based trawlers.

Information was willingly supplied by many owners and/or skippers during the port visits. The Eden based net maker, Paul Einarsson, is particularly acknowledged for giving me access to net plans (but no secrets!) of trawls built for many of the trawlers in the fishery.

Port Distribution and Fishing Areas of SEF Trawlers (source: AFMA).

A total of 78 trawlers are listed for the fishery. about two thirds trawl the shelf and slope grounds between Sydney and NE Tasmania from NSW and Lakes Entrance. The remainder mostly fish upper slope grounds off western Victoria and Tasmania, and/or target orange roughy, mainly around southern Tasmania.

		Main Area of Operation		
Home Port	**No.**	**NSW**	**sthn NSW / east. Vic. / N.E. Tas.**	**west.Vic. / west. & sthn Tasmania**
Sydney	7	7		
Wollongong	4	3		1
Greenwell Pt	3	3		
Ulladulla	9	6	3	
Batemans Bay	2	2		
Bermagui	4	4		
Eden	15		15	
Lakes Entrance	10		7	3
Melbourne	2			2
Portland	6			6
Beachport	2			2
Launceston / Devonport	2			2
Hobart	7			7
Others	5			5
Total	**78**	**25**	**25**	**28**

SEF Trawler Size Distribution
(Source AFMA / NSW Fisheries)

	NSW	Victoria	Tasmania	Other	Total
Length (m)					
<15.0	2				**2**
15.0-19.9	23	8	1	1	**33**
20.0-24.9	17	8	2	1	**28**
25.0-29.9	2	1	1	3	**7**
30.0-34.9			4		**4**
35.0-39.9			1	1	**2**
>40.0		1		1	**2**
	44	**18**	**9**	**7**	**78**

SEF Trawlers: Main Engine Power
(Source AFMA / NSW Fisheries)

Data was sourced mainly from SEF Logbook Gear Details. It is likely that some of the figures entered on the logbook sheets are for horsepower, not kW.

Main Engine kW:	100-199	200-299	300-399	400-499	> 500
Length (m)					
<15.0	2				
15.0-19.9	8	19	7		
20.0-24.9	1	5	11	10	1
25.0-29.9			3	1	2
30.0-34.9					4
35.0-39.9				1	1
>40.0				1	2

Characteristics of SEF Trawl Gear

1. Trawl Gear Accessories

(for 55 NSW, Lakes Entrance and Portland trawlers)

1.1 Doors:

Type	No.	Size range (m)
Vee (steel)	40	2.1 - 2.7
Super-V	3	
curved Vee (Thyborum)	5	2.2 - 2.5
Bison	1	
Polyice (oval)	4	180 - 400 kg
Flat (wooden)	2	2.8 - 2.9

1.2 Sweeps:

East coast: almost all vessels use between 90 and 150 fathoms (160-275 m) of 24 mm diameter combination rope. Shorter sweeps (approx. 50 fm) occasionally used on "rough" bottom..

West coast: usually short sweeps (approx. 50 fm) of 24 mm comb. wire (J.Sealey, pers. com.).

1.3 Lower Bridles:

East coast: 5 - 20 fathoms (9-37 m), mostly 15-20 fm; usually 24 mm comb. wire; some larger vessels (4) used 3" (75 mm) rubber disc lower bridles.

Portland: 20-25 fm of 14-16 mm diam. SWR (J.Sealey, pers. com.).

1.4 Lower Wing Extensions: usually chain; 4 vessels with 3" rubber disc extensions.

1.5 Groundrope Rig: Rubber (tyre) discs (15-25 cm diam.): 65 nets
Looped chain: 16 nets

Four (small) trawlers only used nets with chain groundropes. Many NSW trawlers use nets with either chain or rubber disc groundropes, dependent on seabed conditions. No nets with chain groundropes were observed on Victorian trawlers.

2. *Net Specifications*

2.1 Fish Trawl Designs:

Fish Trawl Designs: For 'market' fishing, there are four basic designs or styles.

"Spag." (Italian): 2 seam net; relatively long wings and low headline height (2-4 m). Usually towed around 2.5 knots. Often used on the upper slope for ling, perch. gemfish and redfish.

Wing trawl: 2 seam net with relatively short wings, moderate headline height (3-5 m). All purpose net for shelf and slope.

"Champion": 4 seam net; modified wing trawl with a narrow 5-20 mesh side panel; higher headline height (4-6 m). All purpose net; towing speed 3.0-3.5 knots for warehou, trevally.

"Seastar" or box trawl: 4 seam net with deep, tapered side panels of 35-40 meshes at the bosom; high opening; sometimes rigged with three bridles. Towing speed 3.0-3.5 knots for warehou, trevally. styles.

2.2 Royal Red Prawn Nets

2 seam nets (45-55 m headline length) with very long wings; low headline height (1.5-3 m); chain groundrope; 40 mm mesh throughout. Usually towed with 100-150 fm sweeps.

2.3 Fish Trawls: *Headline lengths of nets*

Data were available for 94 nets now or recently in use on 45 trawlers based in NSW and Victoria and used for "market fishing" i.e. not for orange roughy.

	2 seam Spag.	**2 seam Wing**	**4 seam Champ.**	**4 seam Seastar**	**not specified**	**Total**
Headline (m)						
<35	1	2	1	2		**6**
35-39	4	8	12	6	4	**34**
40-44	10	15	7	4		**36**
45-49	3	4	3		2	**12**
50-54	1	1	1		1	**4**
55-60	1				1	**2**
	20	**30**	**24**	**12**	**8**	**94**

2.4 Fish Trawls: *Mesh Sizes of Net Panels* (*see* Figure 1)

Mesh sizes were invariably quoted in inches; codend mesh size was assumed to be the legal minimum - 90 mm inside stretched mesh; some vessels working on the west coast and/or for orange roughy use 100 mm mesh.

Mesh size data for the fronts of nets (wings to lengthener) were derived from 94 net plans and/or descriptions provided by fishers; codend data include direct observations.

Mesh size :		**18" 460 mm**	**12" 305 mm**	**9" 228 mm**	**6" 152 mm**	**4-5" 102-127 mm**	**3.5" 90 mm**
Net Panel							
Upper wing	A	1	8	72	9	4	
Square (overhang)	B1	1	7	71	11	4	
Front upper belly	B2		3	73	13	4	1
Lower wing	C		3	52	35	3	
Bunt*	D			2	11	1	
Lower belly	E1			7	73	12	1
Back upper belly (batings)	E2			6	75	6	1
Body (lengthener)	F				9	74	7
Codend extension	G						76
Codend lifting bag	Cod-end						78

* bunt area of the lower wing (usually with smaller mesh and/or heavier twine)

2.5 Fish Trawls: *Twine weight/diameter used in each net panel.*

Twine sizes were either quoted as ply (no. of filaments in laid twine) or as diameter (for braided twine). The table lists the twines in order of thickness/weight; 90 ply twine is closely equivalent in weight to 3 mm diameter twine.

Twine size: (ply/diam.)		**32-36 ply**	**42-48 ply**	**60 ply**	**90 ply 3 mm**	**4 mm**	**6 mm**	**7 mm**	**3 mm double**	**4 mm double**	**6 mm double**
Net Panel											
Upper wing	A	6	6	10	30	4					
Square (overhang)	B1	6	6	12	4	4					
Front upper belly	B2	7	6	18	19	2					
Lower wing	C	6	1	10	27	5					
Lower belly	E1	5	1	20	22	3					
Back upper belly	E2	5	7	16	13						
Body lengthener	F	5	4	17	14	2					
Codend extension	G	4		1	2	35	33		1		
Codend lifting bag					2	1	11	4	3	9	48

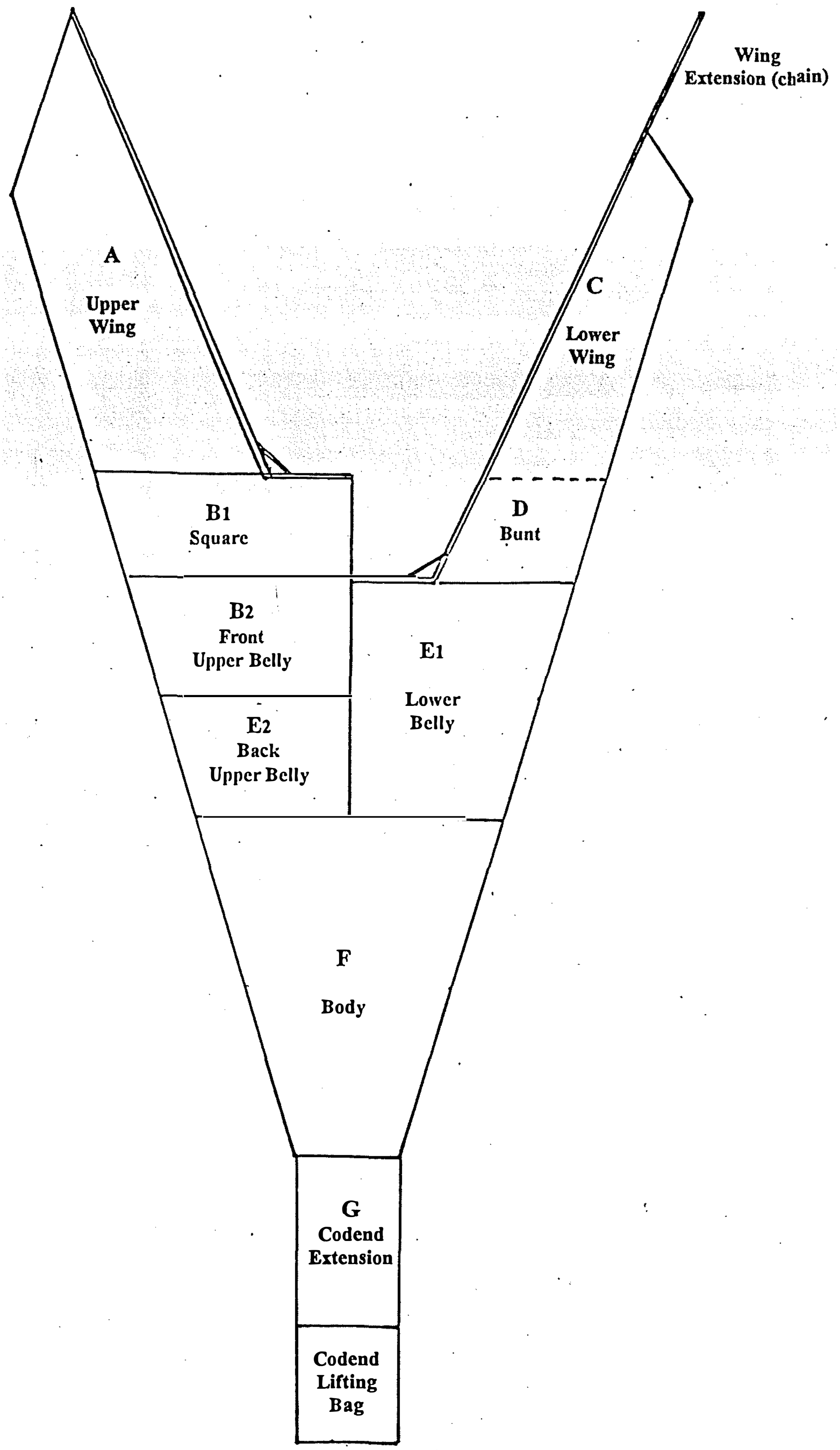

Figure 1: General plan for a 2 seam net showing the panels referred to in the text and tables.

Maximising yield and reducing discards in the South East Trawl Fishery

Workshop 30-31 July 1998

Catch composition and discarding in the South East Trawl Fishery from observer surveys

Not for citation

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Catch Composition and Discarding in the South East Trawl Fishery from Observer Surveys

Introduction

Australia's South East Fishery (SEF) has evolved over this century from a small steam trawl fishery to a complex multi-species, multi-gear fishery which operates between the shallow coastal waters off south eastern Australia to depths of over 1000 m off the continental shelf. A range of gear types are used in the fishery, including Danish seines, droplines, longlines and traps, but most of the catch is taken by otter trawls. So, although the SEF is managed as a single fishery, it is best considered as a variety of distinct sub-fisheries defined by the gear, areas, depths and seasons fished. This is evident in the particular species composition of the catches from the various components of the fishery (Klaer and Tilzey 1994; Smith *et al.* 1997).

SEF catches include over 80 commercial species, and 22 species or species groups comprise 95% of the catch (Tilzey 1994). Sixteen of these species are under quota management. Whilst trawling is often targeted towards the quota species or other species of high commercial value, generally it is considered as a relatively non-selective fishing method. As such, many fish are captured which have little or no commercial value and are subsequently discarded. Some commercial species, including quota species may also be discarded. The reasons behind this are numerous and complex, but put simply, it usually relates to the interaction of market demand, quota value and leasing costs, quota availability and the economic viability of retaining the fish. Nevertheless, such discarding is unproductive and time consuming for fishers who have to sort through the catch and is also seen as a waste of a potentially valuable resource. Furthermore, whilst the effects of discarding have yet to be established at an ecosystem level, the practice attracts negative publicity for the Industry and is considered by some to be contrary to the principles of ecologically sustainable development. For these reasons, it is necessary to consider ways of reducing the level of discarding in the SEF.

On a world-wide scale, when genuine efforts to reduce bycatch and discarding in trawl fisheries have been undertaken, they are often successful. There are certain steps in this process, however, that need to be undertaken to achieve this (Kennelly 1997). The first step is to identify and quantify the retained and discarded catches through a comprehensive observer program. Next, it is necessary for Industry and scientists to work together to determine and trial various ideas in order to find the best solution/s to the problem. Finally, it is important the results are publicised amongst all Industry members and other interest groups.

The good news is that considerable progress has already been made in this process with the SEF. The composition of the catches taken by SEF trawlers has been monitored over a number of years by on-board observers off the coast of New South Wales (Liggins 1996) and throughout the SEF as part of the Integrated Scientific Monitoring Programme (ISMP, Knuckey 1997; Garvey 1997, 1998). These projects provide extensive quantitative information on the species composition of both the retained and discarded catch. This paper presents a summary of this information. Thus, we now know what the problems are and as such we have achieved the first step in the process of tackling the discarding/bycatch issues of the SEF. The next step begins with this workshop, as Industry, scientists, managers and other interested groups work together to discuss possible ways of addressing the issues and develop a research project to trial and identify the best solutions.

Collection of information

Two separate, but related projects have collected information on the catch composition of SEF trawlers. One was a joint Fisheries Research and Development Corporation (FRDC) and NSW Fisheries Research Institute (NSW FRI) funded project entitled "The interaction between fish trawling (in NSW) and other commercial and recreational fisheries". This project began in 1993 and basically consisted of an observer program run on SEF trawlers working out of the NSW ports of Eden, Ulladulla and Newcastle/Tuncurry. The other project is the AFMA-funded Integrated Scientific Monitoring Programme (ISMP). It began in 1994 and used a combination of on-board observers and port-based fish measurers to collect information on the species composition and length frequency of the retained and discarded catch of trawlers working throughout the SEF. After the NSW FRI / FRDC project finished in 1995, the ISMP consisted of two components: data from NSW ports were collected by NSW FRI and data from the main Victorian, Tasmanian and South Australian SEF ports were collected by the Marine and Freshwater Resources Institute (MAFRI). It was only in 1998, that these two components were amalgamated and MAFRI was commissioned to collect all of the ISMP data. Thus, although similar methods were adopted, the data presented in this paper has been collected by both NSW FRI and MAFRI under AFMA funding. AFMA has made these data available to MAFRI for the production of this report.

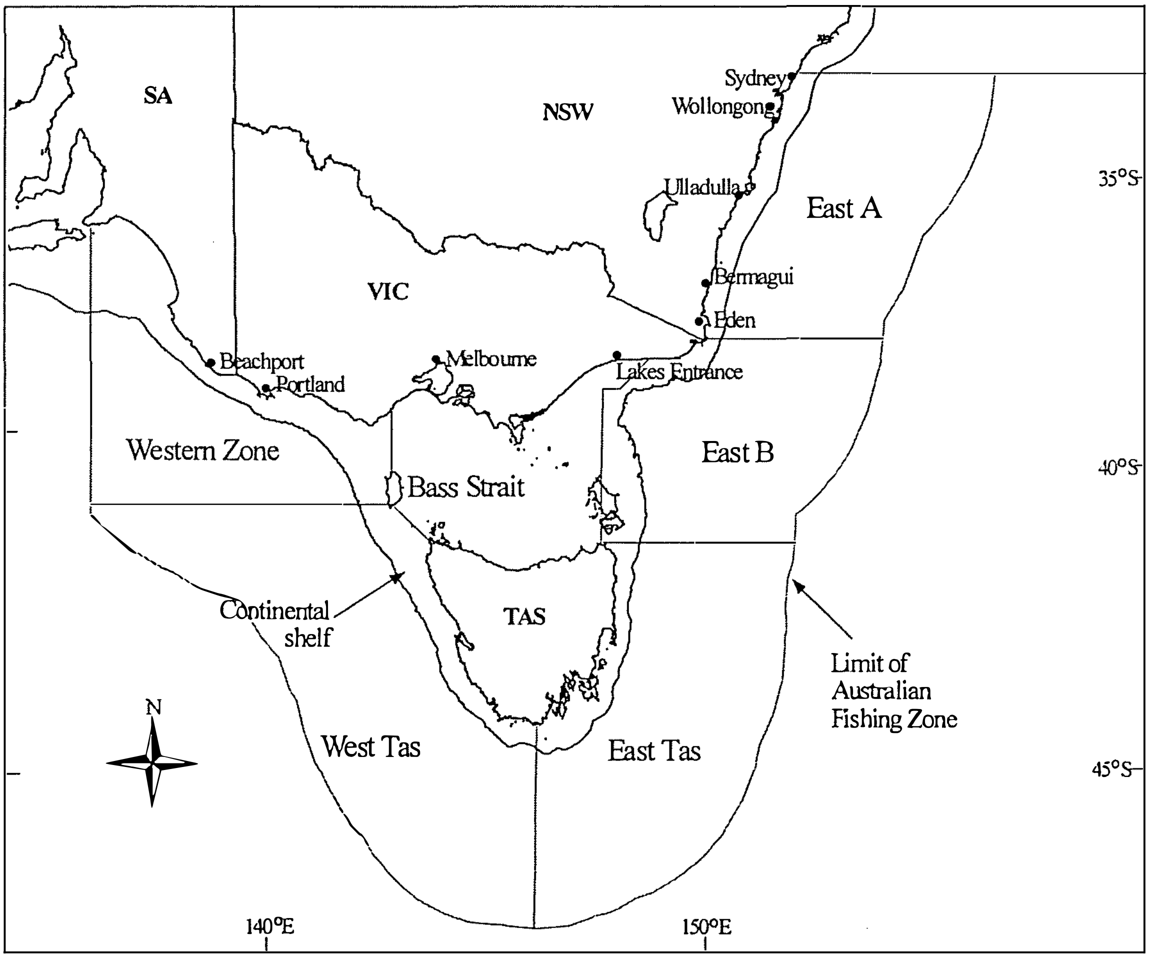

Figure 1 *Zones used to summarise the spatial distribution of sub-fisheries in the South East Fishery.*

Throughout the year, on-board observers collected information from a representative cross-section of fishing trips undertaken by trawlers working in each of the zones of the SEF (Figure 1). On each fishing trip, they usually sampled every shot, estimating the retained and discarded weights (or numbers) of every species caught. Length frequency measurements were also taken from a sub-sample of these catches to provide a size distribution of both the retained and discarded catch of the key species. In addition to the on-board sampling, port-based fish-measurers collected length frequency and otoliths for age determination of the landed catch of each quota species and selected non-quota species. Using this information, it was possible to get a picture of the overall composition of the catch taken by trawlers throughout the SEF and the proportion and size range of the different species that were retained and discarded.

To help understand and explain the catch composition and utilisation, a few broad definitions used to classify the catch are described below (Table 1).

Table 1 *Description of definitions used in this paper to classify the catch taken by SEF trawlers*

Definition	Description
Total catch	All fish and other material caught by the trawl
Retained catch	The component of the total catch that is kept by the fisherman and returned to port.
Discarded catch	The component of the total catch that is discarded back into the water
Fish	Includes scalefish (teleosts) and sharks and rays (elasmobranchs)
Benthos	Includes rocks, sponges and bottom debris
Quota species	The sixteen species that are currently under quota management in the SEF, including blue grenadier, ling, orange roughy, redfish, mirror dory, john dory, ocean perch, tiger flathead, school whiting, silver trevally, jackass morwong, gemfish, blue eye trevalla, blue warehou, spotted warehou and royal red prawn.
Commercial species	Species which can have a market value. Commercial species, which includes all quota species, may be either retained or discarded.
Non-commercial species	Species which to date have no commercial value. By definition, non-commercial species are never a part of the retained catch

The capture of birds and mammals in SEF trawls is rare, but due to the general concern regarding such issues, this information has been reported separately from the capture of fish.

To provide a broad summary of the composition of the catch of fish taken by SEF trawlers in each zone during 1996 and 1997, pie charts have been used to classify the catch using the above definitions.

One of the major purposes of this workshop is to highlight the key discarding issues in the SEF. As such, I have further investigated the 1997 information on the discarded catch to determine its species and size composition.

Results

Whilst AFMA has provided MAFRI and the author with the ISMP data used in this report, the summaries, analyses and interpretation of the data are those of the author.

It is important to note that the results presented here summarise information only from the shots observed by ISMP observers. There has not been equal coverage of vessels within each zone, nor has the coverage necessarily been designed to provide accurate estimates of discarding. Consequently, these results should not be extrapolated to provide estimates of the entire SEF, especially considering the fact that various "sub-fisheries" may exist within each zone. The sampling design of the ISMP was modified in 1998 so that such extrapolations can be undertaken within specified levels of precision for the major quota and non-quota species.

Capture of birds and mammals

The capture of "charismatic megafauna", (birds, mammals, turtles etc) in SEF trawls is rare. Since monitoring SEF trawl catches began, many thousands of shots have been observed and the capture of birds, turtles and dolphins is virtually non-existent. Seals are the only species which are caught in any numbers, but depending on what stage the seals are caught in the trawl, they may be alive when released and still be recorded as "discarded". Details of capture of seals in the various SEF zones during 1996 and 1997 is provided in Table 2.

Table 2 *Number and percentage of shots monitored by ISMP observers in which seals were caught by SEF trawlers in 1996 and 1997. Only zones in which more than 10 shots were observed are included.*

Zone	1996			1997		
	Shots observed	Shots with a seal	% shots with seals	Shots observed	Shots with a seal	% shots with seals
Eastern Zone A	277	4	1.5%	317	7	2.3%
Eastern Zone B	56	2	3.6%	153	2	1.3%
Eastern Tasmania	46	0	0%	28	0	0%
Western Zone	203	1	0.5%	175	0	0%
Bass Strait	15	1	7.1%	50	3	6.1%

Collection of benthos

Benthos is a very broad term which applies to anything lying on or attached to the bottom. In the ISMP observer work, benthos usually covers the rocks, corals, sponges etc and other bottom debris that is brought up in the net. Being demersal trawls, there is usually a certain amount of benthos which is collected by the net during trawling. Details of the weight of benthos as a percentage of the total catch per shot is provided in Table 3.

Table 3 *Number of shots monitored by ISMP observers the mean weight of the total catch per shot excluding benthos (kg±SE) and the mean weight per shot of benthos caught by SEF trawlers in 1996 and 1997. Only zones in which more than 10 shots were observed are included.*

Zone	1996			1997		
	Shots observed	Mean catch weight (kg/shot±SE)	Mean benthos weight (kg/shot±SE)	Shots observed	Mean catch weight (kg/shot±SE)	Mean benthos weight (kg/shot±SE)
Eastern Zone A[1]	277	1097 ± 60		317	1280 ± 75	
Eastern Zone B	56	646 ± 64	44 ± 10 **7%**	153	901 ± 66	33 ± 8 **4%**
Eastern Tasmania	46	941 ± 119	36 ± 8 **4%**	28	1244 ± 156	20 ± 6 **2%**
Western Zone	203	1424 ± 157	19 ± 11 **1%**	175	1378 ± 123	1 ± 0.5 **0%**
Bass Strait	15	951 ± 135	92 ± 24 **10%**	50	782 ± 86	47 ± 16 **6%**
TOTAL[1]	320	1205 ± 101	29 ± 7 **2%**	406	1099 ± 59	20 ± 4 **2%**

[1] Data on benthos in Eastern Zone A has not been recorded separately. Mean weights/shot in the Total column do not include shots from Eastern Zone A.

Capture and discarding of fish

Whilst it is unlikely that discarding can be totally removed from a trawl fishery, there are many people involved in the SETF who believe that there are changes that can be made within the Industry which will significantly reduce the problem. It is hoped that by presenting the information gained by on-board observers, we can focus on the major discarding issues and begin working towards sensible and practical ways of addressing the issues.

The summaries of catch composition and discarding provided here, are an overall view of what was recorded by the ISMP observers in each of the sub-fishery zones during 1996 and 1997. As such, they do not necessarily represent what may actually be caught in any particular shot. This is because catch composition can change depending on a wide range of factors including depth, season, moon phase, weather, and targeting practices. The summaries do, however, give an overview of the general catch composition in the zone and the species which comprise the bulk of the discarding.

Eastern Zone A

Redfish dominated the retained catch in this zone. Other common species were ling, tiger flathead and silver trevally followed by a range of other quota species, including blue and spotted warehou, gemfish, mirror dory, ocean perch, jackass morwong and royal red prawns (Table 4).

During 1996 redfish were also one of the most commonly discarded species, but this decreased noticeably in 1997 (Table 5). The redfish that were being discarded were predominantly under 20 cm in length. Significant amounts of small blue grenadier (usually below 50 cm length) were also discarded. Discarding of these small blue grenadier was prevalent throughout most of the SETF during 1996 and 1997 and is considered to be a result of one or two strong year classes of fish entering the fishery. Other commonly discarded species which can be of commercial value included jack mackerel, blue grenadier and southern frostfish. Toothed whiptails and cucumber fish were two non-commercial species often in the discarded catch.

Eastern Zone B

Tiger flathead, spotted warehou, jackass morwong, ling and blue warehou comprised about 70% of the retained weight of fish in this zone (Table 6). There is a minimum size limit on tiger flathead in NSW, so fish below about 33 cm are discarded (Fig. 3a). This is evident in the size range of the retained catch.

As in the rest of the fishery, small blue grenadier were discarded. Barracouta, southern frostfish and jack mackerel were again a major component of the discarded catch. Skates, whiptails, gurnards, swell sharks and draftboard sharks were commonly discarded non-commercial species (Table 7).

Eastern Tasmania

The fishery in the Eastern Tasmania zone is comprised of two distinct sub-fisheries: the orange roughy fishery on the sea-mount during winter and the mixed species summer fishery of the east Tasmanian coast. The species comprising the bulk of the retained catch off Eastern Tasmania were those associated with the orange roughy fishery. Orange roughy comprised about 60 - 70% of the catch by weight and smooth and spikey oreos were also common in the catch (Table 8). The mixed species summer fishery accounted for the presence of jackass morwong, spotted and blue warehou, blue grenadier, ling and mirror dory in the retained catch. Historically, about three quarters of the landings of mirror dory were from Eastern Zone A and the rest caught in Eastern Zone B. Since 1996, this trend has changed, with a far greater proportion of the mirror dory catch coming from Tasmania and west of Bass Strait..

Very little of the discarding in this zone was from the orange roughy fishery. Most of the discarding in this zone resulted from the mixed species summer fishery. Again, small blue grenadier were prevalent in the discarded catches. Notably, there were significant amount of mirror dory discarded in this fishery. These fish were usually less than 35 cm in length. Other discarded commercial species included southern frostfish, barracouta, gemfish and ling. Non-commercial species which were discarded included whiptails, skates, draughtboard shark and New Zealand dory.

Western Tasmania

The SEF in western Tasmania also consists of two distinct fisheries: a general mixed species fishery that occurs throughout the year and a fishery targeting spawning blue grenadier between June and August. As would be expected, the retained catch in the latter consists predominantly (70%) of blue grenadier. Other retained species include spotted warehou, orange roughy, spikey oreo, ling and deepwater shark species. The retained catch in the non-winter fishery has many similar species including spotted warehou, orange roughy, spikey oreo, ling, blue grenadier and deepwater shark, except the proportion of blue grenadier in the catch is far lower (around 10% by weight).

There were insufficient shots monitored by ISMP observers in the non-winter fishery in 1996 and the blue grenadier winter fishery in 1997 to support analysis of the discarded catch in these years. As a result, only one years data are summarised for each fishery. In the non-winter fishery, around 45% of the weight of the discarded catch was whiptails. Owston's dogfish were also common in the discarded catch. Both of these species are non-commercial. In the blue grenadier winter fishery, whiptails were also the bulk of the discarded catch with other non-commercial species including sawtail shark, New Zealand dory and draughtboard shark also discarded in significant amounts. Smaller blue grenadier were also discarded.

Western Zone

The retained catch in the Western Zone consisted mainly of orange roughy, blue grenadier, blue and spotted warehou, ling, western gemfish and squid. Of these, the arrow squid is the only non-quota species and is considered a valuable bycatch of the fishery in this area. Any squid greater than 20 cm mantle length are usually retained (Knuckey and Ryan 1997).

Commercial species which are discarded in significant numbers in this zone include mainly blue grenadier, blue warehou and spotted warehou. Again, as in other parts of the SEF, the significant discarding of blue grenadier in 1996 and 1997 consisted of the small fish (<50 cm) newly recruited to the fishery which were extremely abundant in these years. High-grading of both blue and spotted warehou was also evident in this zone although there was often very little difference in the size range of fish that were discarded to those retained. Dogfish, barracouta and southern frostfish were among the most commonly discarded non-quota commercial species. The non-commercial species that were discarded comprised mainly whiptails, New Zealand dory and draughtboard shark.

Bass Strait

The SETF fishery in Bass Strait includes a significant Danish seine fishery. The composition of the retained catch presented in Table 16 includes the Danish seine component. As such, the main species in the retained catch are school whiting and tiger flathead. These are both quota species which make up about 80% of the retained catch. A small amount of jackass morwong and mirror dory are also kept. Other retained non-quota commercial species include, octopus spp, squid, red mullet and gummy shark.

The composition of the discarded catch in Bass Strait during 1996 and 1997 did not include observations from the Danish seine fleet although many of the species are likely to be similar. In the catches of board trawlers, the non-quota commercial species that were discarded include barracouta, jack mackerel, southern frostfish various dories and leatherjackets (Table 17). Gurnards, skates, globefish, swellsharks, draughtboard sharks and New Zealand dories were some of the more prominent non-commercial species.

General discussion

The composition of the catches taken by SEF trawlers varies considerably between the different zones. This is reflected in the different retained and discarded components of the catch throughout the fishery. As a result, defining the discarding issues that confront the SETF is not simple and developing viable solutions will also be difficult. Nevertheless, in broad terms, the summaries above do highlight some species which are commonly caught and discarded across the different sub-fisheries. These are discussed below. If their levels of discarding of these species could be reduced, it would make a significant impact on the overall levels of discarding in the SEF.

Small blue grenadier were a significant component of the discarded catch in many zones of the fishery. Whilst the data are not presented here, information from previous years show that this has not always been the case. The large catches in recent years have been attributed to at least one (and possibly more) strong year classes whose recruits are now entering the fishery. This highlights that there are also temporal aspects to discarding in the SEF which have not been considered in the current paper. Whiptails or rattails are related to grenadier and have a short trunk with a long tapering tail. They are non-commercial species which form a major component of the discarded catch in all of the zones. They are nearly always less than 50 cm length. These fish are of a similar size and shape to the blue grenadier that were being discarded. Without any information on their behaviour to a trawl, one would expect that any modification of gear that reduced the capture of small grenadier would also significantly reduce the capture of whiptails.

In Eastern Zone A, redfish was another quota species for which the smaller fish (<20) were heavily discarded. Unlike the blue grenadier, high-grading of redfish has been occurring off the NSW coast for numerous years although the rate of discarding has varied both spatially and temporally (Liggins 1996). A similar situation has been recorded for mirror dory off NSW (Liggins 1996) but discarding rates reduced significantly in 1996 and 1997 except in Eastern Tasmania (Knuckey 1998). Another quota species for which Liggins (1996) highlighted significant discarding was ocean perch. He identified large numbers of very small ocean perch (more often the inshore species) have been consistently caught and discarded. This practice was still apparent during 1996 and 1997 although due to their small size, they did not form a large percentage of the discarded catch by weight.

Apart from blue grenadier, the main quota species that formed a significant part of the discarded catch to the west of Bass Strait were blue and spotted warehou. Whilst a certain amount of high-grading of these species occur, much of the discarding resulted from individual large shots where only a small percentage of the shot is retained and little sorting of the catch occurs.

Significant discarding of gemfish also occurred, but as a quota species which has had a minimal TAC in the eastern zones over the last few years, the reasons behind the discarding of gemfish are likely to be almost totally quota driven.

Barracouta and southern frostfish are non-quota commercial species which regularly comprised significant portions of the discarded catch in the different zones. They are large, pelagic (free swimming), carnivorous fish closely related to the gemfish. Jack mackerel were another pelagic species which was widely discarded despite have some commercial value. They are a thin streamlined fish that may reach over 50 cm length.

Apart from the whiptails mentioned above, there are other pelagic non-commercial species that were commonly discarded. Cucumber fish are a slender species that were often discarded in the eastern zones. Although not a large part of the discarded catch by weight, their very small size means large numbers are discarded. A similar situation exists for the small New Zealand dories which must be trawled up in extremely large numbers to form such a significant component of the discarded catch in some zones. Whilst most dories have some commercial value, this species are too small to be retained.

Many of the other non-commercial species caught throughout the SEF are bottom dwelling (demersal) fish. In nearly every zone, the various skates and rays as well as the different types of catsharks (swellsharks and draughtboard sharks) formed a large percentage of the discarded catch. In the eastern zones, different species of gurnards were often a significant component of the discarded catch.

It is worth noting that the two sub-fisheries within the SEF which have the lowest discarding rates are the targeted spawning fisheries for orange roughy and blue grenadier. In these fisheries, more than 70% of the catch is retained; even higher in the orange roughy fishery. As such, the discarding issues in these fisheries are probably not as pronounced as those in other areas, nevertheless the reduction of the capture of whiptails and New Zealand dories in the blue grenadier winter fishery would be advantageous.

In summary, this paper has broadly described the composition of the retained and discarded trawl catches in the different zones of the SEF and highlighted some of the major discarding issues. The next step, and the reason for this workshop, is to look at ways to reduce this discarding whilst maintaining or improving the value of the retained catch. Stated simply, levels of discarding in the SEF can be improved in one of two ways: utilise more of the fish that are caught; and/or, do not catch as many fish that are ultimately discarded. Whilst both of these solutions are possible, neither is easy. Their achievement will require long-term commitment, support and open discussion from all people involved in the fishery including fishers, managers, researchers and processors. This workshop will provide a forum to develop this process.

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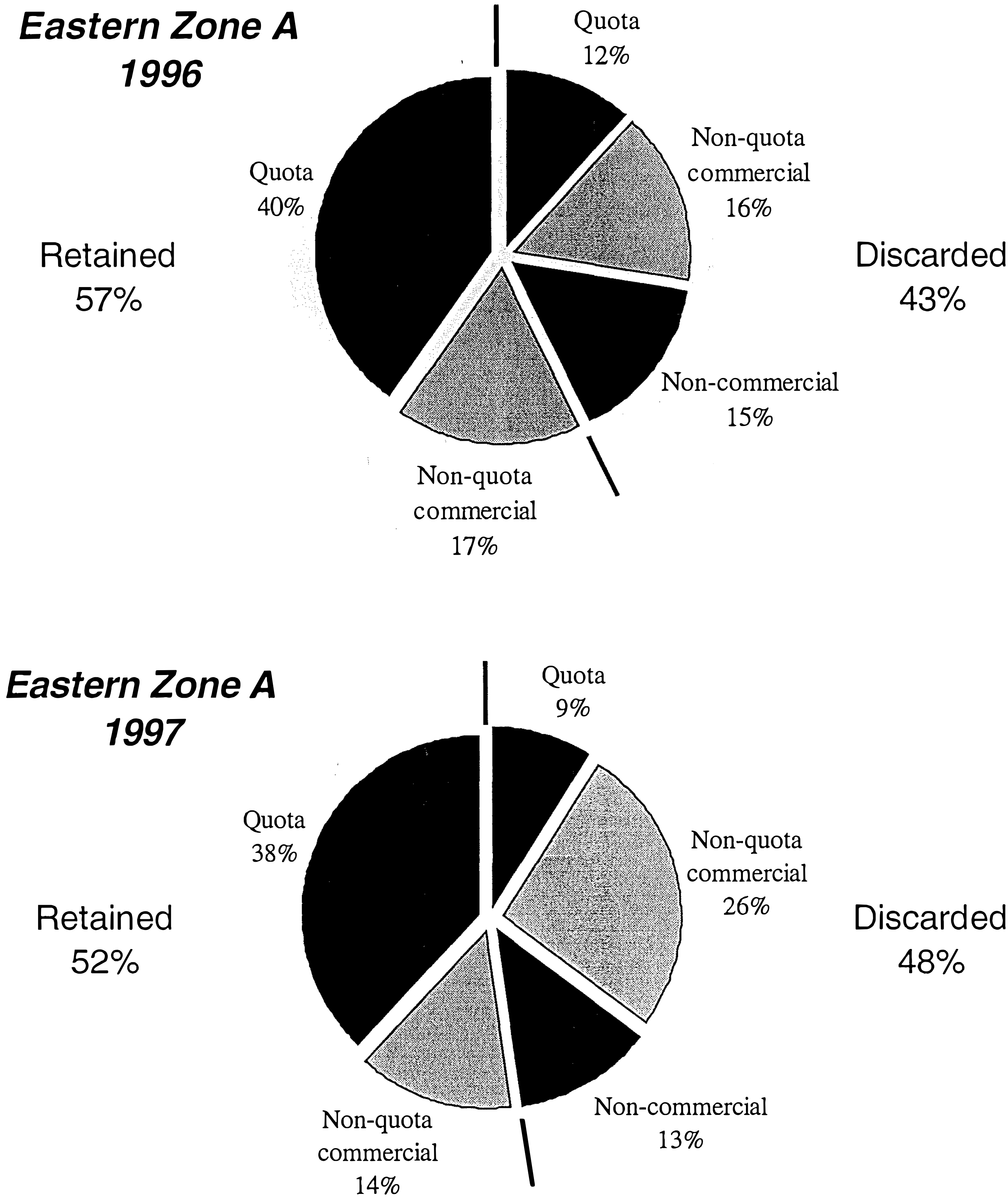


Figure 2 *Percentage (by weight) of quota species, non-quota commercial species and non-commercial species in the retained and discarded catch of SEF trawl vessels in Eastern Zone A during 1996 and 1997.*

Table 4 *Composition of the retained catch (% of total retained weight) from SEF trawl vessels working in Eastern Zone A during 1996 and 1997. (Data from SEF1 logbooks).*

ZONE	1996		1997	
	Species	% of total retained weight	Species	% of total retained weight
Eastern Zone A	Redfish	25%	Redfish	29%
	Tiger flathead	11%	Ling	9%
	Ling	7%	Tiger flathead	8%
	Silver trevally	6%	Silver trevally	7%
	Royal red prawn	6%	Gemfish	5%
	Blue warehou	5%	Mixed fish	4%
	Mixed fish	4%	Mirror dory	4%
	Spotted warehou	4%	Royal red prawn	4%
	Gemfish	3%	Ocean perch	3%
	Jackass morwong	3%	Jackass morwong	3%
	Mirror dory	3%	Squid	3%
	Ocean perch	3%	Spotted warehou	3%
	John dory	2%	Southern frostfish	2%
	Shark	2%	Shark	2%
	Dogfish	2%	Dogfish	2%
	Squid	2%	School whiting	1%
	Southern frostfish	2%	John dory	1%
	Cuttlefish	1%	Blue grenadier	1%
	Leatherjackets	1%	Blue warehou	1%
	Octopus	1%	Cuttlefish	1%

Eastern Zone A

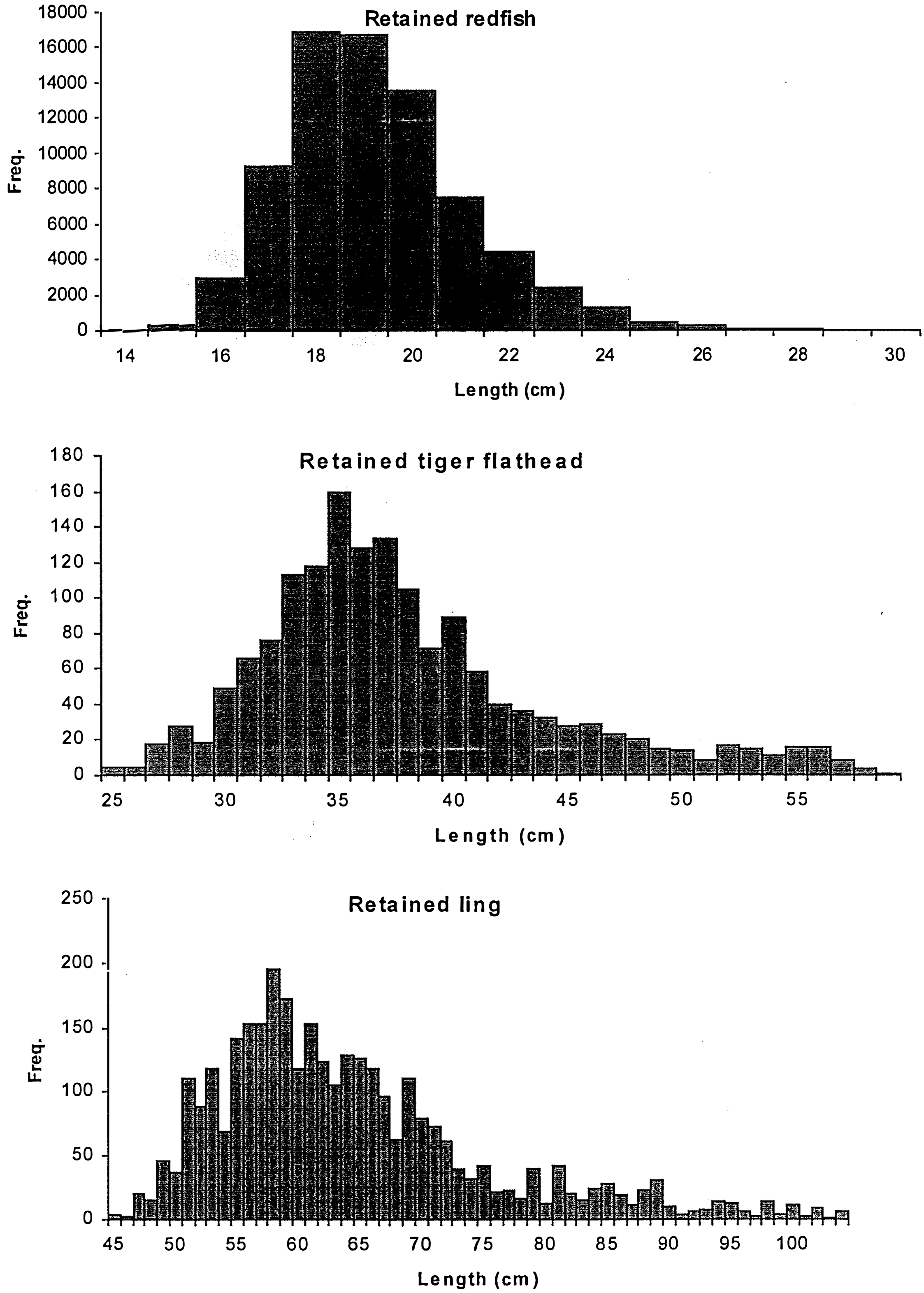
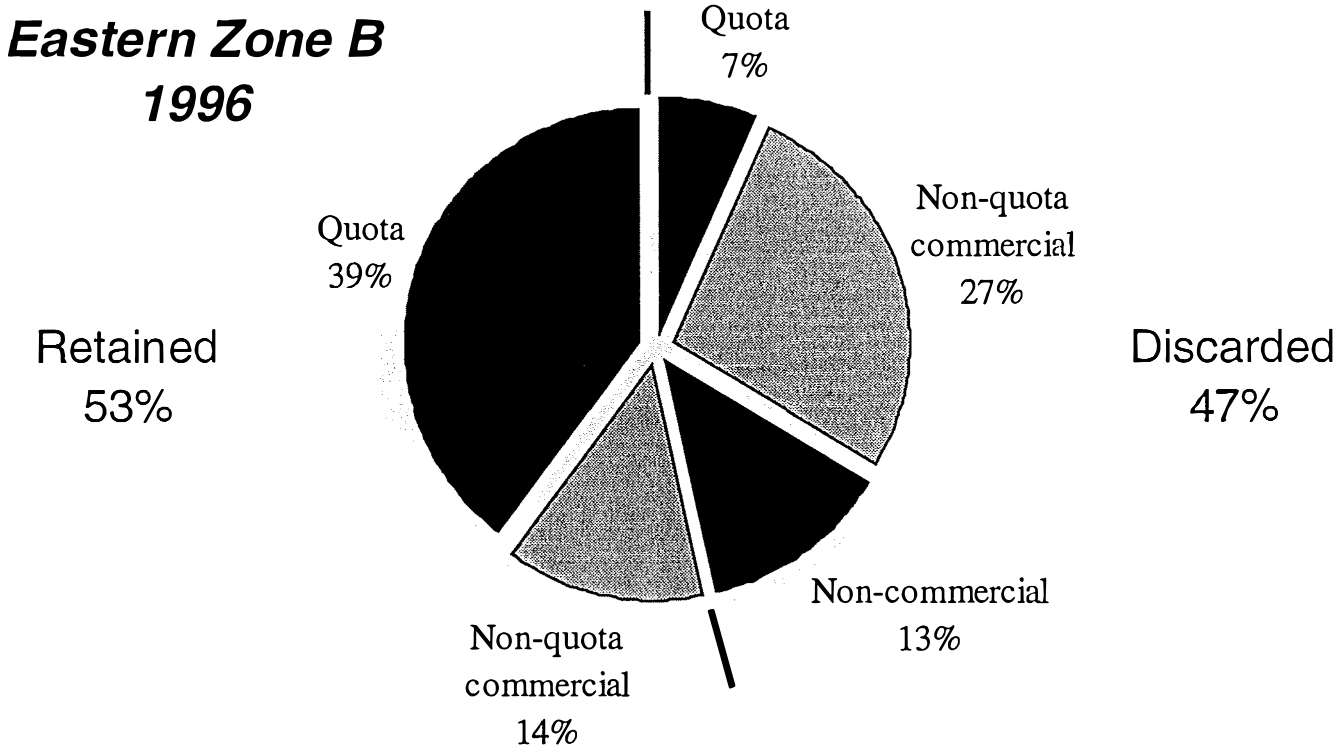


Figure 2a. Length frequency of the retained catch of selected quota species commonly caught in Eastern Zone A during 1996 and 1997. Data from ISMP on-board observers.

Table 5 *Composition of the discarded catch (% of total discarded weight) from SEF trawl vessels working in Eastern Zone A during 1996 and 1997.*

ZONE	1996		1997	
	Species	% of total discarded weight	Species	% of total discarded weight
EASTERN ZONE A	Southern frostfish	9%	Jack mackerel	16%
	Redfish	9%	Blue grenadier	10%
	Jack mackerel	6%	Southern frostfish	7%
	Blue grenadier	6%	Piked dogfish	7%
	Cucumber fish	5%	Toothed whiptail	5%
	Toothed whiptail	4%	Cucumber fish	5%
	Mirror dory	4%	Skate spp	3%
	Greenback stingaree	3%	Barracouta	3%
	Deepwater gurnard	3%	Spotted warehou	3%
	Australian burrfish	3%	Australian burrfish	3%
	Crabs	3%	Cocky gurnard	3%
	Ocean perch (inshore)	3%	Spiny flathead	2%
	Gargoyle fish	3%	Gargoyle fish	2%
	Silver dory	3%	Greenback stingaree	2%
	Skates	2%	Deepwater gurnard	2%
	Tiger flathead	2%	Banded bellowfish	2%
	Piked dogfish	2%	Electric ray	2%
	Whiptails	2%		
	Velvet leatherjacket	2%		
	Spiny flathead	2%		
	Other species	24%	Other species	24%



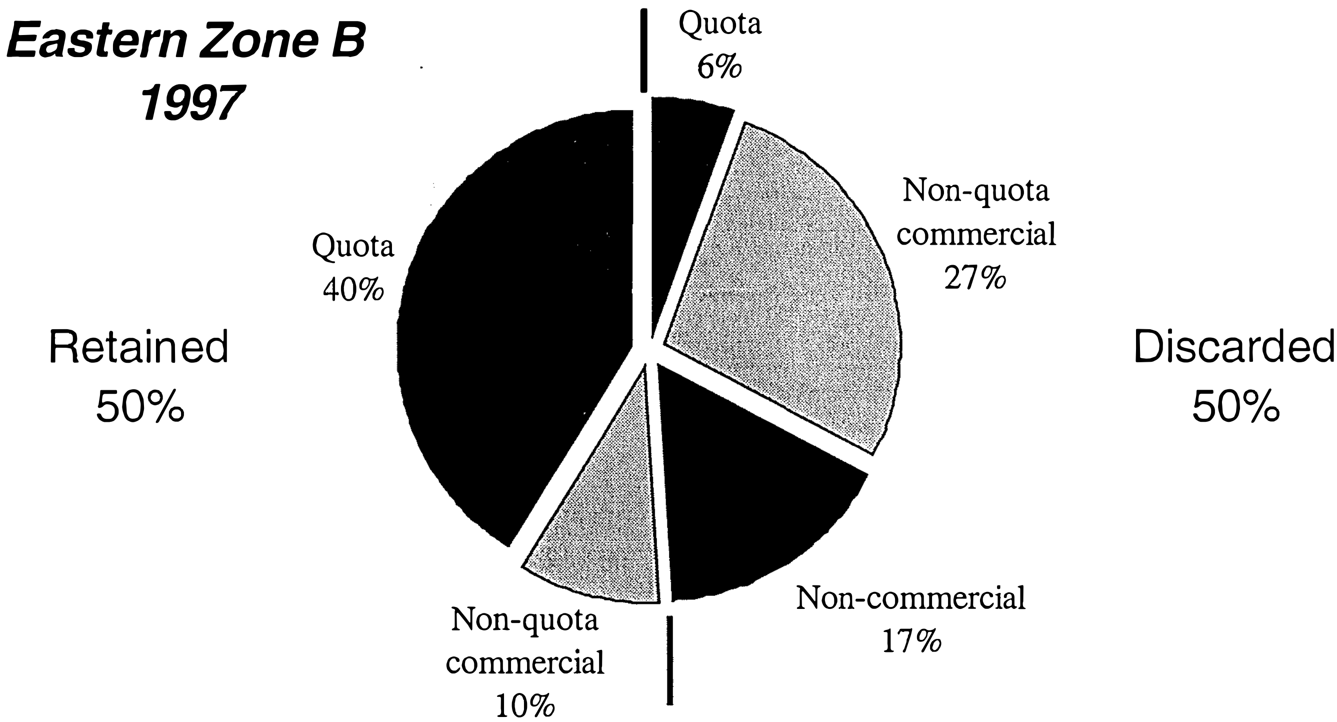


Figure 3 *Percentage (by weight) of quota species, non-quota commercial species and non-commercial species in the retained and discarded catch of SEF trawl vessels in Eastern Zone B during 1996 and 1997.*

Table 6 *Composition of the retained catch (% of total retained weight) from SEF trawl vessels working in Eastern Zone B during 1996 and 1997. (Data from SEF1 logbooks).*

ZONE	1996		1997	
	Species	% of total retained weight	Species	% of total retained weight
Eastern Zone B	Tiger flathead	21%	Tiger flathead	30%
	Spotted warehou	20%	Spotted warehou	14%
	Jackass morwong	10%	Jackass morwong	13%
	Ling	9%	Ling	8%
	Blue warehou	5%	Blue warehou	6%
	Mixed fish	4%	Mixed fish	4%
	Shark	4%	Squid	4%
	Redfish	3%	Blue grenadier	3%
	Dogfish	3%	Redfish	2%
	Squid	2%	Gemfish	2%
	Octopus	2%	Mirror dory	2%
	Ocean perch	2%	Ocean perch	1%
	Blue grenadier	2%	Dogfish	1%
	Orange roughy	1%	Shark	1%
	Mirror dory	1%	Barracouta	1%
	Spikey oreo	1%	Octopus	1%
	John dory	1%	John dory	1%
	Barracouta	1%	Silver trevally	0%
	Silver trevally	1%	Jack mackerel	0%
	Gemfish	1%	Spikey oreo	0%

Eastern Zone B

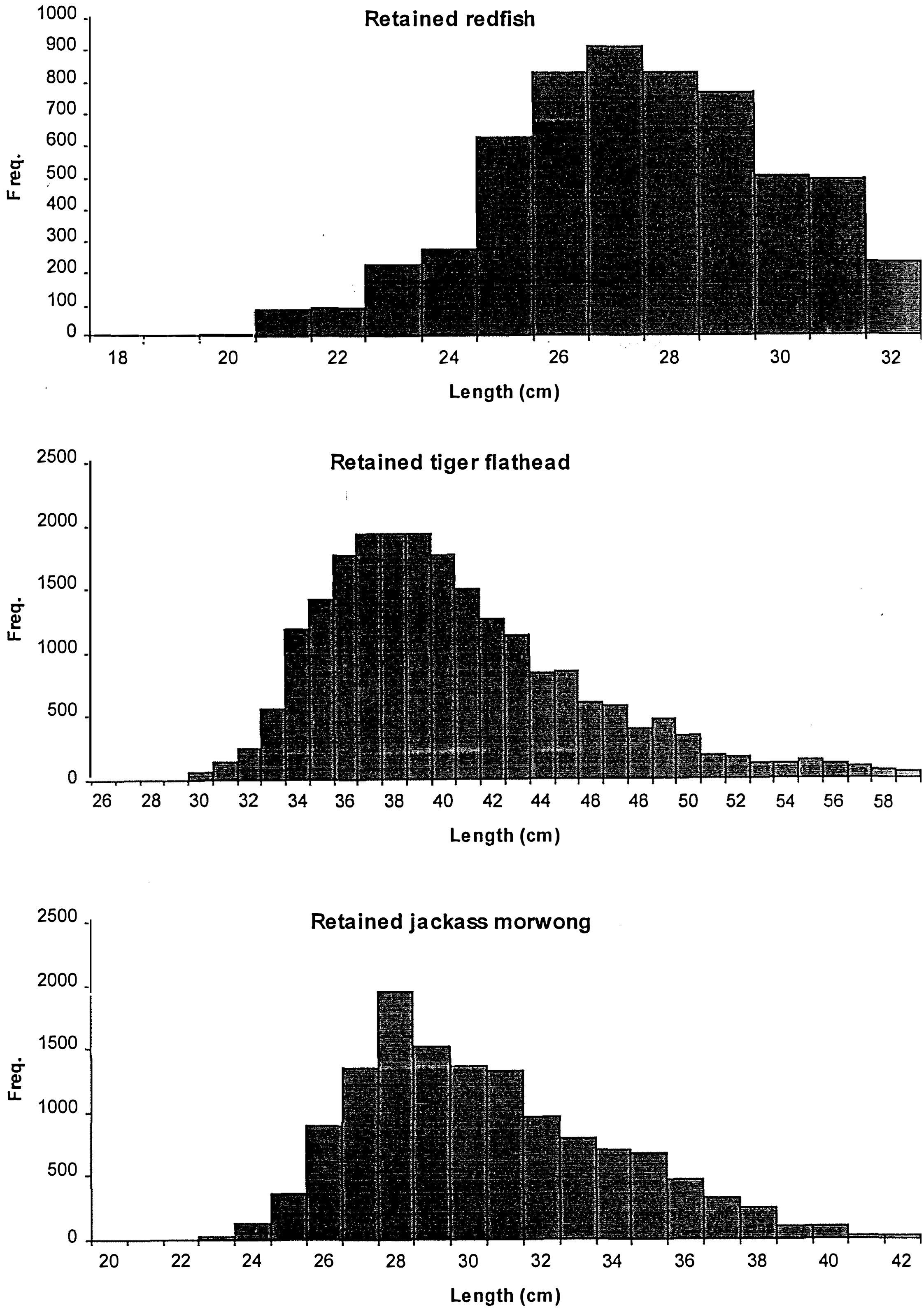


Figure 3a. Length frequency of the retained catch of selected quota species commonly caught in Eastern Zone B during 1996 and 1997. Data from ISMP on-board observers.

Table 7 Composition of the discarded catch (% of total discarded weight) from SEF trawl vessels in Eastern Zone B during 1996 and 1997.

ZONE	1996		1997	
	Species	% of total discarded weight	Species	% of total discarded weight
EASTERN ZONE B	Toothed whiptail	13%	Barracouta	15%
	Cocky gurnard	9%	Skates	14%
	Skates	9%	Cocky gurnard	7%
	Southern frostfish	7%	Blue grenadier	6%
	Whiptails	6%	Jack mackerel	6%
	Blue grenadier	4%	Leatherjackets	5%
	Draftboard shark	4%	Dogfish	5%
	Barracouta	4%	Draftboard shark	4%
	Jack mackerel	3%	Spotted swellshark	4%
	Greeneye dogfish	3%	Toothed whiptail	4%
	Threespine cardinalfish	2%	Globefish	3%
	Bugs	2%	Whiptails	2%
	Tiger flathead	2%	Southern frostfish	2%
	Jackass morwong	2%	Thetis fish	2%
	Globefish	2%	Port Jackson shark	2%
	Banded bellowfish	2%		
	King dory	2%		
	Barred grubfish	2%		
	Cucumber fish	2%		
	Other species	21%	Other species	19%

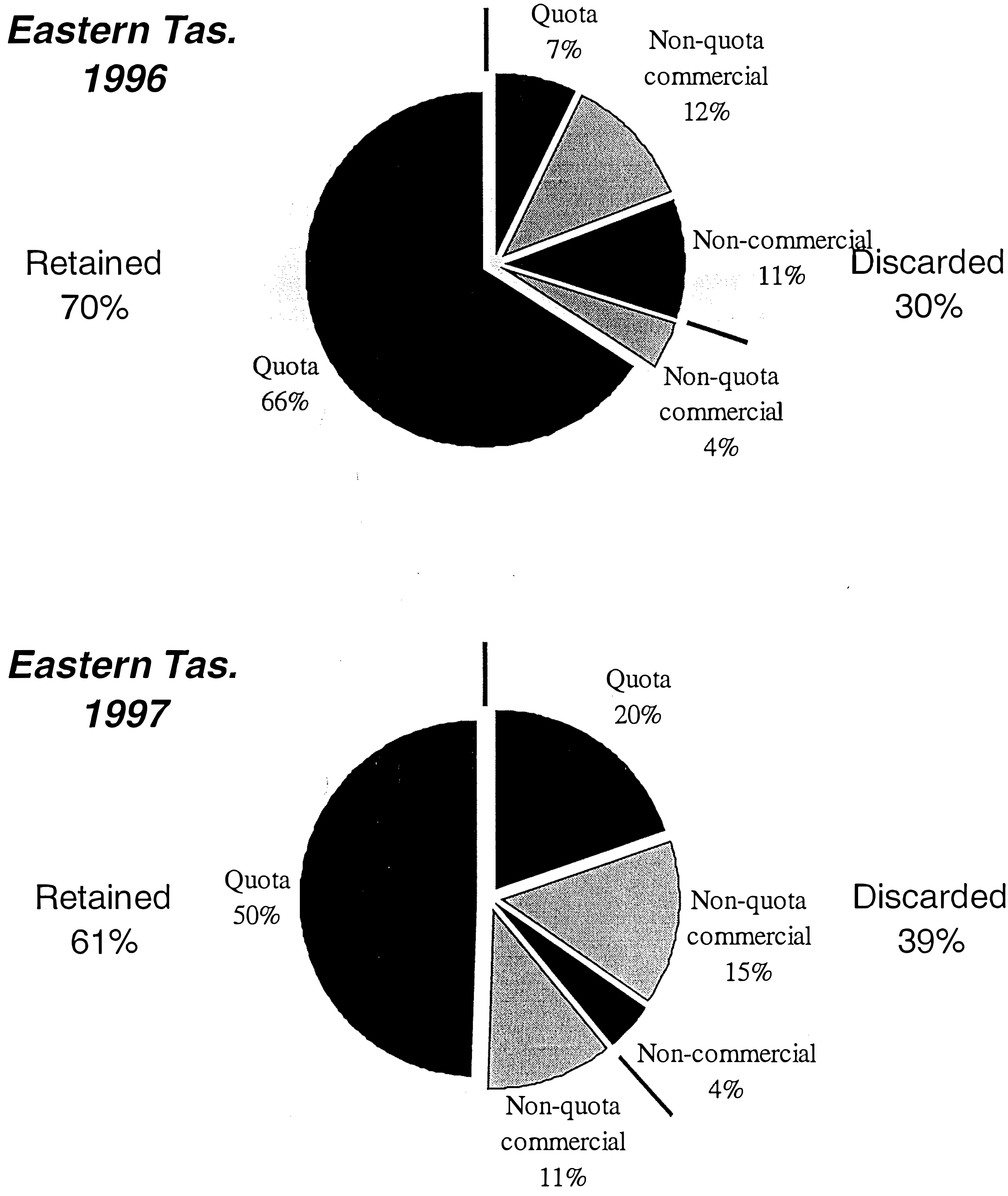


Figure 4 *Percentage (by weight) of quota species, non-quota commercial species and non-commercial species in the retained and discarded catch of SEF trawl vessels in Eastern Tasmania during 1996 and 1997.*

Table 8 *Composition of the retained catch (% of total retained weight) from SEF trawl vessels working in Eastern Tasmania during 1996 and 1997. (Data from SEF1 logbooks).*

ZONE	1996		1997	
	Species	% of total retained weight	Species	% of total retained weight
Eastern Tas.	Orange roughy	72%	Orange roughy	65%
	Smooth oreo	6%	Smooth oreo	12%
	Jackass morwong	4%	Spikey oreo	8%
	Blue grenadier	4%	Spotted warehou	4%
	Spotted warehou	3%	Jackass morwong	3%
	Blue warehou	2%	Blue grenadier	3%
	Tiger flathead	1%	Tiger flathead	1%
	Ling	1%	Blue warehou	1%
	Spikey oreo	1%	Ling	1%
	Mirror dory	1%	Stargazers	0%
	Blue eye trevalla	1%	Mirror dory	0%
	Shark	1%	Mixed fish	0%
	Stargazers	1%	Shark	0%

Table 9 *Composition of the discarded catch (% of total discarded weight) from SEF trawl vessels in Eastern Tasmania during 1996 and 1997.*

ZONE	1996		1997	
	Species	% of total discarded weight	Species	% of total discarded weight
EASTERN TAS	Toothed whiptail	20%	Mirror dory	27%
	Mirror dory	10%	Blue grenadier	14%
	Skates	9%	Toothed whiptail	8%
	Whiptails	8%	Southern frostfish	7%
	Gemfish	7%	Barracouta	7%
	Draftboard shark	5%	Skates	6%
	Silver dory	4%	Ling	6%
	Ocean perch (inshore)	3%	Spikey oreo	3%
	NZ Dory	3%	Gemfish	3%
	Mixed	2%	Melbourne skate	3%
	Boarfish	2%	Draftboard shark	3%
	Mixed ghost sharks	2%	Whiptails	2%
	Barred grubfish	2%	NZ Dory	2%
	Ling	2%		
	Cucumber fish	2%		
	Barracouta	2%		
	Other species	18%	Other species	10%

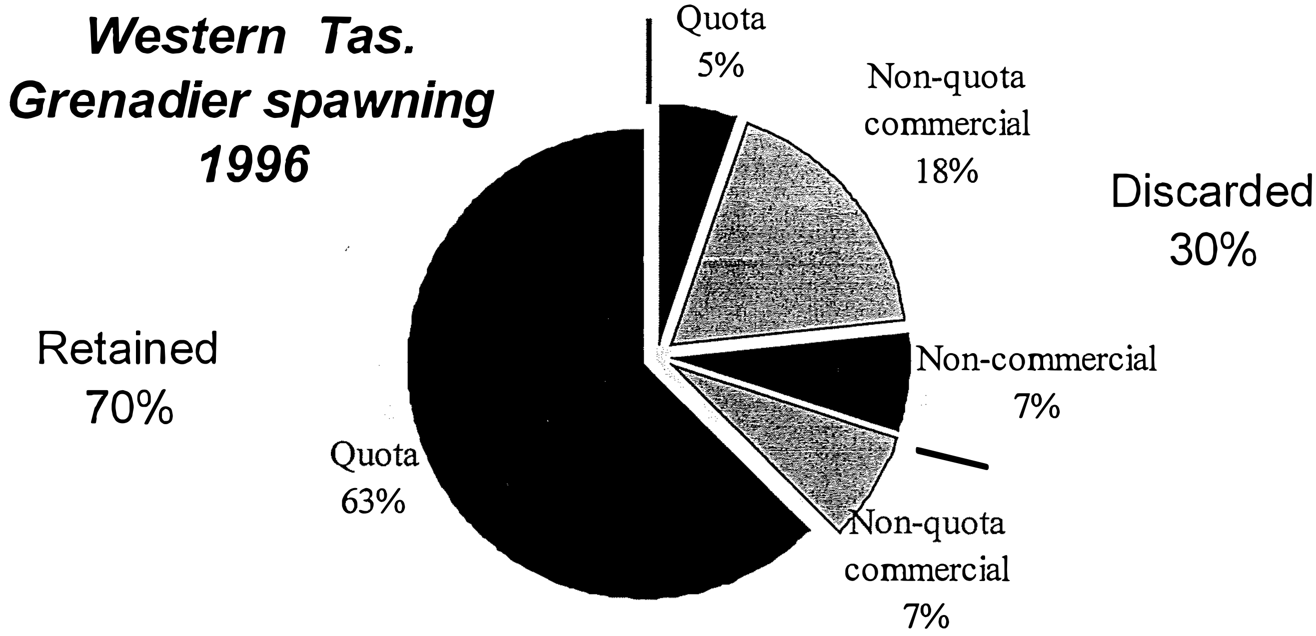


Figure 5 *Percentage (by weight) of quota species, non-quota commercial species and non-commercial species in the retained and discarded catch of SEF trawl vessels in 1996 winter fishery*

Table 10 *Composition of the retained catch (% of total retained weight) from SEF trawl vessels working in Western Tasmania(winter fishery) during 1996 and 1997. (Data from SEF1 logbooks).*

ZONE	1996		1997	
	Species	% of total retained weight	Species	% of total retained weight
Western Tas. (winter)	Blue grenadier	70%	Blue grenadier	87%
	Orange roughy	7%	Spikey oreo	3%
	Spotted warehou	6%	Spotted warehou	2%
	Spikey oreo	5%	Ling	2%
	Ling	4%	Orange roughy	1%
	Shark	2%	Shark	1%
	Blue warehou	2%	Blue eye trevalla	1%
	King dory	1%	Southern frostfish	1%
	Dogfish	1%	Dogfish	0%
	Smooth oreo	0%	Smooth oreo	0%
	Ribaldo	0%	King dory	0%
	Mirror dory	0%	Ribaldo	0%
	Ocean perch	0%	Ocean perch	0%

Table 11 *Composition of the retained catch (% of total retained weight) from SEF trawl vessels working in Western Tasmania(non-winter fishery) during 1996 and 1997. (Data from SEF1 logbooks).*

ZONE	1996		1997	
	Species	% of total retained weight	Species	% of total retained weight
Western Tas.	Spotted warehou	24%	Spotted warehou	33%
	Orange roughy	24%	Spikey oreo	13%
	Blue grenadier	14%	Ling	12%
	Spikey oreo	12%	Orange roughy	11%
	Ling	9%	Blue grenadier	9%
	Dogfish	4%	Shark	6%
	Shark	2%	Dogfish	3%
	Smooth oreo	2%	Smooth oreo	2%
	Mirror dory	2%	King dory	2%
	King dory	2%	Ribaldo	2%
	Ribaldo	1%	Mirror dory	2%
	Ocean perch	1%	Black shark	1%
	Blue warehou	1%	Jackass morwong	1%
	Jackass morwong	1%	Blue eye trevalla	1%
	Blue eye trevalla	0%	Ocean perch	1%
	Gemfish	0%	Southern frostfish	1%
	Mixed fish	0%	Mixed fish	1%

Table 12 *Composition of the discarded catch (% of total discarded weight) from SEF trawl vessels in the Western Tasmanian winter (spawning blue grenadier) fishery during 1996.*

ZONE	1996		1997	
	Species	% of total discarded weight	Species	% of total discarded weight
WESTERN TAS (Winter)	Whiptails	37%		
	Blue grenadier	16%		
	Sawtail shark	10%		
	NZ Dory	8%		
	Draftboard shark	7%		
	King dory	4%		
	Spiny flathead	3%		
	Skates	3%		
	Cucumber fish	3%		
	Fur seals	2%		
	Banded bellowfish	2%		
	Other species	4%		

Table 13 *Composition of the discarded catch (% of total discarded weight) from SEF trawl vessels in the Western Tasmanian non-winter fishery during 1997.*

ZONE	1996		1997	
	Species	% of total discarded weight	Species	% of total discarded weight
WESTERN TAS (non-winter)			Whiptails	45%
			Owston's dogfish	16%
			Skates	3%
			Ribaldo	3%
			Other species	32%

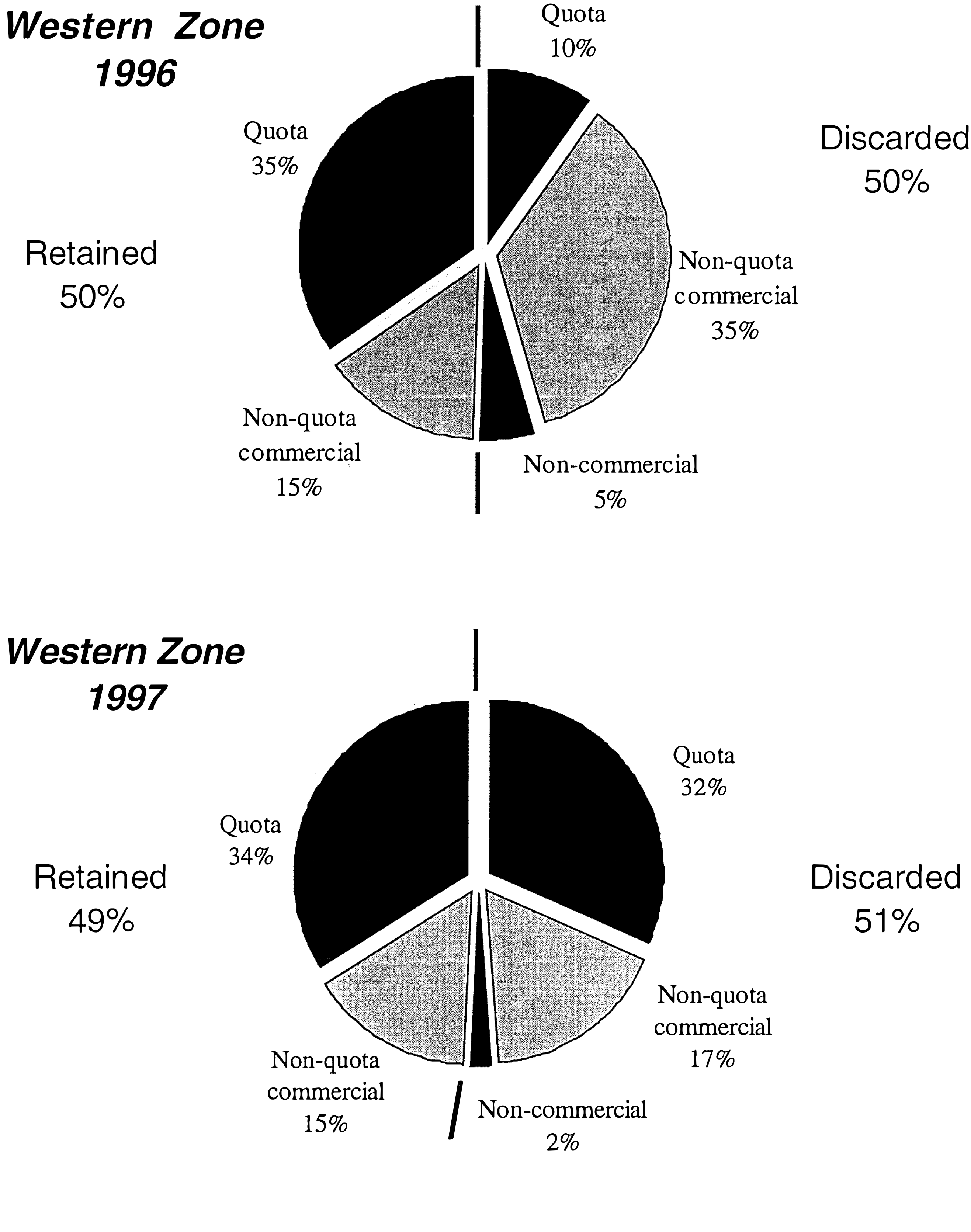


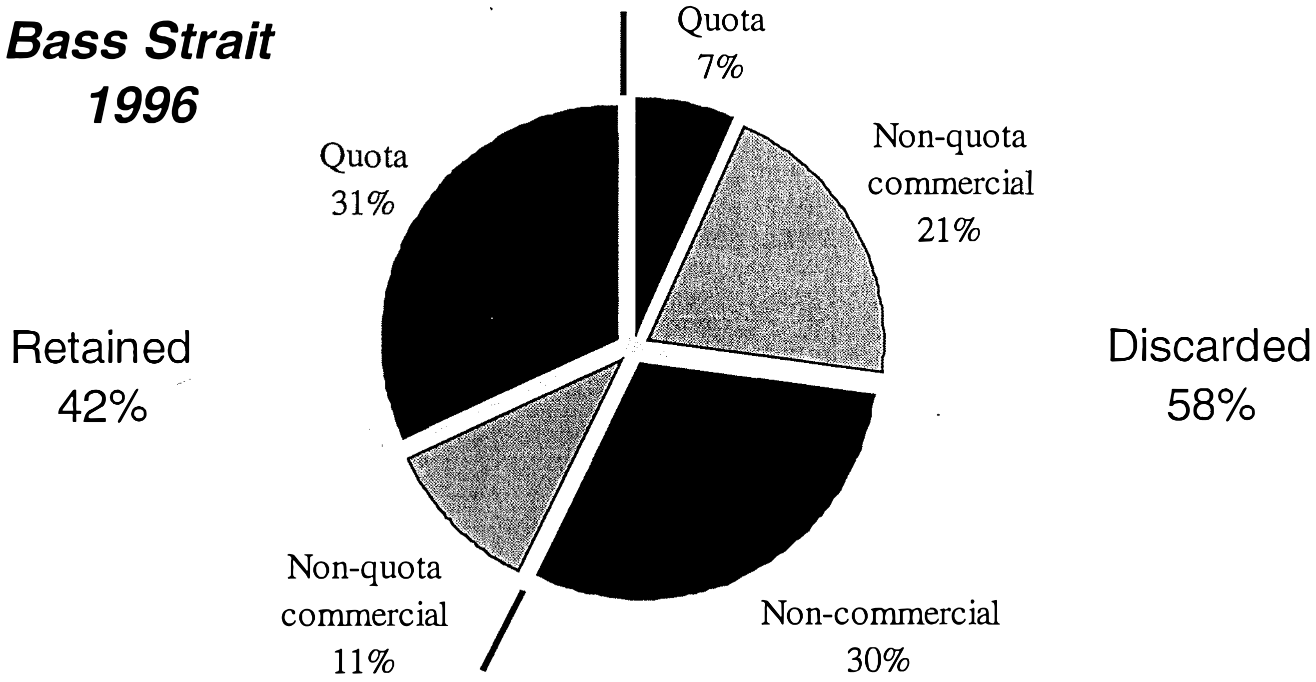
Figure 6 *Percentage (by weight) of quota species, non-quota commercial species and non-commercial species in the retained and discarded catch of SEF trawl vessels in the Western Zone during 1996 and 1997.*

Table 14 Composition of the retained catch (% of total retained weight) from SEF trawl vessels working in the Western Zone during 1996 and 1997. (Data from SEF1 logbooks).

ZONE	1996 Species	1996 % of total retained weight	1997 Species	1997 % of total retained weight
Western Zone	Orange roughy	30%	Spotted warehou	16%
	Blue grenadier	15%	Blue grenadier	14%
	Spotted warehou	13%	Ling	8%
	Ling	6%	Blue warehou	8%
	Blue warehou	4%	Orange roughy	7%
	Squid	4%	Gemfish	5%
	Gemfish	4%	Squid	4%
	Mixed fish	3%	Mixed fish	4%
	King dory	2%	Mirror dory	4%
	Mirror dory	2%	Spikey oreo	3%
	Tiger flathead	2%	King dory	3%
	Stargazers	2%	Barracouta	2%
	Dogfish	2%	Dogfish	2%
	Spikey oreo	1%	Stargazers	2%
	Barracouta	1%	School whiting	2%
	Latchet	1%	Tiger flathead	2%
	Shark	1%	Shark	2%
	School whiting	1%	Latchet	1%
	Smooth oreo	1%	Smooth oreo	1%
	Jackass morwong	1%	Blue eye trevalla	1%

Table 15 Composition of the discarded catch (% of total discarded weight) from SEF trawl vessels in the Western Zone during 1996 and 1997.

ZONE	1996 Species	1996 % of total discarded weight	1997 Species	1997 % of total discarded weight
WESTERN ZONE	NZ Dory	32%	Blue grenadier	38%
	Whiptails	12%	Blue warehou	13%
	Spotted warehou	11%	Whiptails	12%
	Blue grenadier	7%	Spotted warehou	9%
	Greeneye dogfish	6%	NZ Dory	7%
	Rubyfish	5%	Draftboard shark	4%
	Barracouta	3%	Greeneye dogfish	3%
	Southern frostfish	2%		
	Prawns	2%		
	Draftboard shark	2%		
	Other species	19%	Other species	15%



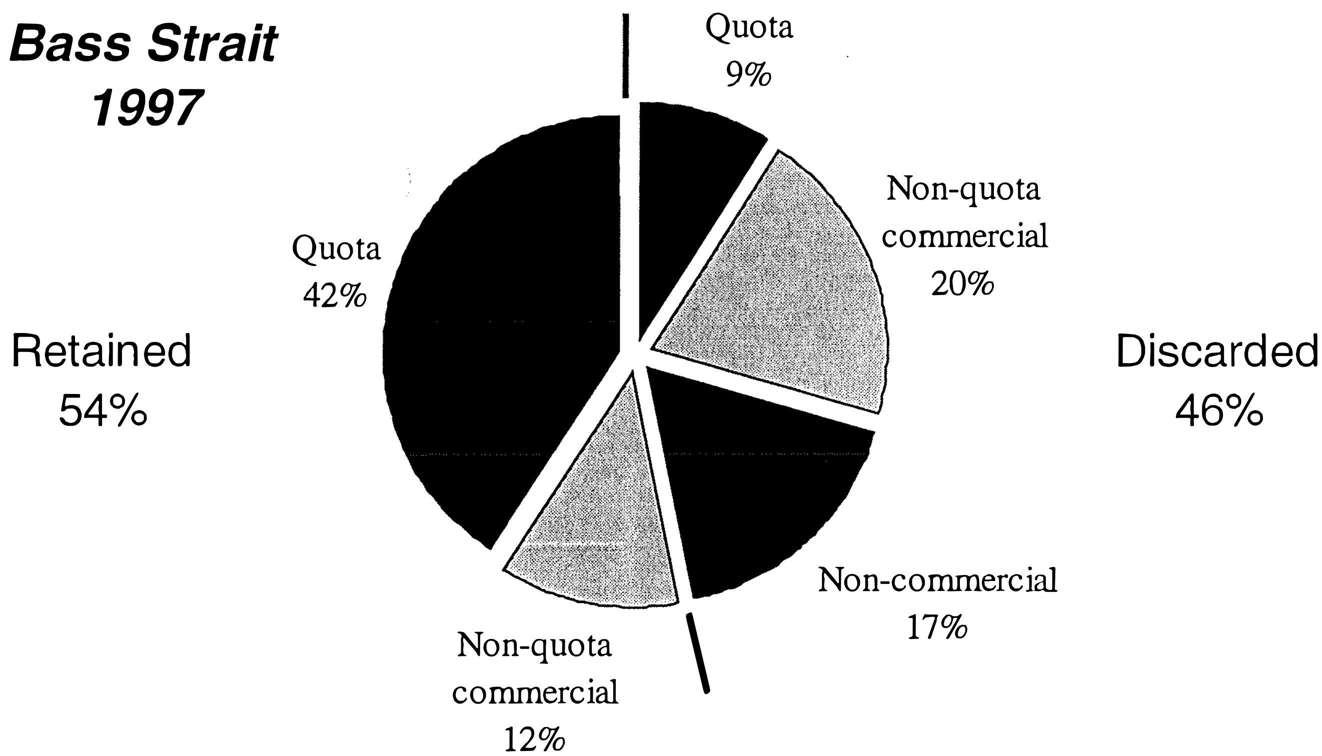


Figure 7 *Percentage (by weight) of quota species, non-quota commercial species and non-commercial species in the retained and discarded catch of SEF trawl vessels in Bass Strait during 1996 and 1997.*

Table 16 *Composition of the retained catch (% of total retained weight) from SEF trawl vessels (including Danish seine) working in Bass Strait during 1996 and 1997. (Data from SEF1 logbooks).*

ZONE	1996		1997	
	Species	% of total retained weight	Species	% of total retained weight
Bass Strait	School whiting	55%	School whiting	47%
	Tiger flathead	23%	Tiger flathead	38%
	Octopus	11%	Octopus	3%
	Mixed fish	3%	Mixed fish	2%
	King George whiting	1%	Jackass morwong	1%
	Crabs	1%	Squid	1%
	Angel shark	1%	Red mullet	1%
	Red mullet	1%	Boarfishes	1%
	Gummy shark	1%	Cuttlefish	1%
	Jackass morwong	0%	Gummy shark	1%

Table 17 *Composition of the discarded catch (% of total discarded weight) from SEF trawl vessels (not including Danish seine) in Bass Strait during 1996 and 1997.*

ZONE	1996		1997	
	Species	% of total discarded weight	Species	% of total discarded weight
BASS STRAIT	Cocky gurnard	21%	Skates	13%
	Ruddy gurnard perch	10%	Cocky gurnard	12%
	Skates	9%	Spotted swellshark	10%
	Barracouta	8%	Spotted warehou	9%
	Jack mackerel	6%	Jack mackerel	7%
	Globefish	5%	Globefish	4%
	NZ Dory	4%	Port Jackson shark	4%
	Bugs	4%	Draftboard shark	3%
	Mirror dory	4%	Blue grenadier	3%
	Dogfish	3%	Southern frostfish	3%
	John dory	2%	Leatherjackets	2%
	Jackass morwong	2%	Ling	2%
	Spotted swellshark	2%	Toothed whiptail	2%
	Cucumber fish	2%	Dogfish	2%
	Whiptails	2%	Melbourne skate	2%
			Barracouta	2%
			Sponge	2%
	Other species	17%	Other species	19%

Maximising yield and reducing discards in the South East Trawl Fishery

Workshop 30-31 July 1998

Options for gear modifications to increase the selectivity of demersal fish trawls in the SETF

Presented by

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Options for gear modifications to increase the selectivity of demersal fish trawls in the South East Trawl Fishery

This paper is a brief review of gear modifications that can be made to increase the selectivity of a demersal fish trawl. These modifications range from simple alterations to existing trawl gear to the use of relatively complex separator panels and grids. A few of these modifications have already undergone preliminary testing in the South East Trawl (SET) Fishery and their results are discussed here. Wherever possible, attempts have also been made to comment on the suitability of these modifications to the SET Fishery.

Historically, research into trawl selectivity has focussed mainly on the codend. This is because during the fishing operation the codend is where the majority of fish selection takes place. Codends have traditionally been constructed from diamond mesh netting, however, their ability to allow fish to escape is limited because diamond meshes tend to close as the codend fills with the catch. The region where fish can escape is therefore restricted to a narrow band of 'open' meshes immediately ahead of the catch.

In recent years, technological advance coupled with a greater understanding of fish behaviour has lead to the development of new methods to increase trawl selectivity. These methods are based on one of two techniques. The first technique is based on utilising behavioural differences between various fish species, and examples include separator trawls, groundgear modifications and alterations to sweeps and bridles. The second technique utilises size differences between various species, and includes the use of inclined grids, a range of codend rigging modifications and square-mesh netting.

1. Selection based on fish behaviour

Separator trawls

A separator trawl relies on behavioural differences between fish and other animals to separate the catch into species groups. This trawl is designed with a horizontal panel of netting that effectively divides the trawl into two compartments (Figure 1). Each compartment leads to a separate codend or escape opening to allow unwanted fish to escape. During the fishing operation, many animals enter the trawl and exhibit species specific behaviour. This may include attempts to swim with the trawl, under the groundgear, over the headline or simply straight into the trawl. By careful design and placement of the panel, separation of many species and their escape or retention into separate codends is possible. Careful selection of mesh size in each codend will then allow the size selection of fish to be optimised.

Valdemarsen *et al* (1985) tested a separator trawl in the Barents Sea and found that 70% of cod (*Gadus morhua*) and almost 100% of plaice (*Pleuronectes platessa*) entered the lower compartment while up to 70% of haddock (*Melanogrammus aeglefinus*) entered the upper compartment. In the North sea this type of trawl has been successfully used to separate Norway lobster (*Nephrops norvegicus*) from finfish species such as haddock and whiting (*Merlangius merlangus*). Through direct observations using underwater cameras, researchers at the Marine Laboratory in Aberdeen, Scotland, found that *Nephrops* rise less than 70cm above the seabed when approached by the trawl while most

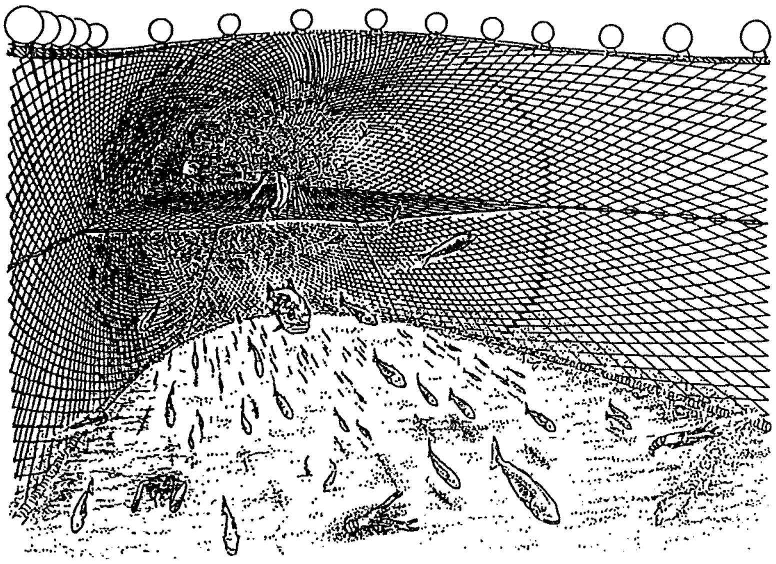

Figure 1. A separator trawl showing the horizontal separator panel (Galbraith and Main, 1989).

finfish rise above this height. Subsequent tests with the separator panel at this height resulted in 100% of *Nephrops* and almost 95% of groundfish (skates, flatfish etc) caught in the lower compartment while over 90% of haddock were caught in the upper compartment (Galbraith and Main, 1989). They also found that trawl drag was not significantly increased by the addition of the separator panel. In Alaskan waters this type of trawl was used to reduce the bycatch of halibut (*Hippoglossus stenolepsis*) while catching Pacific cod (*Gadus macrocephalus*). The separator panel was located about 0.5m above the lower panel so that bottom dwelling halibut and other species could be excluded from the trawl through an escape opening in the lower panel. The results showed that over 40% of halibut but only 6% of cod were excluded from the trawl (Stone & Bublitz, 1995).

In 1984, the Australian Maritime College (AMC) tested the performance of a cut-away wing trawl fitted with a horizontal separator panel. The design and rigging of the separator panel was initially determined from scale model tests in the flume tank and was followed up with full scale tests off the east coast of Tasmania in depths ranging from 30m to 600m (Table 1 & 2). The height of the separator panel was 2m above the lower panel and trawl headline height was 6 – 7m.

Table1. Catches from 4 reciprocal daylight tows in 128 - 152m.

Species	Top codend		Bottom codend		Total catch (nos.)
	% of total catch	Size range (cm)	% of total catch	Size range (cm)	
Flathead	0	-	100	31 - 54.5	73
Latchet	0	-	100	24 - 44	359
Morwong	1.6	29 - 39	98.4	22.5 - 39.5	2438
J. Mackerel	64.5	22 - 39	35.5	24.5 - 37	2342
Spotted trevalla	27.1	28 - 40.5	72.9	24 - 36	1239

Table 2. Catches from 4 daylight tows in 290 - 608m.

Species	Top codend		Bottom codend		Total catch (nos.)
	% of total catch	Size range (cm)	% of total catch	Size range (cm)	
King dory	2.8	26 – 45	97.2	17 – 59	533
Ling	4.2	66 – 70	95.8	49 – 101	165
Grenadier	59.1	54 – 95	40.9	39 - 80	44
Perch	0	-	100	21 - 47	248

The above results suggest that separator trawls have some potential in the South East Trawl (SET) Fishery, however, further work is required to fine-tune the trawl for optimum species selection. The advantages of using this trawl commercially include the ability to increase size selectivity should smaller species be caught predominantly in one or the other codend. This would be achieved by increasing codend mesh size to retain the larger fish while allowing small fish to escape. The upper or lower codend can also be left open to allow the escape of selected species such as bycatch or those for which the fisher either has no quota or chooses not to utilise his quota. Alternatively, one of the compartments may simply lead to an escape opening to allow fish to escape. The quality of fish caught in this trawl should be improved through reduced sorting times and contact with animals with spines or hard shells. Should the lower panel be damaged, the trawl also has the ability to continue fishing effectively. The major disadvantage of this type of trawl is its increased complexity in terms of design, rigging and maintenance.

Groundgear modifications

The modification of groundgears as a means of increasing trawl selectivity is a method that with few exceptions does not appear to have been widely tested. Existing groundgear designs have been developed mainly by fishers using a trial-and-error approach, with the aim of ensuring that the trawl maintains seabed contact and can safely pass over obstacles without sustaining damage. In all likelihood scant regard has been paid to designing groundgear to reduce the capture of specific fish species.

In the early 1990's, DeAlteris *et al* (1996) attempted to reduce the capture of bycatch in the Northwest Atlantic bottom trawl fishery. This fishery targets silver hake (*Merluccius bilinearis*) using demersal semi-balloon trawls constructed from small mesh netting measuring 76mm (3") or less. This work was the result of concerns over the capture of juvenile flatfish that are a staple part of the adjacent Northwest groundfish fishery, as well as a management plan that regulates the bycatch of 'regulated' species to 5% or less of the total catch. Footrope length for all trawls was 34.1m (112.0 ft) and the control trawl was rigged with an equivalent length of 10mm chain groundgear (Figure 2). Experimental trawl No. 1 was fitted with 8mm dropper chains of varying lengths, ranging from 330mm at the wingends to 940mm in the bosom. Experimental trawl No.2 had the centre seven dropper chains and adjacent groundchain removed, thus providing an escape gap near the bosom of the lower panel measuring approximately 4.6m long x 0.6m high. Experimental trawl No. 3 had the height of the droppers reduced by half, although the escape gap remained the same size as trawl No. 2. Experimental trawl No. 4 had the escape gap reduced to 2.1m and dropper height also reduced by half.

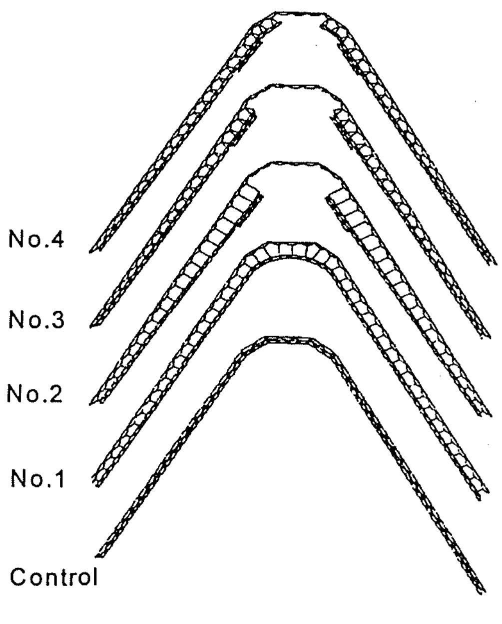

Figure 2. Groundgear arrangements for the control and experimental trawls (DeAlteris et al, 1996).

Compared to the control trawl, only experimental trawl No. 4 resulted in significant reductions in flatfish bycatch while maintaining catches of silver hake (Table 3). All other experimental trawls either maintained catches of flatfish bycatch or lost significant amounts of silver hake (DeAlteris *et al*, 1996).

Table 3. Catch results from groundgear modifications in the Northwest Atlantic bottom trawl fishery (DeAlteris *et al*, 1996).

	Experimental trawl No. 1 (n = 6)		Experimental trawl No. 2 (n = 13)		Experimental trawl No. 3 (n = 9)		Experimental trawl No. 4 (n = 5)	
Species group	Weight (kg) Control	Weight (kg) Trawl No.1	Weight (kg) Control	Weight (kg) Trawl No.1	Weight (kg) Control	Weight (kg) Trawl No.1	Weight (kg) Control	Weight (kg) Trawl No.1
Silver hake	43.3	31.0	3505.3	875.4**	759.0	236.0*	98.6	128.5
Red hake	0.0	0.0	3501.7	217.3**	1022.9	64.5*	68.8	39.5
All flatfish	85.7	90.5	1145.6	25.9**	829.0	48.2**	424.3	16.4*
Sharks/skates	695.1	647.9	5213.5	244.2	3116.3	227.0	1782.2	83.3
Other	665.8	698.7	3383.1	836.5	2792.9	544.2	807.8	218.0
Total catch	1489.9	1568.1	16749.2	2199.3	8250.1	1119.9	3181.7	485.7
Regulated flatfish	85.7	84.7	241.8	4.3	381.5	26.0	332.7	13.0
Regulated groundfish	339.1	580.7	241.8	4.5	381.5	26.5	333.2	22.0

*P-value < 0.05; **P-value < 0.01

The above results also suggest that increasing dropper length may be another option to reduce bycatch. Stone & Bublitz (1995) tested this groundgear modification in conjunction with separator panel tests and found that it allowed large numbers of flatfish to escape from the trawl.

These modifications may have some application in the SET Fishery as a means of reducing catches of bottom dwelling bycatch species and debris. They may also be suitable to reduce the capture of bottom dwelling quota species such as tiger flathead (*Neoplatycephalus richardsoni*), ocean perch (*Helicolenus* spp.) and school whiting (*Sillago flindersi*) where this is a desired outcome.

Sweeps and bridles

The main role of sweeps (and to a lesser extent bridles) is to herd fish towards the trawl mouth. Factors which influence the successful herding of fish is sweep length and angle relative to the towing direction (commonly referred to as angle of attack). Generally speaking, longer sweeps will catch larger fish as smaller fish may become exhausted by the herding process, be overtaken by the sweeps and subsequently escape. Engas (1994) found that catch rates for larger cod and haddock increased with increased sweep length while smaller fish were increasingly under-represented in the catch (Figure 3).

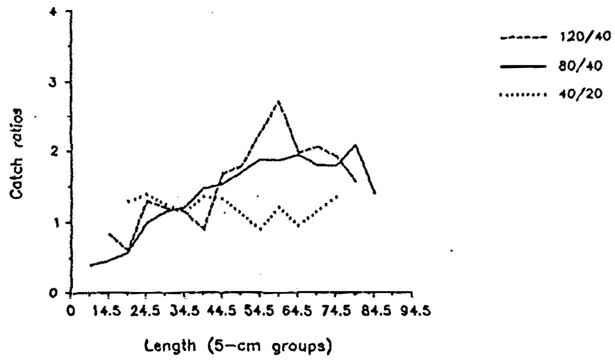

Figure 3. Comparison of cod catch ratios (catch with long sweep/catch with short sweep) by length (Engas & Godo, 1989).

To efficiently herd fish, sweeps are normally rigged at angles of attack between 10 and 20°. Strange (1984) found that the catching efficiency for cod and haddock was significantly reduced at sweep angles greater than 20 °, however, in recent years New Zealand fishers have been using sweep angles of 30° or more when targeting blue grenadier (*Macruronus novaezelandiae*). The angle of attack also affects the speed that the fish must swim to avoid the approaching sweep and be herded towards the trawl mouth. Referred to as the herding speed, this is the product of towing speed and the sine of the sweep angle (Table 4). Note that fish are not forced to swim at the towing speed when sweep angle is within the normal range, and that it is only when the angle approaches 90° (ie. when they are in the trawl mouth) are they forced to swim at similar speeds to the towing speed. At higher sweep angles fish will therefore have to make an increased number of avoidance manoeuvres and at higher speed. Small fish may then become exhausted quite quickly and escape from the trawl.

Table 4. The relationship between herding speed and towing speed.

Towing speed (kts)	Sweep angle (degrees)	Herding speed (kts)
3.0	10	0.5
3.0	20	1.0
3.0	30	1.5
3.0	90	3.0

2. Selection based on fish size

Sort X and other grids

The Sort X grid was initially developed to reduce the capture of small redfish (*Sebastes* spp.) in the Barents Sea. Previous tests in this region found that square-mesh codends were often unsuitable to reduce catches of this species due to high catch volumes and subsequent masking of mesh openings. The Sort X grid consists of two separate rigid grids connected to a canvas guiding frame (Figure 4). This frame guides escaped fish away from the trawl and keeps the Sort X system balanced during the fishing operation. The two grids are fixed to the trawl at an angle of attack to the towing direction and small fish pass through the bars and escape. Large fish are prevented from escaping and the grids guide these animals towards the codend. The Sort X is usually located in the trawl extension and the distance between the second grid and the lower panel of the trawl is approximately 20 to 30cm. The Sort X comes in a variety of sizes and a cassette system allows rapid removal of the bars and changing of bar spacing. The selection of fish from the trawl using this system is independent of catch

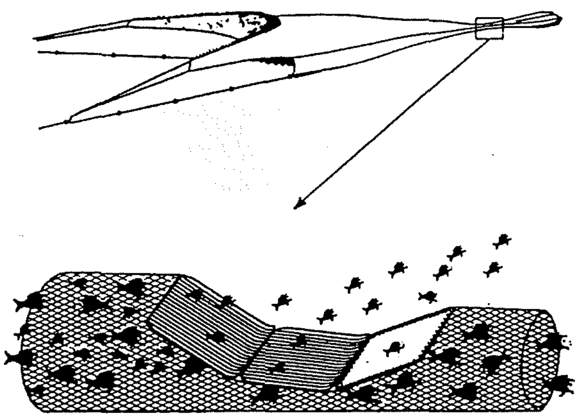

Figure 4. The Sort X grid with location and sorting principle shown (Larsen & Isaksen, 1993).

rate and volume, and up to 95% of small cod and haddock have been excluded using this device (Anon). The manufacturers of this grid claim that its use allows small fish to escape more rapidly than diamond or square-mesh codends as the fish do not need to alter their swimming position to escape; this being more difficult at higher towing speeds. Furthermore, they claim that the Sort X remains effective when catch rates are high as the individual escape openings are larger and less prone to blockage, and the likelihood of encounter with these openings is higher. The Sort X grid has potential for use in the SET Fishery to exclude small and/or juvenile fish from the trawl although tests would need to be required to determine the optimum bar spacing and grid size that can be towed efficiently and safely by the trawlers.

In 1992, the Canadian Department of Fisheries and Oceans (DFO) tested a single inclined grid off the coast of Nova Scotia in a fishery that targets silver hake. This species usually ranges in size from 15 to 40cm and is considerably smaller than other groundfish species such as haddock (35 to 60cm) and cod (40 to 110cm). The grid measured 1.4m x 2.0m and was located in the extension of a demersal trawl (Figure 5). Grid angle was 45 to 50° and bar spacing was 40mm. A funnel of netting immediately ahead of the grid was used to guide all animals to the lower section of the grid. A second codend was attached to the top of the extension to retain all animals that would normally be excluded by the grid. Based on 32 tows the results showed that 93% of silver hake passed through bars of the grid and

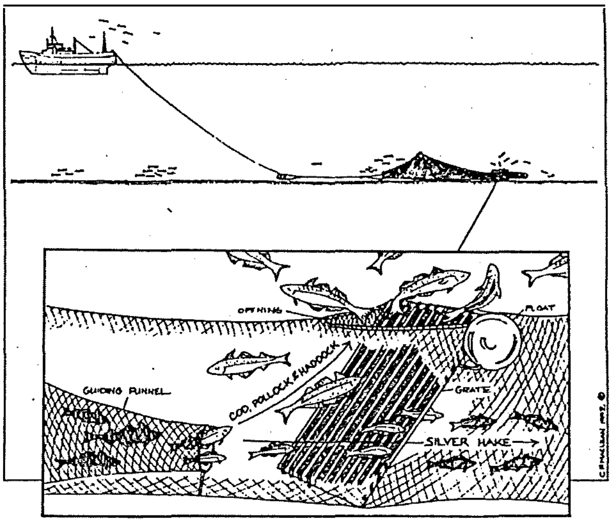

Figure 5. Rigid separator grid with location and sorting principle shown (Anon, 1992)

were collected in the codend. Pollock (*Theragra chalcogramma*), haddock and cod exclusion rates were 96%, 95% and 92% respectively. Interestingly, almost 50% of pollock and haddock that were small enough to pass through the bars swam instead though the escape opening and were collected in the second codend (Anon, 1992).

These grids are usually smaller in size than the Sort X grid and are only suitable for excluding animals larger than the target species. In New Zealand similar grids have been tested to exclude seals and other large animals from midwater squid trawls.

Increased trawl mesh size

There appears to have been little attempt to investigate the effect of larger mesh in the body of the trawl on the selection of fish. In one notable exception, DeAlteris *et al* (1990) compared the catches of a demersal trawl constructed entirely from 140mm mesh (including the codend) and a second trawl constructed from 120mm mesh in the wings and main trawl body, 108mm in the extension piece, and 140mm in the codend. From a total of 32 paired alternate hauls each of approximately 150 minutes duration, no significant difference was found in the numbers or length-frequency distribution of cod, haddock and yellowtail flounder (*Limanda ferrugina*). Presumably this result supports the premise that selection occurs mainly in the codend and that mesh size in the body of the trawl has little effect on fish catches.

This modification could be quickly and cheaply tested in the SET Fishery to measure the reduction (if any) on catches of rocks and other bottom debris, and small bottom dwelling animals such as sponges, starfish and fish.

Codend design

Although the selection of fish occurs throughout the catching process, from the time the fish first become aware of the trawl up until they reach the codend (or escape from the trawl), it is usually in the codend where the majority of fish selection takes place. All things being equal, the larger the codend mesh size the greater the number of small fish that can escape. However, the ability of fish to escape from the codend is also affected by catch rate and volume, mesh orientation and codend design. Codends are usually constructed from diamond mesh netting. As catch volume increases these codends adopt a bulbous shape and tension in the meshes is increased. Meshes in the fore part of the codend then become almost totally closed with only a narrow band of meshes immediately ahead of the catch open sufficiently for small fish to escape (Figure 6a). If catch rates are high, fish pressed up against the netting may quickly block these meshes. The addition of (lastridge) ropes 'hung' along the length of the codend will go some way to preventing mesh closure, providing the length of each rope is less than the stretched length of the codend. These ropes will also limit the extent to which the codend adopts a bulbous shape, although ropes extending around the circumference of the codend (beckets) will further reduce this problem. Another option for maintaining open meshes is to reduce the circumference of the codend while maintaining the circumference of the extension piece. This will have the effect of 'forcing' the codend meshes to remain open.

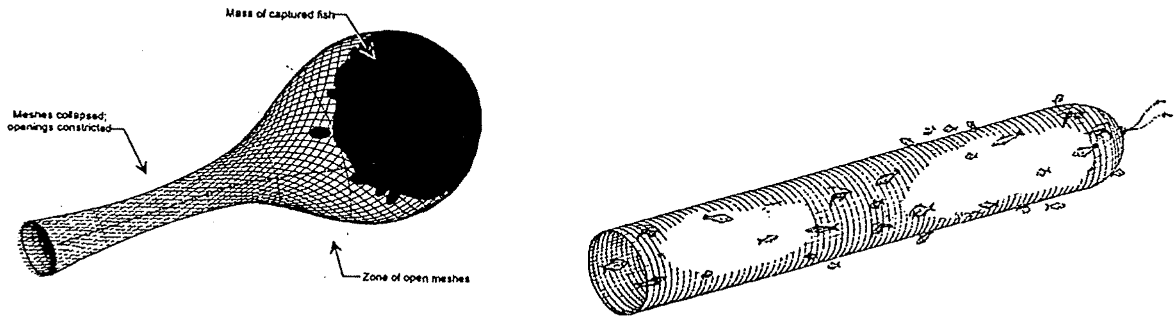

Figure 6. a) A traditional diamond mesh codend (Loverich, 1995) and
b) a square-mesh codend (Eayrs et al, 1997).

Fish caught in the SET Fishery come in a wide range of body shapes and sizes, however, most fishers use a double braided polyethylene codend constructed from diamond mesh netting and a nominal mesh size of 95mm. The likelihood that this is the optimum mesh size to maximise the selectivity of all species is doubtful and the potential for further research is high. Some SET fishers also use codend beckets and while the rope is usually hung along the length of the codend (at both codend seams), underwater observations by the AMC suggest they have little effect on mesh opening.

Square-mesh codends

Square-mesh codends are designed to reduce the capture of small fish and other animals. Unlike diamond mesh netting square-mesh retains its cylindrical shape irrespective of catch volume, and as the mesh openings do not close under load, small fish can escape along the entire length of the codend (Figure 6b). Square-mesh codends can be constructed either from knotted or knotless netting, however, in the case of the former knot slippage can result in mesh distortion and altered selectivity characteristics. In comparing 120mm diamond and square-mesh codends in the Alaskan pollock fishery, Bublitz (1995) reported that the square-mesh reduced the catch of small pollock (<39cm) by 73% with only a 3% reduction in marketable fish. Cooper and Hickey (1988) found that square-mesh codends between 130 to 155mm had similar selection characteristics to diamond mesh codends with a mesh size 10 to 15mm larger. They also found that for cod, haddock and pollock, square-mesh codends of equivalent size to diamond mesh have: higher 50% retention lengths (L_{50}); higher selection factors (L_{50}/mesh size); and lower selection ranges ($L_{75} - L_{25}$). However, for flatfish species the diamond mesh was more effective in releasing juveniles. Disadvantages of square-mesh codends include material wastage when constructed from a panel of diamond mesh netting and a lack of material availability. Initially, mending of knotless material is more difficult than traditional material, however, with some experience this problem is quickly overcome. The advantages of knotless material include a more uniform mesh shape and reduced abrasion damage to fish due to the absence of knots.

With few exceptions square-mesh codends have not been extensively studied in the SET Fishery. The AMC is currently testing various square-mesh sizes using a trouser trawl and preliminary results suggest that the potential for excluding small fish is high.

Square-mesh windows

The use of square-mesh windows has been extensively studied overseas, however, in Australia its use has been limited. Square-mesh windows have been tested in a variety of locations in the upper panel of the trawl including the codend, extension piece and near the bosom of the headrope. They have proven to be particularly effective in fisheries whereby particular species (such as haddock) exhibit distinctive upward escape reactions. Arkley (1990) reported that the use of 80mm square-mesh windows (measuring 4m long and 30 bars wide) in 70mm *Nephrops* trawls reduced discards of haddock by 47% and marketable haddock by 6%. The use of these square-mesh panels in this fishery is due to become mandatory in January, 2000 (Tait, pers comm. 1998). In Maine, USA, square-mesh panels extending along the length of the footrope have been used to successfully exclude starfish, crabs and bottom debris from shrimp trawls (Eayrs, pers obs.).

Conclusion

This paper has attempted to review a number of modifications that can be made to increase the selectivity of a demersal trawl. All of these modifications have been tested in the Northern hemisphere and many are based on an understanding of the behaviour of both target and non-target species in that part of the World. All of these modifications have some application in the SET Fishery, however, their success or otherwise will be largely influenced by the behaviour of fish and other animals in this fishery and the ability of fishers and researchers to utilise this knowledge. To date, this knowledge is scant, being limited mainly to the intuition and experience of SET fishers and published research from overseas. While other options for obtaining this information includes the use of large aquaria or divers visually observing the trawl, the development of portable low-light underwater cameras that can be used onboard commercial trawlers offers greater flexibility over a wide range of fishing conditions. The use of underwater cameras will allow the development of modifications based on behavioural differences. They will also provide invaluable information about the performance of size selection modifications and the behaviour of fish to these modifications. In short, the use of underwater cameras will fast-track the development of modifications to increase trawl selectivity.

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Maximising yield and reducing discards in the South East Trawl Fishery

Workshop 30-31 July 1998

Introduction of gear modifications to reduce bycatch in fish trawls - overseas case studies

Presented by

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A Review of Fish Behaviour in Relation to Species Separation and Bycatch Reduction in Mixed Fisheries

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SUMMARY

Clear differences in reaction behaviours have been observed between different species of fish and also between fish and invertebrates and these have lead to the separation of many species of fish and invertebrates in fishing gears. The same observations have led to extensive basic studies of the physiological limits that determine the ability of each species to react to a stimulus. A summary of publications on the thresholds and limits to behavioural response, is presented. Recent examples of the applications of separation techniques involving differences in behaviour are reviewed. It is clear from these that where research effort has been applied there is a rapid development of existing ideas to meet the needs of particular fishery problems. It is noticeable how successful the developments have been when the research effort has been directed by effective teams to investigate and solve their local problems. This is particularly clear with the evolution of systems to separate shrimp or prawns from juvenile fish. One approach, and apparently the most successful, aims to exclude all active swimming fish, the other tries (less effectively) to compromise and retain the larger fish as part of the marketable catch. There has been much less research published on techniques to separate fish species yet there are many groups of fish species with potential for separation.

INTRODUCTION

Observations of species differences in reaction patterns of behaviour when stimulated by towed gears have been made over the past 35 years by many different methods although the use of towed observation vehicles like the Aberdeen divers vehicle and remote controlled towed vehicles carrying TV and flash cameras have been the main source of observations since 1975 (Wardle and Hall, 1994). The diving observations by a large team at the Aberdeen Marine Laboratory betwee 1965 and 1970 of the Scottish seine net reported by Hemmings (1973) were the first to show clear examples of differences in the reaction behaviour of fish species. Flat fish being herded close to the sea bed by the ropes, exhausted in the mouth of the net and rising only enough to clear the ground rope when falling back. Haddock stacking high in the narrowing net mouth and surplus fish overflowing the headline as it closed and saithe diving under the raised ground rope when droppers were used. These studies were followed by many more diving and remote controlled towed vehicle (RCTV) observations from 1975 to the present and form a foundation for many of the recent practical developments (Wardle 1983, 1985, 1993). The observations such as those above have led to practical experiments where it was shown how fish species could be sent to different cod-ends depending on their reaction behaviour in the mouth of the trawl net (Main and Sangster, 1982a).

Fish behaviour was of course made use of in the evolution of species specific gears. Danish seines for flat fish had a low headline and great care was taken that the herding ropes and ground line pressed hard on the sea bed. Prawn trawls were made wide to sweep the sea bed but with low headlines to leave out those fish that rise. Beam trawls towed fast catch mainly flats and other ground hugging species. Herring and haddock trawls need high headlines and even kites rigged above the net to drive the naturally rising fish down. Some of the separation issues are due to the economic need for the fishermen to catch more than just the target species so he used a high headline net for prawns that also caught the haddock. He then needs a system to let out the increased numbers of juveniles trapped and so on.

The issue of bycatch of both fish and turtles in the northern Gulf of Mexico penaeid shrimp fishery, where 70% of the discarded fish are important juveniles to the demersal fishery, has generated a long series of research projects summarised by Watson (1988). These included development of diving observations and experimental work and culminated in a status report in which some 51 conceptual designs for bycatch reduction have been evaluated (Watson *et al.*, 1993). The objectives were to evaluate existing by-catch reduction techniques; collect data on the behaviour of fish and shrimp when encountering shrimp trawls etc.; develop and evaluate new by-catch reduction techniques. It was found that reduction for individual fish species varied according to the designs. In some designs they achieved 50% reductions of fish bycatch while retaining 90% of the shrimp. Both in Norway and Australia major research efforts have been devoted to developing new approaches to separate species in trawl fisheries.

Since publication of the Bergen ICES symposium on Fish Behaviour in relation to fishing operations in 1992 (Wardle and Hollingworth, 1993), which discussed a number of papers on both species and size separation, there have been many new developments and these publications lead the reader into the various practical aspects of species separation and these are reviewed and their findings in this context briefly outlined below.

Species Differences in Reaction Behaviours and Their Limits

General principles

Observation of the differences in the behaviours observed in nets has led to basic research that looks into the reasons why. Most behaviour can be explained as a response to a stimulus where the response is limited by the abilities of the fish. It is important to realise that these responses have evolved within the evolution of each species of fish as part of its general biology in relation to its adaptations to its natural environment see

Ferno (1992). The ability of the fish to respond is limited by performance thresholds that are in turn set by the physiological adaptations of the particular species. In poikilotherms such as the teleosts and the invertebrates caught in commercial fisheries, change in sea temperature can raise or lower such thresholds. Some species can compensate for such changes others do not.

Swimming ability

A simple example of species separation will occur in any trawl when similar sized pelagic and demersal fish are herded together in the mouth of the trawl. For example a group of mackerel (*Scomber scombris*) might be seen out-swimming a group of saithe (*Pollachius virens*) of the same size which are being exhausted and dropping back to the cod-end. The saithe are caught and the mackerel swim away and the speed and size relationships are explained by studies of endurance swimming performance such as He and Wardle (1988). A survey of thresholds for swimming ability are published in a review by Videler and Wardle (1991).

Light and sound

Behavioural thresholds for some species for light level reactions have been demonstrated Glass *et al.* (1986), Glass and Wardle (1989), Cui *et al.* (1990) and Walsh and Hickey (1993). The role of sound in towed fishing gears has been discussed in Wardle (1993) and more recently the sensitivity of fish to infra sound seems to be species specific Enger and Karlsen (1993). There may be scope for careful application of sound. For example exploiting the very different hearing abilities of mackerel and herring but these do not yet appear to have been found in practice unless they occur unknowingly in purse seine or drift net fisheries. Local sound generated by humming wires attached to grids has been tried by Watson *et al.* (1993) to help deter fish from passing through shrimp grids.

A Review of Recent Published Findings

Shrimp, prawns and juvenile fish separation

A major, worldwide problem is the capture of large quantities of juvenile fish in trawls constructed with small mesh cod-ends which are needed in order to capture the smaller shrimp and prawns. Many of the recent published studies are biased towards the assessment and development of methods to deal with shrimp fish separation. Some of these studies in experimenting with the various gear modifications have incidentally noticed changes in the range of fish species caught indicating some effects are species specific.

The by-catch of a turbid water penaeid prawn fishery off South Africa showed 109 mainly juvenile species of teleost fish with a few species only dominating in weight and number. Slow towing speed was significant in avoiding capture of larger pelagic fish species. A detailed study showed that season (as cool and warm samples) and depth (as shallow and deep samples) had significant influence on availability of some teleost species but all were present in significant quantities throughout the year (Fennessy *et al.*, 1994).

A detailed study looked at the species caught in shrimp trawls off Greenland. It shows the importance of the conflict between capture of shrimp in this case *Pandalus borealis* and the damage to juvenile commercial fish species growing up in the same area such as redfish, Greenland halibut, cod and 40 other species sampled in the 40 mm shrimp nets (Pedersen and Kanneworff, 1995).

A number of groups are tackling related problems in Australian shrimp fisheries and productive experimental work is being reported. Andrew *et al.* (1991) compared the catch composition of a variety of rigs of one size of trawl net. These ranged from single trawl with no sweeps to trawl with long sweeps and triple trawl rigs where three trawls are towed side by side with no sweeps. The experiments were carried out at around 30-40 m at night in the summer. The authors show that the herded reactive swimmers such as the larger finfish (red spot whiting, *Sillago bassensis* and sand flathead, *Platycephalus caeruleopunctatus*) are increased relative to the prawns (*Penaeus plebejus* and *esculentus*) and shovelnose lobsters (*Ibacus* spp.) when long sweeps are used on the single trawl, whereas the triple trawl which is now used by many of the Australian fishermen catches more of red spot whiting but not sand flathead.

Light level was not measured during these tests but by computing solar constants for these dates, at 40 metres depth, for 30° south, on 5 December through 12 December, it can be estimated that light level does not go below minus 4 Log lux and there was a moon raising this light level during the evening of the 5th but all night on the 12th (Kim, pers. comm.). The positive effect of sweep herding on the larger finfish is discussed by Andrew *et al.* (1991) in relation to the findings of the few previously published studies made when the Vigneron Dahl gear was first introduced in the 1920s. The non reaction of the invertebrate species to the sweeps is discussed in relation to published work on *Nephrops* reactions. The authors point out that species specific differences in vulnerability to capture by trawls using long sweeps have clear implications in fisheries management confirming similar work such as that reported by Engas and West (1987), Engas and Godo (1989) and Mahon and Smith (1989). They conclude that long sweeps do effect the species composition of the trawl in this fishery and this feature could confidently be regulated to reduce fish catches.

A major problem in the Australian trawl fishery for prawn and shrimp species as in many parts of the world is the large part of the catch is made up of juvenile fish trapped by the small meshes needed to trap prawns (Robins-Troeger, 1994). In the Australian prawn fisheries these fish can weigh anything from six to 15 times the weight of the prawn catch (Robins-Troeger *et al.*, 1995). Robins-Troeger (1994) describes how the Morrison soft turtle excluder, made from 150 mm monofilament mesh, when fitted eliminated catch of turtle and increased loss of unwanted juveniles of commercial species by 30% there were problems in loosing prawns and marketable crabs.

Andrew *et al.* (1993) showed how in an offshore fishery the fitting of the Morrison soft TED did not reduce the prawn or invertebrate catch but did reduce the discards by 32%. These contained 15-25 species of non commercial benthic teleost fish and invertebrates but also significant juveniles of commercial species as well. The very variable and conflicting findings of other studies are reviewed and discussed in Robins-Troeger (1994) and lead to the conclusion that these nets vary in their performance in different fisheries and conditions. The same research groups in Australia report the development of a more effective AusTED which when tested in a variety of fishing conditions did not loose any of the valuable prawn catch but did reduce the turtle and juvenile fish catches. The device is described by Mounsey *et al.* (1995) and results from the test are in Robins-Troeger *et al.* (1995). More recent work by the Australians has looked at the use of the Nordmore grid (see below, Isaksen *et al.*, 1992) in these fish shrimp fisheries and where the by-catch is not of value to the fishermen this system is now used in preference to the TED types mentioned above (Broadhurst pers. comm., 1995).

In a fishery where the adult fish are needed to supplement the catch the difference in reactivity of Australian prawns and fish is made use of in an application developed by Broadhurst and Kennely (1994).

Prawns (three species were studied) behaved quite differently from finfish in this study where 54% of the fish (mulloway) left the net via a square mesh panel ahead of the cod-end whereas the prawns did not show any loss. Prawns were lost if the whole cod-end was square mesh. The author reviews observations of behaviour and concludes that the reactive swimming responses of fish cause these to leave in a size selective fashion whereas the non-reactive behaviour of prawns lets these drift past the square mesh window to the cod-end. When square meshes are present in the rear most part of the cod-end, the prawns leak out through the open meshes during the haul or haul back. This finding was similar to that of Briggs (1992) where RCTV observations showed how the invertebrate *Nephrops* scuttle along the base of the trawl whereas many of the small undersize whiting find their way up and through the top square mesh panel of this net. Comparative fishing with twin trawls showed the system to conserve the *Nephrops* within the net while loosing most of the juvenile whiting.

The first studies in separation were those showing how *Nephrops* could be separated from finfish simply by introducing a horizontal separating panel 70 cm above the ground line in a high opening Boris dual purpose fish/prawn trawl Main and Sangster (1982b). In this case diving observations had concluded that *Nephrops* never rose more than 70 cm from the sea bed whereas many of the small and large fish species tended to rise up over the ground line and the separating panel if this was staggered back from the ground line.

Use of net colour

It is interesting that the square mesh panel used by Briggs (1992; Fig. 7) is white whereas the net is darker the author describes the whiting trying to pass through the diamond meshes just ahead of the white panel and then emerging through the first lines of open square white meshes. However there is an indication that lights were used during the camera observations (p147) and presence of artificial light would modify the net colour pattern as seen by the fish from the inside. In natural light the behaviour might be different.

Both the last approaches involve retention of the larger fish by the square mesh panels. The problem here has always been to make all the active fish attempt to leave via the selection panel whatever their size so that all are tested for size. The natural reaction of fish to panels is that they keep clear of them and pass along the central space. However recent findings investigating this behaviour have shown that the natural behaviour can be switched to trying to pass outside the cod-end tube if this is made to appear like an approaching preditory mouth to the fish funnelled towards it from the net mouth. The illusion can be built into the net as a defined change in contrast of the net material. As mentioned above, this has been used unconsciously in a number of studies due to the random nature of the colour of available panels of different mesh sizes. The black mouth or black tunnel experiments and application in a cod end are reported by Glass *et al.* (1995) and Glass and Wardle (1995) and have implications for both species and size selection devices of all sorts.

Total exclusion of swimming fish

A different approach for the separation of shrimp was taken in developments in Norway and is described by Isaksen *et al.* (1992). Here the inability of the shrimp to react and swim compared to the dynamic responses and avoidance behaviour of even the smallest teleost fish was observed by Karlsen (1976) when a rising net panel was angled upwards across the funnel of the shrimp trawl. The shrimp pass through the panel to the cod-end whereas the majority of fish rise and pass out through an aperture at the top of the net. Following this finding fishermen in the Norwegian fishery were obliged to fit the panel whenever more than three cod or haddock were caught with each 10 kg of shrimp. One of the problems here was that certain sizes of red fish (*Sebastes marinus*) juveniles were meshed bursting the panel. In 1989 the Nordmore grid was developed and has now replaced this net panel, solving the problem with red fish. Many fishermen volunteered to use the grid even when not required by the law as they had less sorting of the catch. The results with this gear have been so convincing that there is now the compulsory use of the grid in this fishery (Isaksen *et al.*, 1992).

Separation of fish species

There have also been reports on experiments looking at specific effects on the fish species by trawls gill nets and long lines. The subtle differences in capture by towed sampling gears were indicated by Engas and Godo (1989) when one of the species was being lost under the bobbin rig altering the ratios of species sampled. Engas and Soldal (1992) showed the numbers of small (L<30 cm) haddock and cod were greater during day hauls compared with night hauls but the number of haddock were consistently greater when compared with cod in hauls made in daytime compared with hauls at night leading to a shift in the ratio of cod/haddock day and night. They were using a Campelen 1800 trawl with a 4 m headline height in autumn in the Barents Sea at 270-340 m deep. The same trend was not found in winter hauls although the catch rates were lower. The authors concluded that such apparent differences in capture rate probably reflect small differences in the reaction behaviours of the species for example at different light levels or temperatures. Interpreting these catch results as indices for 30 cm cod and haddock in October 1989 they suggested the daytime samples gave 3.3 and 21.5 times the night time value. Species specific reaction behaviour can lead to some species being easily sampled by a particular trawl rig whereas other species seen by other techniques are absent from the trawl catch. A series of related papers on this issue are introduced and discussed by Engas (1991).

Adams *et al.* (1995) compared a survey made using TV camera transets with trawl survey samples from the same deep water grounds and they illustrate big differences in the assessment of species and their abundance. A similar approach comparing observation from a manned submersible and the trawl catch was reported by Kreiger (1993) where densities of Pacific ocean perch (*Sebastes alutus*) were estimated by a 400 mesh Eastern trawl with 14 m wing tip opening and <2 m headline height, with sweeps and board spread of 28 m and found to be about twice the numbers estimated by observation from the submersible. The difference was attributed by the authors to the herding of this species by the trawl sweeps. Densities of other species approached unity with submersible estimates indicating less herding of these species by the sweeps.

Small differences between behaviour of fish species result in numerous artisanal fishing devices being used to catch the fish from different niches of a complex fish community.

In a multispecies fishery such as that described by Gobert (1994) in Martinique, out of 186 species identified in the area 124 are identified in fishermens catches. It is suggested that the diversity of methods of fishing used allows the fishermen to target any of the species and sizes of this demersal resource just by using the appropriate variations in gear which may involve variations in size, shape, mesh size, soak durations, fishing depths and baits etc. This implies that single species or groups of species can be selected by application of an appropriate technique. Angling is well known for its specific aimed nature with specific tackle evolved throughout the world for specific fishing aims. A comprehensive review of species selectivity of long lining by Lokkeborg and Bjordal (1992) indicates that species can be selected by strategic fishing at specific depths or in layers of the right temperature. That baits are related to the foraging habits and preferences can be species specific. That hook design can make the gear more appropriate for a particular species.

Although it might be concluded from some experiments that catch of drift nets would be light level dependent (Fujimori *et al.*, 1990), Yatsu *et al.* (1995) conclude that diel activity patterns are more important in determining the catch rates for different species. However one must admit that visibility of the net (Cui *et al.*, 1991), animal activity (Collette and Talbot, 1972) and their distribution (Clark and Levi, 1988) are all controlled by light level and each affects the behaviour of the fish and so capture by static gears like drift nets with potentially complex results.

Some very similar species such as herring and sprat are found in closely mixed schools according to Tortsen and Gjosaeter (1995). In this case it seems to be due to overlap in need for the same size of food organisms calanoid copepods. When caught by single small beach seine hauls, sprat can occur mixed with herring in any proportion when both species are between sizes 6 to 12 cm (Torstensen and Gjosaeter, 1995; Fig. 8). As the herring grow larger than the sprat quite rapidly their food changes and they are no longer found together.

Gill nets are highly selective gears where the use of appropriate mesh size avoids capture of the juveniles of the target species (Hamley, 1975). A careful study by Petrakis and Stergiou (1995) shows that there are also potentials for selecting single species where the net mesh matches the target and there is no other dominant species of the same size present.

Problems arise within large commercial fisheries where quotas impose pressures on fishermen to be more precise in their fishing techniques. In pelagic trawling, mackerel, herring and horse mackerel can be found apparently in mixed schools of commercially sized fish and a recent study supported by the EU reports experiments both in aquarium and at sea where a search for differences between these species might be used to separate them in a pelagic trawl. Mackerel sink in sea water and must continue to swim to maintain depth, horse mackerel are usually neutrally buoyant and herring may be neutral at the surface but become heavy at depth. These three species will form mixed schools in an aquarium tank and will separate out by gentle chivying of the fish. In fast moving gears their swimming performance characteristics are very similar at the same size. In swimming experiments where they are made to react to netting panels, funnels and barriers all three species show identical responses. There is some indication at sea that if the species are different in size they will show different responses to the presence of selective grids (Marlen *et al.*, 1994).

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Bio

Christopher W Glass, Senior Fisheries Scientist, Marine Fisheries Division

Dr Chris Glass is on sabbatical from The Marine Laboratory in Aberdeen Scotland. He is Director of Manomets Marine Division and currently directs Bycatch Reduction research programs run in conjunction with the Massachusetts Division of Marine Fisheries. These programs examine the applicability of various bycatch reduction devices (developed overseas and in the U.S.) to address some of the problems concerned with capture and discarding of large numbers of undersized (or non-target) fish in New England trawl fisheries.

Before joining Manomet, Glass worked for 14 years as a Senior Fisheries Scientist and Marine Aquarium Manager at The Marine Laboratory in Aberdeen, Scotland. He specialised in the study of fish behaviour and applied his expertise to develop more selective fishing gears. He has extensive experience of European fisheries and apart from the U.K. and Ireland has worked on fisheries projects in Norway, Germany, Holland, and Greece (Crete). Prior to taking up post in Aberdeen he worked as a research diver at the Discovery Bay Marine Lab. in Jamaica and studied fish populations around the coastline of St Helena Island in the South Atlantic Ocean.

Glass has a B.Sc. in Marine Biology and Animal Behaviour from The Queens University, Belfast and a Ph.D. from The University of Glasgow, Glasgow.

Maximising yield and reducing discards in the South East Trawl Fishery

Workshop 30-31 July 1998

Bioeconomic aspects of reducing bycatch

Presented by

David MacDonald

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Bioeconomic aspects of reducing bycatch

The SEF is not unique in wishing to reduce discarding. Fisheries around the world have been working on technological fixes to this problem - mesh size, mesh shape, trawl design, gear type, escape ports - with varying success. However even successful technological fixes have been concluded to have adverse effects on the fishery or ecosystem as a whole - restricting setting on dolphins for Eastern Pacific tuna increases bycatch of other and more endangered species; increased mesh size in the North Sea demersal fishery was concluded to be counterproductive because many of the smaller fish that would be saved were predators on juveniles of important commercial species. Clearly, technological fixes cannot be considered in isolation from the system in which they operate.

Fishers are a major component of the system in which technological fixes have to work. Unless fishers' agree with the need for technological fixes, they can easily subvert bycatch reduction measures. For example in the SEF, fishers use double codends to reduce chafing, but when the mesh size of the outer and inner codends are the same, the overall effective codend mesh size is reduced. Codends can be extended to collapse meshes, rendering any mesh size restriction useless. Specifically designed prawn trawls with separator panels to reduce bycatch can be flown upside down. A Portuguese trawler off Eastern North America was infamously impounded after the discovery of smaller-than-legal mesh nets hidden onboard. In short, technological fixes by themselves may not be sufficient to reduce discarding.

We propose to detail the factors that have been used (successfully or not)to reduce bycatch either in support of, or instead of, technological fixes. Our goal in this scoping exercise is to be inclusive and extensive so that as many potential (non-technological) ideas for bycatch reduction as possible can be identified. A cursory evaluation of each factor (including the level of performance measurement required for each approach) will be undertaken to identify those factors worthy of further and more detailed consideration in the context of the SEF. Specific examples that will be considered may include:

- The New Zealand hoki fishery, where reduction in bycatch restrictions on hake may have led to increased targeting on hake;
- Prawn fishers in NSW estuaries who enthusiastically adopted technological fixes to reduce discards;
- Bering Sea fisheries where almost real-time reporting of discards enables managers to steer the fleet away from areas where bycatch of "illegal" species (salmon and halibut) are high; Bering Sea fisheries and the Tasmanian SRL fishery where seasonal area closures are used to protect spawning stocks of vulnerable species;
- Northern Atlantic fisheries where certain areas (depths) are closed to protect juvenile nursery areas;
- Economic instruments that either penalise or provide benefits for reduced bycatch and improved quality, for example providing rewards for fish caught with more selective gear;
- Basing ITQs on biological value of landed catches (a function of number and size) rather than just biomass; and flexible quota arrangements that encourage better reporting and reduced bycatch.

The form of the scoping exercise would be a brief evaluation of the reported benefits and pitfalls of the different methods with an evaluation of which particular methods had potential for further development as potentially valuable approaches in the SEF.

Maximising yield and reducing discards in the South East Trawl Fishery

Workshop 30-31 July 1998

Copy of the project proposal sent to FRDC

FRDC R&D FUNDING APPLICATION
PART A ADMINISTRATIVE SUMMARY
A1 PROJECT TITLE

Maximising yield and reducing discards in the South East Trawl Fishery through gear development and evaluation.

A2 APPLICANT

Organisation: Marine and Freshwater Resources Institute
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A5 CO-INVESTIGATOR Continued

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A6 PREDICTED COMMENCEMENT AND COMPLETION DATE

Commencement Date	Jul 1998
Completion Date	Jun 2002

A7 PROJECT BUDGET SUMMARY

Contribution by the FRDC (C1 - C4)

Year	Salaries	Travel	Operating	Capital	Total
98/99	217,297.18	35,281.00	149,000.00	30,000.00	431,578.18
99/00	254,412.24	49,455.00	166,000.00	-	469,867.24
00/01	243,501.32	37,245.00	100,000.00	-	380,746.32
01/02	130,000.00	7,778.00	-	-	137,778.00
Total	**845,210.74**	**129,759.00**	**415,000.00**	**30,000.00**	**1,419,969.74**

Contribution by the Applicant (C5)

Year	Salaries	Travel	Operating	Capital	Total
98/99	50,000.00	-	108,648.00	128,250.00	286,898.00
99/00	52,500.00	-	127,206.00	-	179,706.00
00/01	55,125.00	-	121,751.00	-	176,876.00
Total	**157,625.00**	**-**	**357,605.00**	**128,250.00**	**643,480.00**

Contribution by Other Sources (C6)

Year	Salaries	Travel	Operating	Capital	Total
Budget Total	**1,002,835.74**	**129,759.00**	**772,605.00**	**158,250.00**	**2,063,449.74**

A8 CERTIFICATION

The Principal Investigator and the person acting for and on behalf of the Applicant certify that all information contained in and forming part of this application to the Fisheries Research and Development Corporation is complete, accurate and provided in good faith at the date given to the Corporation and that any changes to the information will be notified to the Corporation as soon as possible.

Signed by the Principal Investigator

A8 CERTIFICATION Continued

The principal Investigator and the persons acting for and on behalf of the Applicant and collaborating agencies certify that all information contained in and fonning part of this application to the Fisheries Research and Development Corporation is complete, accurate and provided in good faith at the date given to the Corporation and that any changes to the information will be notified to the Corporation as soon as possible.

Signed by the Principal Investigator

Signature Date:

Name

Signed for and on behalf of the Applicant, Marine and Freshwater Resources Institute

Signature Date:

Name

Signed for and on behalf of the project collaborator, New South Wales Fisheries Research Institute

Signature Date:

Name

Signed for and on behalf of the project collaborator, Australian Maritime College

Signature Date:

Name

Signed for and on behalf of the project collaborator, CSIRO

Signature Date:

Name

PART B PROJECT DESCRIPTION

The Project Description should provide all the information necessary to enable the application to be fully evaluated

B1 PROJECT IDENTIFICATION

FRDC Programs	Resources Sustainability
Key Areas	Resources Status
	Fisheries Management Improvement
	[Species] LING,GRENADIER - Blue,GEMFISH,BARRACOUTA,TREVALLY - Silver,MACKEREL - Jack,MORWONG,FLATHEAD - Tiger,FLATHEAD - Deepwater,DORY - Mirror,DORY - Silver,DORY - King,DORY - John,REDFISH,WAREHOU - Blue,WHITING - School,WAREHOU - Silver,BLUE EYE,PRAWN - Royal Red

B2 BACKGROUND

There has always been a certain amount of discarding of unsaleable fish from trawl vessels operating in the South East Fishery (SEF). The codend mesh size used in SEF trawl nets was originally based on a study conducted to optimise the catch of flathead in the 1950's. Since then, the fishery has expanded from shelf waters to the continental slope and deeper waters down to 1000 m and now includes a far greater number of species. As a consequence the original mesh size is unlikely to be appropriate for the various sub-fisheries that exist in the SEF now. Following the implementation of quota management for 16 species caught in the SEF however, the discarding problem has been exacerbated, mainly through the practice of "high-grading" (discarding low value fish in preference for higher value grades of quota species). The extent of discarding that has been occurring in the trawl sector of the SEF has been highlighted by the current on-board monitoring program and an extensive study conducted off the NSW coast. These revealed that in certain components of the SEF, over 50% of the catch was discarded and although many of the discards were of non-commercial species, a significant proportion were SEF quota species, including redfish, mirror dory, blue warehou, gemfish, tiger flathead, blue grenadier, spotted warehou and ocean perch.

Not only is such discarding unproductive and time consuming for the fishers who have to sort through the catch, but it is seen as a waste of potentially valuable resources and contrary to the principles of ecologically sustainable development (ESD). Furthermore, whilst it has yet to be proven that high levels of discarding are wasteful or counterproductive at an ecosystem level, the practice attracts negative publicity and is frowned upon by conservation groups and the general public.

Discarding, high-grading and other problems associated with trawl fishing are not peculiar to the SEF. At the recent World Fisheries Congress, there were numerous papers which presented similar problems in other fisheries around the world. The concern by the fishers and general public about the perceived wastage, habitat modification, bad practices, potential stock depletion and interruption to the food chain has been a powerful driving force behind the research projects designed to address such problems. The good news was that in most cases, a dedicated research program to investigate means of overcoming such problems has been successful as long as it has been done with full participation with industry. Thus, an extensive range of "tools" have been developed to improve trawl gear selectivity and overcome many of the perceived problems associated with trawling.

Although the SEF is managed as a single fishery, the fishing methods, catch compositions and consequent bycatch and discarding scenarios in the eastern sectors of the SEF are unique and quite different to those in the western and southern sectors. Industry has stressed that modifications that solve bycatch problems in one area may not be appropriate across the fishery and would prefer a project that incorporates research in the main areas either side of Bass Strait. As such, separate experiments will be undertaken in the eastern and western regions of the SEF which will be customised to address the particular needs within each sub-fishery. However, the same approach and similar sampling and analytical methodologies will be applied across the project.

B3 NEED

An understanding of gear selectivity is essential for the effective management of any fishery. Control of gear selectivity is a pre-requisite to regulating fishing mortalities associated with total catches (retained and discarded components). Like the majority of the world's fisheries, selectivities of trawls in the SEF are regulated by means of legally defined minimum mesh sizes (currently 90 mm). The implications of this mesh size on the selectivity for the various species in the SEF is the subject of a current study by CSIRO and MAFRI. There is a

B3 NEED Continued

great potential however, to use the recent advancements in trawl technology such as different shapes and sizes of mesh panels and codends, exclusion devices and modified trawl rigging to help modify SEF trawls and improve their selectivity towards targeted species and reduce the catch of species that are usually discarded. With a sound knowledge of the use of such tools, they can be readily applied in the SEF although they do need to be designed to meet the specific gear / species configurations that occur in this fishery.

There would be many benefits for SEF fishers if gear selectivity or fishing practices could be modified to maximise the yield of their catch whilst reducing the catch of unwanted fish. The problem is to develop practical solutions to the various selectivity-related problems in the SEF which will be taken up by the fishers. Such development is the basis of this FRDC application by MAFRI, NSW FRI, AMC and CSIRO. The project incorporates research off the southern coast of NSW and in the western Bass Strait areas of the fishery because the trawl methods, catch compositions and consequent bycatch issues are very different in these areas and will likely require quite different solutions.

B4 OBJECTIVES

1	Through extensive Industry participation, develop and evaluate practical modifications to trawl gear designs in the SEF that optimise catches and reduce discards off the southern coast of New South Wales and western Bass Strait
2	Calculate expected changes in the level of discards and the long-term yield resulting from the gear modifications identified in objective 1 for localised sub-fisheries and the SEF as a whole.

B5 INDUSTRY AND MANAGEMENT CONSULTATION

In 1996 the South East Fishery Assessment Group indicated that a gear selectivity study to investigate discarding problems in the SEF, especially with regard to quota species would be given a high priority amongst its research needs. As a consequence, a number of pre-proposals were submitted to address this issue. This research was accorded a high research priority by the SETMAC Research Sub-Committee and SETMAC. Initially it was recommended that the project be a collaborative study between NSW FRI, MAFRI and AMC who all expressed interest in this work.

The SETMAC Research Sub-Committee in 1996 suggested that the project should initially concentrate on the minimisation of discarding by trawler operators working off the NSW coast before tackling the problems of discarding in other areas of the SEF. The need for extensive collaboration and communication with Industry was also highlighted and incorporated into the final project proposal. Despite its support from SEFAG and the SETMAC Research Sub-Committee, the project did not receive funding from FRDC when it was first submitted last year.

Since that time, interest in the project has increased. The FRDC Effects of Trawling Scientific subprogram convened a meeting on the 30 June 1997 to discuss the project and other trawling issues raised in the SEF. At this meeting the following effects of trawl issues were proposed as high priorities for the SEF, consistent with SEFMAC's research priorities.

Discarding
- mortality of target species (high grading, size limits)
- possible impacts on non-target species and ecosystems
- public perception of wastage
- charismatic megafauna (seals)

Escapement/survival
- survival of animals passing through trawl nets
- survival of discards

Physical interactions
- impacts of trawl gear on the bottom
- the spatial extent of trawl impacts
- developing new fishing gear to minimise fishing impacts

The discarding issue was highlighted as the most immediate problem. The Effects of Trawling Steering Committee (11 July 1997) endorsed these recommendations and recommended that AMC, MAFRI, NSW and CSIRO collaborate to prepare this pre-proposal to focus on ways of minimising the effects of discarding in the SEF. Additionally, the proposal should be coordinated with Jeremy Prince's new SEF projects funded to begin in July 1997. Consequently, Drs Colin Buxton (AMC), David Smith (MAFRI), Rick Fletcher (NSW) and Keith Sainsbury (CSIRO) met on 21 July to agree on the process for developing a proposal. Dr Ian Poiner chaired the meeting and Dr Derek Staples (BRS, SEFMAC and SEFMAC Research Committee) and Ms Christine Grieves (AFMA SEF Manager) also attended.

B5 INDUSTRY AND MANAGEMENT CONSULTATION Continued

Input was received from the various institutions and a pre-proposal was submitted to the SETMAC research sub-committee on 24 July who accorded it a high research priority. They requested that a full proposal be developed.

B6 DIRECT BENEFITS AND BENEFICIARIES

The major beneficiaries of this project will be the SEF fishers. There will however be benefits to other non-trawl fishers, state-endorsed fishers and recreational fishers who share many of the species caught by SEF trawlers.

B7 FLOW OF BENEFITS

Fishery (including aquaculture) Managed by:	Commercial Sector	Recreational Sector	Traditional Fishing (by Aboriginal & Torres Strait Islander people) Sector
NSW	8.00	5.00	-
SA	8.00	-	-
Tas	3.00	5.00	-
Vic	6.00	5.00	-
Australian Fisheries Management Authority			
AFMA - South East Fishery	60.0	-	-
Total	85.00	15.00	-

Non Fisheries Beneficiaries (eg grains producers)

Summary Flow of Benefits	
Sub Total Commercial Sector	85.00
Sub Total Recreational Sector	15.00
Sub Total Traditional Fishing Sector	-
Sub Total Non-Fisheries Beneficiaries	-
Summary Flow of Benefits	100.00

B8 FORM OF RESULTS

The most important form of results will be the verbal and practical use of the modifed gear on Industry vessels.

The photographic footage of fish behaviour in relation to standard and modified trawl nets will be edited and used to produce a short video which will be loaned to Industry members to promote the results of the project.

The project will seek to establish a number of Industry members who will initially test the modified gear and assist in promoting the credibility of the new gear/methods to the wider industry audience.

On-going results of the project will be conveyed to Industry through regular meetings in the respective ports.

Results will also be published in scientific journals and fishing industry magazines.

B9 EXTENSION OF RESULTS

Because the project will be based primarily on Industry vessels many of the results will be extended to Industry by word of mouth by the fishers. Nevertheless, the most practical and self-explanatory means of relaying the information to Industry is through the trial and use of the modified gear on their vessels. This will be happening on some Industry vessels throughout the term of the project. Once the gear is developed, the extension of its use on all vessels operating in the SEF is an extensive project in itself, and as such it was agreed at the FRDC SEF Effects of Trawling Sub-Program Meeting (21 July) that this should be undertaken as a separate project.

The results of the project will also be extended to other interested agencies, including recreational and environmental groups. We already have letters of support for this project from the peak recreational fishing bodies in each of the states: VRFish (Victoria), ACORF (NSW) and RecFish (Tasmania) and they will be getting regular reports on the progress of the project. A variety of environmental Groups will be presented with the results of the project including Australian Conservation Foundation, Marine and Coastal Community Network, Australian Marine Conservation Society and Environment Australia's Marine Portfolio Group and Endangered

B9 EXTENSION OF RESULTS Continued

Species Unit. Presentations to the recreational and environmental groups will include targeted reports and videos as well as oral presentations at appropriate forum.

In addition to the above, extension of the results will be made to AFMA and managers of the SEF as well as their environment section and to SETMAC, which includes a permanent conservation observer

B10 RISK ANALYSIS

It is assumed that commercial trawlers will able to be chartered at a cost of $2000 / day if they retain the catch. Whilst this would seem reasonable based on previous charters of similar vessels, actual charter costs have yet ot be determined.

Past experience in similar bycatch reduction work in the NPF and on NSW inshore trawlers has shown that there can be significant amounts of sea time required to fine-tune and incorporate gear modifications into commercial trawls. Nevertheless, success has resulted from persistance at this phase of the project. At present the project only has two years of work on commercial vessels. More time may be required, however, at the later stages of the project, catches by modified gear may be similar to standard commercial gear, and charter cost may be significantly reduced.

B11 METHODS

The project is divided into two stages. Stage 1 will be undertaken over three years and includes conducting, analysing and reporting all of the gear trials and comparisons made in the east coast and western Bass Strait. These results will undergo a comprehensive review in April 2001involving all collaborators and the FRDC Effects of Trawling Sub-commitee. Pending the results of the review, Stage 2 will be initiated in the fourth year and will involve incorporation of the results of the gear modification into a SEF-wide model of the fishery. Details of these two separate stages are outlined below.

STAGE 1

With the areas of potential selectivity problems identified, research officers, including a gear technologist, will liaise with Industry with the specific aim of discussing their ideas to overcome such problems. This is an important phase of the program, as it will introduce the aims, methods and benefits of the project to Industry, whilst developing the communication links between researchers and Industry that are essential if results of the project are to be embraced and implemented. Personnel from the AMC, MAFRI, NSW Fisheries and CSIRO as well as the present ISMP observers will discuss and note industries concerns over bycatch issues, the species and sizes of bycatch they would like to see excluded, techniques tried by industry or believed to have the potential to reduce bycatch. The suitability of overseas bycatch reduction techniques to the SET trawl sector and the role of fish behaviour in reducing the capture of bycatch will be discussed. Key industry personnel will be identified to act as industry representatives. Their role will be to filter by word of mouth progress of the project, and will be invited to participate in gear development including gear tests onboard their vessel.

The next phase of the project will be to trial some of the methods commonly used in other trawl fisheries to overcome selectivity and discarding problems. These methods will need to be "tuned" to the particular problems of the SEF which will take a lot of trial and error gear modifications. Such modifications will also have to take into account the multispecies nature of the fishery and find a solution (or range of solutions) that can optimise the yield over a range of species whilst reducing the discards. This will initially be achieved using trials in the AMC's flume tank followed by testing onboard commercial vessels. In western Bass Strait, the AMC's training vessel, FTV Bluefin will also be used for initial gear tests and camera trials. Fishing gear will then be tested and further refined onboard commercial fishing vessels. During all work on commercial vessels, the catch will be retained by the vessel to offset the charter costs. The prime aspect of these trials is to compare the quantities and size distribution of catches taken by the experimental and control gears. Nevertheless, during all testing phases the engineering performance and behaviour of fish will be monitored to evaluate trawl performance and aid further refinement. Although initial trials of gear will be undertaken in flume tanks or on research vessels, all of the ongoing tests will be carried out on board commercial vessels.

Because gear selectivity is determined not only by the gear itself, but also by the behaviour of the fish to the gear, it is important to incorporate animal behaviour as a variable in selectivity as well as gear design. To this end, video cameras will be deployed on commercial and modified trawl nets to observe fish behaviour during capture. This is also important because some gear modifications, whilst reducing the catch of unwanted fish, cause high mortality of the fish they are excluding. This footage will be examined alongside catch results to help in the design and modification of the gear. It is important to ensure that the modifications are practical solutions to the selectivity problems and can therefore be easily incorporated as normal fishing practice by SEF fishers. It is envisaged that by using the procedure outlined above, this should be a feasible goal. Quantitative comparisons will be undertaken during the trial period to establish two or three of the most successful gear modifications for use in the more rigorous statistical comparisons outlined below.

B11 METHODS Continued

The third phase involves manipulative experiments which statistically compare catches from modified trawls against those from standard gears. These involve factorial experiments which use alternate tows, paired trawls or trouser trawls in pairwise comparisons. It is important to emphasise however that the SEF consists of numerous sub-fisheries. The fishing methods, catch compositions and consequent bycatch and discarding scenarios in the eastern sectors of the SEF are unique and quite different to those in the western and southern sectors. As such, separate experiments will be undertaken in the eastern and western regions of the SEF which will be customised to address the particular needs within each sub-fishery. However, the same approach and similar sampling and analytical methodologies of will be applied across the project as follows.

Within each area, season and depth are important factors which will need to be incorporated into the experimental design accross which the modified gear needs to be tested. Both of these factors significantly effect the species composition of catches and therefore the results of the experiments. It is envisaged that threre will be two levels within each of these factors. In the eastern regions, season will incorporate summer and winter fishing and depth will be divided into shelf and upper slope. The fishery in the western regions of the SEF will have summer and winter seasons and be divided into upper slope and mid slope depths. Measurement variables will include the species composition and weight and number of these species that are retained and discarded. These will be replicated using multiple hauls.

The results of Stage 1 of the project will be analysed and reported with respect to the effectiveness of the modified gear in reducing the catch of species that are currently discarded in the fishery and their impact on the catch and sizes of fish currently retained. This will be done with respect to the particular sub-fishery within the SEF that the specific gear modifications have been trialed. This will be largely aimed at the benefits to the individual fishers and the management problems in a particular area. In addition, the selectivity of the modified gear will be determined for each species by comparing the size range of the catch against that from a relatively non-selective or uniform sampling gear. Methods such as covered codends are useful for this purpose. A comprehensive review of the results of Stage 1 will be undertaken by all collaborators and the FRDC Effects of Trawling Sub-Committee. Based on the results of the review, the second stage of the project will be initiated in the fourth year.

STAGE 2

The final phase of the project will be to evaluate the impacts of gear modification in the SEF on the long-term yields and economics on a fishery-wide basis. The results from gear trials in the individual areas (primarily selectivity of the gear with different mesh and gear configurations) will be evaluated with respect to their implications to the management of the fishery as a whole. This component of the study would use multispecies selectivity models to estimate the by-catch and long-term yield expected with alternative gears, and would determine the likely reliability of these predictions. The analyses would integrate results of previously FRDC funded projects (especially FRDC96/140 Evaluation of selectivity in the South-East Fishery to determine its sustainable aggregate yield, and FRDC94/40 Habitat and fisheries production in the South-East Fishery ecosystem), with the Integrated Scientific Monitoring Program (ISMP) data, research survey results in several regions (especially the eastern Victoria shelf, the NSW shelf and the Tasmanian shelf areas), and results from objectives 1 of this study.

The ISMP and research survey data will be used specifically to estimate the effective selectivity of present fishing gears in regions for which there is survey data. The adequacy of model predictions would be determined by comparing this estimate with the model predictions based on current gear in each region. The models and data produced from FRDC projects 96/140 and 94/40 will be used in conjunction with the ISMP and research survey data to develop a SEF-wide and region specific analysis of the reduction in by-catch and increase in long-term yields expected from using alternative gears identified by objectives 1 of this project. This will include an analysis of the effect on economic yield per recruit for the main fish species.

The output of this component of the research will be a spatial model that can be used to test the effect of alternative management interventions on the short and long-term harvest and economic returns from the entire fishery.

B12 PERFORMANCE INDICATORS

Demonstration of the utility of modified gears to reduce catches of fish that are currently discarded by the fishery

Demonstration of the impact of modified gears on catches of sizes and species of fish that are currently retained by the fishery

Development of selectivity ogives for the major commercial species taken by SEF trawlers for both "standard" and modified trawl gears.

B12 PERFORMANCE INDICATORS Continued

Identification of the long term implications on the multispecies yield per recruit of the SEF.

B13 MILESTONES

01-Oct-98	Project initiation, funds dispersed and project staff employed
31-Jan-99	Initial gear and camera trials underway on commercial vessels and Bluefin. Results from initial port meetings available.
30-Jun-99	Initial gear trials completed. Report available on initial gear trials. Extensive gear comparisons on commercial vessels underway.
01-Jan-00	Report on first year of gear trials presented at port meetings. Results of second port meetings available.
01-Jul-00	Preliminary Report 2nd phase of gear comparisons available
01-Jan-01	Extensive 2nd phase of gear comparisons completed and preliminary results available. Technical work completed
01-Apr-01	Analysis of gear modification results completed Major review of project with collaborators and FRDC Effects of Trawling subcommittee. Pending the results of the review, the SEF-wide economic and YPR modelling phase of the project will be agreed to begin in the fourth year of the project.
30-Jun-01	Results of gear modification project presented at port meetings Report on gear modification submitted.
31-Dec-01	Preliminary report on multispecies YPR modelling and implications on a fishery-wide basis.
30-Jun-02	Final report submitted Results of study presented to Industry and other interest groups

B14 OTHER RELATED PROJECTS

FRDC Project 96/225: A study of the impact of fishing pressure on midwater ecosystems
— Biospherics Pty Ltd, Jeremy Prince

FRDC Project 96/140 Evaluation of selectivity in the South East Fishery to determine its sustainable aggregate yield. Involving yield per recruit modelling
— CSIRO and MAFRI, Nic Bax and Ian Knuckey

FRDC Project 97/210 The effects of haul seining in Victorian bays and inlets
— MAFRI, Ian Knuckey

FRDC Project Development of discard-reducing gears and practices in the estuarine prawn and haul fisheries of NSW
— NSW FRI Steve Kennelly

FRDC Report 92/79 Bycatch & discarding practices in South East Trawl Fishery
— NSW, Geoff Liggins

AFMA Rpoert. Design of an Integrated Scientific Monitoring Programme for the South East Fishery
— MAFRI / NIWA, Dave Smith, Dave Gilbert, Anne Gason and Ian Knuckey

Analysis of the SETF logbooks to identify the extent of trawl areas and how they change over time — MAFRI and BRS, Ian Knuckey and John Garvey

SEF logbook analysis of changes in catch and effort on blue grenadier and warehou
— MAFRI, David Smith

Development of a deepwater (to 600m) trawl video camera to monitor the performance of trawls
— AMC, Steve Eayrs

Changes after 20 years in relative abundance and size composition of commercial fishes caught during fishery independent suveys on SEF trawl grounds.
— NSW, N. Andrew and K. Graham.

AFMA Project - Integrated Scientific Monitoring Program. On board scientific observers collect information on the retained and discarded componets of the SEF trawlers
— MAFRI Ian Knuckey, NSW FRI Geoff Liggins

FRDC Pre-proposal On-board monitoring of SEF non-trawl vessels - a pilot study.

B14 OTHER RELATED PROJECTS Continued

— MAFRI, Ian Knuckey

B15 FACILITIES

All of the Institutes involved in the project (MAFRI, NSW FRI, AMC and CSIRO) have a reputation for high quality research. There is adequate office facilities, computing support, and library services to support the staff required on the project.

In addition to the above, AMC has world-class facilities for gear trials and analysis of gear performance. These include a purpose built flume tank and their training vessel Bluefin.

B16 STAFF

Name	Position	Qualifications	Time
Scientist NSW	Research scientist for E Coast	BSc / PhD	100.00
Scientist VIC	Research scientist W Bass Strait	BSc / PhD	100.00
Technician NSW	Technician for E coast	Grad Dip. / trawling experience	100.00
Technician VIC	Technician W Bass Strait	Grad. Dip. / Trawling experience	15.00
Gear Scientist AMC	Gear Scientist AMC	BSc / MSc	100.00
Mr Geoff Liggins	Fisheries Scientist	BSc Hons, M. Comp	10.00
Mr Ian Knuckey	Senior Fisheries Scientist	BSc (Hons)	20.00
Mr Steve Eayrs	Senior Gear Technologist	B App. Sci	10.00
Data analyst 4 CSIRO	Data analyst	BSc (Hons)	60.00
Modeller 6 CSIRO	Modeller	PhD	25.00

Maximising yield and reducing discards in the South East Trawl Fishery

Workshop 30-31 July 1998

Selected correspondence regarding the project proposal

NSW Advisory Council on Recreational Fishing (ACoRF)

Dr W Fletcher
Director
Fisheries Research Institute
PO Box 21
CRONULLA NSW 2230

Dear Rick

I am writing in regard to your research proposal on "Maximising yield and reducing discards in the South East Fishery through gear development and evaluation", which has been submitted to the Fisheries Research and Development Corporation (FRDC).

I am aware of the problems associated with the discarding of large quantities of small fish in the South East Trawl Fishery. I also understand the problems associated with the capture of quota species in a multi-species fishery. These issues need to be resolved and some solutions may arise from fishing gear selectivity research.

As you know, the New South Wales Advisory Council on Recreational Fishing (ACoRF) is concerned about destructive and wasteful fishing techniques. ACoRF has consistently argued for more sustainable harvesting practices and supported research into by-catch reduction techniques. Therefore, ACoRF supports your research proposal into maximising yields and reducing discards in the South East Fishery.

Yours sincerely

Bruce Schumacher
Chairman
NSW ACoRF

TASMANIAN AMATEUR SEA FISHERMENS' ASSOCIATION Inc.

52 Creek Road,
HOBART TAS 7008

Ph.03 6228 6920

27 March, 1998

Marine and Freshwater Resources Institute,
(Marine Fisheries Division),
P.O. Box 114,
QUEENSCLIFF 3225
Victoria

Attention: Mr. Ian Knuckey - SET bycatch proposal

Dear Sir,

Our Association has had the opportunity to peruse the application from the collaborative partners, namely MAFRI (Marine and Freshwater Resources Institute, NSWFRI (New South Wales Fisheries Research Institute, AMC (Australian Maritime College), CSIRO (Commonwealth Scientific & Industrial Research Organisation), to your body, for funding to carry out a study as outlined in their application to your Institute.

We are very pleased to see the collaborative parties embarking on a program that if given the appropriate funding and carried out, would we believe, provide data which would be invaluable to the process of managing our resources in a sustainable manner. We commend them for this effort and encourage your Institute to grant the required funding to allow such a worthwhile project to be undertaken.

Yours sincerely,

D.K. PATON
President - TASFA Inc.

PROFILE

The Tasmanian Amateur Sea Fishermen's Association Inc. is a body that has been formed, not as a fishermen's club, but as a representative voice for recreational sea fishers to protect their interests and to assist the Government in the decision-making process regarding changes in legislation that may affect these people.

Membership of the Association is open and offered to anyone interested in recreation sea fishing in Tasmania. Affiliation is also offered to properly constituted groups. Once affiliated such a Group's nominated delegate is offered a seat on the Board of Directors.

TASFA Inc. is the body representing Tasmania's interest nationally through RECFISH Australia.

VRFISH
fish for the future
ACN 068 111 624

3/250 Victoria Parade
East Melbourne VIC 3002
Ph: (03) 9412 5164
Fax: (03) 9412 5159
Email: info@vrfish.com.au

MF/12/0018/1

980104 1

20 March 1998

Dr David Smith
Deputy Director
Marine & Freshwater Resources Institute
PO Box 114
QUEENSCLIFF 3225

Dear David

VRFish represents recreational fishing interests in Victoria, and we would like to support your application to commence a project on maximising yield and reducing discards in the South East Trawl Fishery.

As you are aware VRFish has raised this issue in calling for a ban on commercial netting in Bays and Inlets in Victoria. It is evident to this organisation that there is a lack of data on the impact of by-catch by commercial fishing operations.

At the World Fisheries Congress in 1996 we were given some information regarding the results of the by-catch issue on a world scale, and the decline in world fish stocks. The Federal Government has recognised the problem and will address this issue over the coming months.

The recreational fisher and VRFish are concerned with the decline in fish stocks and the long-term sustainability of the resource, any project that results in data being gathered on preventing further decline, and leads to improvements in gear development is fully supported.

Yours sincerely

P. J. Washington

Patrick Washington OAM
Chairman

FISHERIES RESEARCH & DEVELOPMENT CORPORATION

Wednesday 4 March 1998

Mr Ian Knuckey
MAFRI

FAX Number: 03 5258 0270

Pages (inclusive): 1

RE: 98/204 "Maximising yield and reducing discards in the South East Trawl fishery through gear development and evaluation"

Dear Mr Knuckey

Your application was considered by the FRDC Board this week.

The Board requested that a meeting of all collaborators be convened to address the following issues:

- The cost was considered too high and needed to be significantly reduced,
- Needed more consultation with the recreational sector given the intended flow of benefit,
- The extension strategy needs to be expanded to include other interested groups,
- Consider the structure of the application and if alternative models would provide more effective use of resources.

Please indicate if you are able to convene the meeting in Canberra on Thursday 12 March 1998? Further, please contact the co-investigators and Dr Ian Poiner to confirm their availability for attendance. It is proposed that the meeting will commence at 10am and conclude at approximately 4pm to allow the travel to be a one day trip.

If you have any questions please call (02 6285 4485).

Please confirm the receipt of this advice.

Yours sincerely

Dr Patrick Hone
Programs Manager

Ian Knuckey

From: Ian Knuckey [I.Knuckey@mafri.com.au]
To: HONE Patrick
Cc: POINER Ian; BUXTON Colin; FLETCHER Rick; SAINSBURY Keith
Subject: Project 98/204

Dear Dr Hone.

I am writing in reply to your fax of 4/3/98 requesting a meeting of all collaborators to address the following issues raised by the FRDC Board with respect to our project "Maximising yield and reducing discards in the South East trawl Fishery through gear development and evaluation".

The issues were:

1 The cost was considered too high and needed to be significantly reduced;

2 Needed more consultation with the recreational sector given the intended flow of benefits;

3 The extension strategy needs to be expanded to include other interested groups;

4 Consider the structure of the application and if alternative models would provide more effective use of the resources.

Given the short notice, neither all of the collaborators nor Ian Poiner were able to all get to Canberra for a meeting on 12/3/98, but the collaborators held a meeting on 11/3/98 using teleconference facilities to discuss these issues. I present below a summary of the results of these discussions.

Issues 2 and 3 are discussed first. Issues 1 and 4 are tackled together, as it was felt that that the two were co-dependent.

Issue 2

Given the sensitive nature of discarding issues and the highly political interactions between the commercial fishing industry and other interested groups such as the recreational sector, there was unanimous concern at the degree of collaboration that FRDC require at the initial stages of the project. It was suggested that the issue may be resolved if each State agency approached their respective recreational peak bodies to obtain a letter of support for the general objectives of the project.

Issue 3

Whilst noting similar concerns as above, we acknowledged that there was a lack of extension of the results of the project to groups other than commercial fishers. It was felt that this would be best addressed during the 3rd year of the project, when workable solutions to some of the discarding issues are available. Although most of the extension to Industry was to be through work of mouth and the trialling of modified gear on Industry vessels, reports and videos will be produced which can be targeted towards other interest groups as well as Industry.

Issues 1 and 4

In light of the need for reduced costs in the project and suggestions from FRDC that a staged approach could be a viable option, the collaborators devoted considerable time into addressing the structure of the project and alternative models that would provide more effective use of the resources. As a result, we propose a project structure which reduces the cost of the 3 year project by around $220,000 but incorporates a second project phase to be introduced in a fourth year pending a review of the project results in the 3rd year. The cost of the fourth year phase is expected to be around $150,000.

The general changes to the project are as follows:

Capital costs can be reduced by at least $20,000 by the shared use of net monitoring equipment by CSIRO and AMC.

Recruitment costs of $8,000 will be borne by the individual agencies.

Each Agency will consider meeting an increased percentage of the oncosts to provide savings of at least $70,000.

Closer collaboration between AMC and MAFRI will result in the reduction of the need for a MAFRI based technician to around 20%, achieving a saving of $70,000. This will be somewhat offset by the inclusion of FRDC costs to cover 20% of the time of the principle investigator (about $50,000).

Finally, we proposed to stage the project by introducing a fourth year in which the bulk of the modelling aspects of the project will be undertaken (ie implications on multispecies yield per recruit and the long term yield of the entire SEF). It was agreed that the undertaking of this second stage will depend on a major review of the project during the third year to consider the results. This staged strategy would remove a further $100,000 from the initial 3 year project but if the gear modifications are successful, these funds will be required in the fourth year.

With these alterations, a broad indication of the revised FRDC budget can be summarised as shown

Year 1 444,000
Year 2 470,000
Year 3 350,000

Year 4 150,000

All of the collaborators agreed to this proposal, as it was felt to address the issues outlined by FRDC, whilst still maintaining the close collaboration between the four Agancies and achieving the original objectives.

We would appreciate feedback from FRDC to determine whether the proposed changes to the project adequately address the issues raised by the FRDC Board. If they do, we will present a detailed revised project proposal. If there are still major concerns, we feel it will be necessary to meet with FRDC as soon as possible to ascertain more specific requirements of FRDC before further changes to the project are made.

Yours sincerely

Ian Knuckey

22 April 1998

FISHERIES RESEARCH & DEVELOPMENT CORPORATION

Mr Ian Knuckey
Marine and Freshwater Resources Institute
Marine Fisheries Division
PO Box 114
QUEENSCLIFF VIC 3225

Fax: 03 5258 0270
Pages (inclusive): 1

Dear Mr Knuckey

RE: 98/204 - Effects of trawling subprogram - maximising yield and reducing discards in the South East Trawl Fishery through gear development and evaluation

Your application was considered by the FRDC Board this week. The Board made the following points about the application:

- The cost was excessive.
- FRDC percentage funding of the project was too high.
- The scope was poorly described and did not clearly identify the issues, their relative priority and what was to be done.
- Insufficient detail was provided on the methods.
- The extension strategy was insufficient and did not adequately match the target audience.
- The size of the application and the various parties involved would be difficult to manage. More detail was required on how the application would be managed.

The Board has approved the expenditure of up to $30,000 for a project development workshop. This should be managed on an expense basis. The Board has approved sufficient funds for the workshop so that you can be employed for short period to undertake the following:

1. Organise and act as convener for the workshop. A possible date for the workshop could be back to back with the SEFMAC at the end of May.
2. Liaise with Dr Ian Poiner, who will chair the workshop, and FRDC.
3. Invite FRDC Board director, Mr Sandy Wood-Meredith.
4. It is suggested that expertise from overseas would be helpful at the workshop, in particular New Zealand.
5. Facilitate the production of a paper (s) that documents the issues and the state of play for the SEF in relation to by-catch and related Australian and world developments.
6. Ensure that all participants receive the briefing paper (s) 2 weeks before the workshop.
7. Facilitates the development of the subsequent new application after the workshop. The deadline for the next Board Meeting is 1 June.

If you have any questions please call (02 6285 4485).

Yours sincerely

Patrick Hone

Dr Patrick Hone

PLEASE ACKNOWLEDGE RECEIPT OF THIS FAX AS SOON AS POSSIBLE

Maximising yield and reducing discards in the South East Trawl Fishery

Workshop 30-31 July 1998

A few comments on bycatch reduction in the South East Trawl Fishery

Prepared by

Roger Larson

Associate Professor
Norwegian College of Fishery Science
University of Tromso, Norway

The SEF Trawl Bycatch Study

This background paper was prepared by Roger B. Larsen, Associate Professor at the Norwegian College of Fishery Science, University of Tromso, Norway.

Roger Larsen was one of the principal Norwegian scientists instrumental in developing and introducing effective Bycatch Reduction Devices into the Scandinavian trawl fisheries. He recently completed a year's sabbatical study-leave at NSW Fisheries Research Institute, Cronulla where he was involved mainly in bycatch reduction studies in the NSW prawn and estuary fisheries.

The Southern Fish Trawl By-catch Issue

Problems:

i) Mixed species fishery,

ii) Various landing/minimum landing sizes of fish,

iii) Different sizes of Vessels and Gears,

iv) One mesh size in the cod-end,

v) Differences in behaviour, swimming ability and shapes of fish,

vi) The number of species targeted may vary with season and area.

vii) Differences in catch sizes and catch rates

Solving by-catch problems.

An absolute must before a project is started is that there's a general agreement about the nature of the by-catch problem, and that all parts involved are really dedicated in seeking methods to improve the fishery. There may be "a million" reasons for improving the way trawls are exploiting fish stocks. The best selling arguments, however, should be that stocks may be endangered if nothing is done, that the trawl fishery may be shut down for long periods, etc. By improving the selectivity in the gear, cleaner fisheries could be conducted and the efficiency of the gear would improve, and fishermen would reduce their time sorting catches. Introduction and use of (almost any forms of) selective devices in the gears, would improve the reputation of this fishery.

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Traditionally, attempts of solving the by-catch problem has usually been done at or in the cod-end of the gear. The way the fish trawls work, the cod-end or the area close to it would be most beneficial for improving the selectivity of the gear. That is, it may be possible to reduce the by-catch of certain species/sizes of fish by altering bridle lengths, towing speeds, ground rope configuration, mesh sizes/configurations in the mouth of the net, etc., but usually such methods takes very long time to quantify and the effects may turn out to be negligible or not practical. Attempts to address/solve by-catch problems should therefor be made in the aft part of the trawl.

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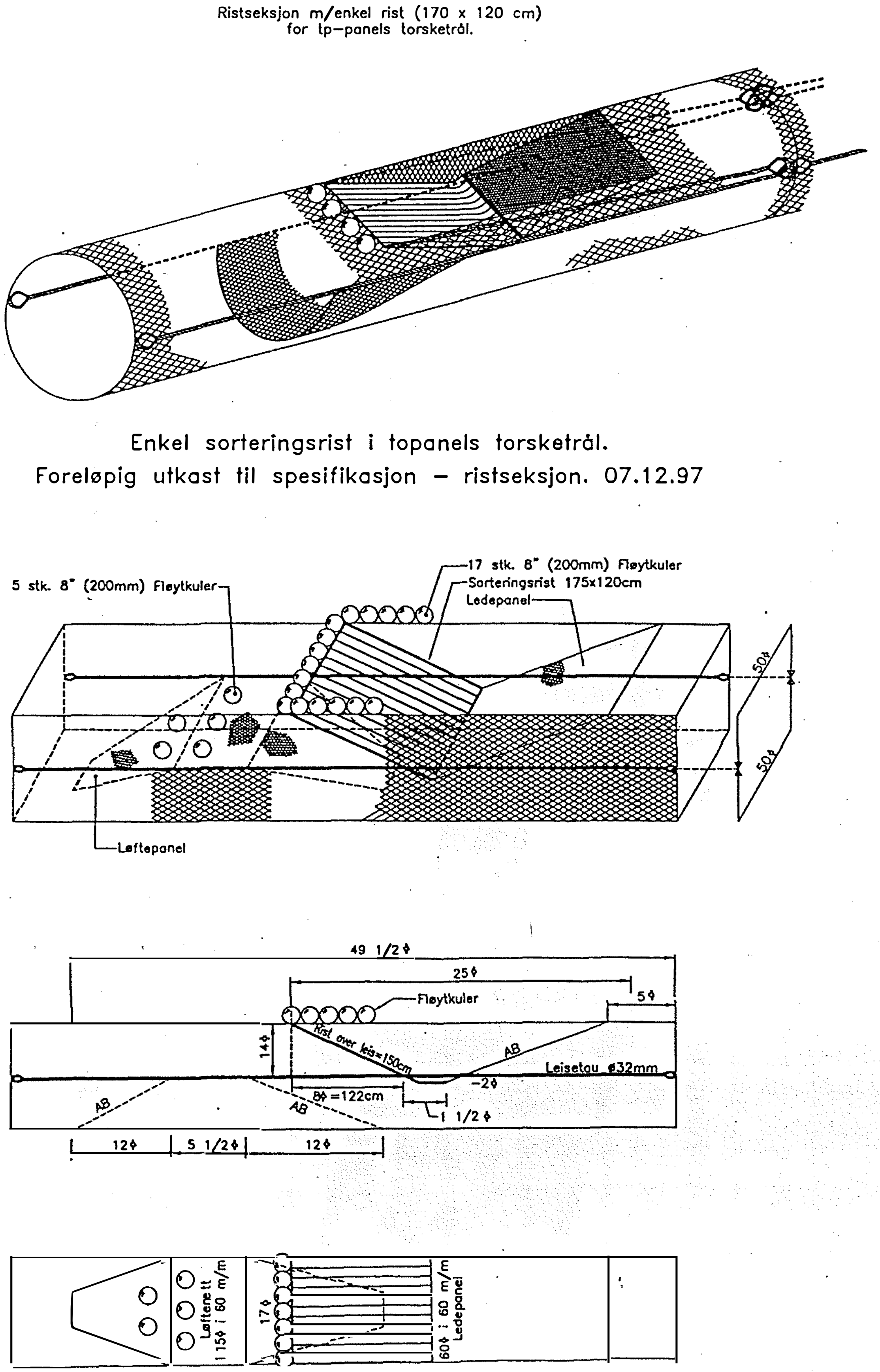
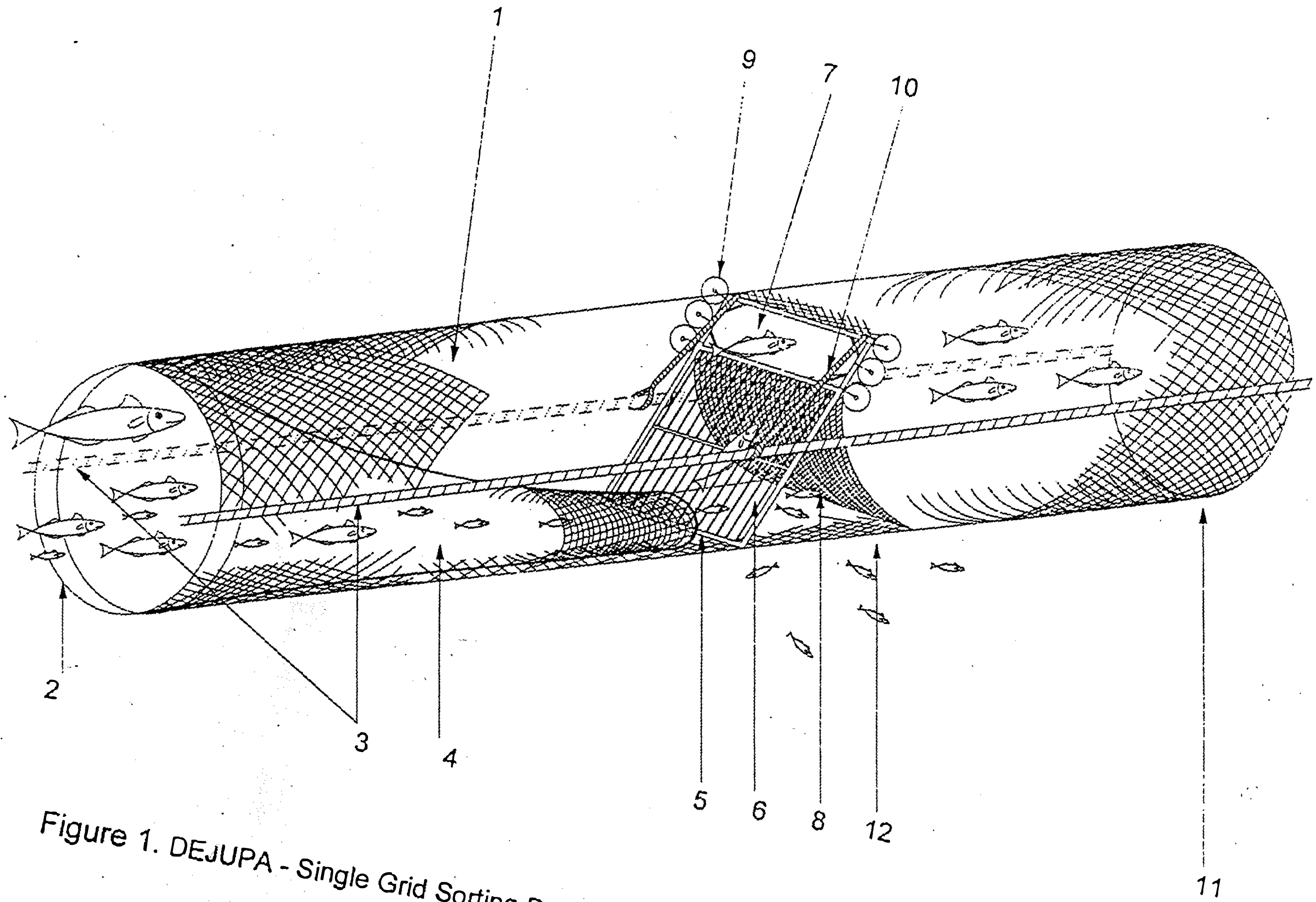


Fig. 1 Skisser av enkelrist



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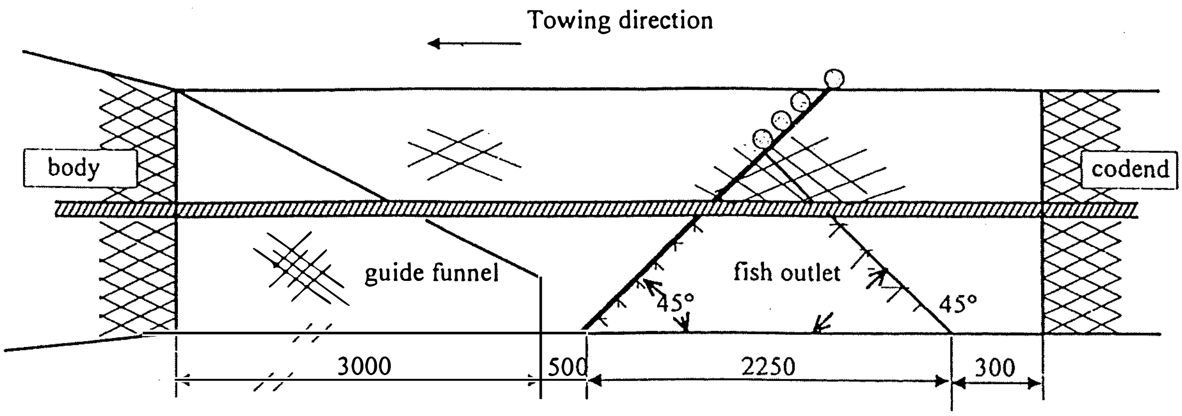
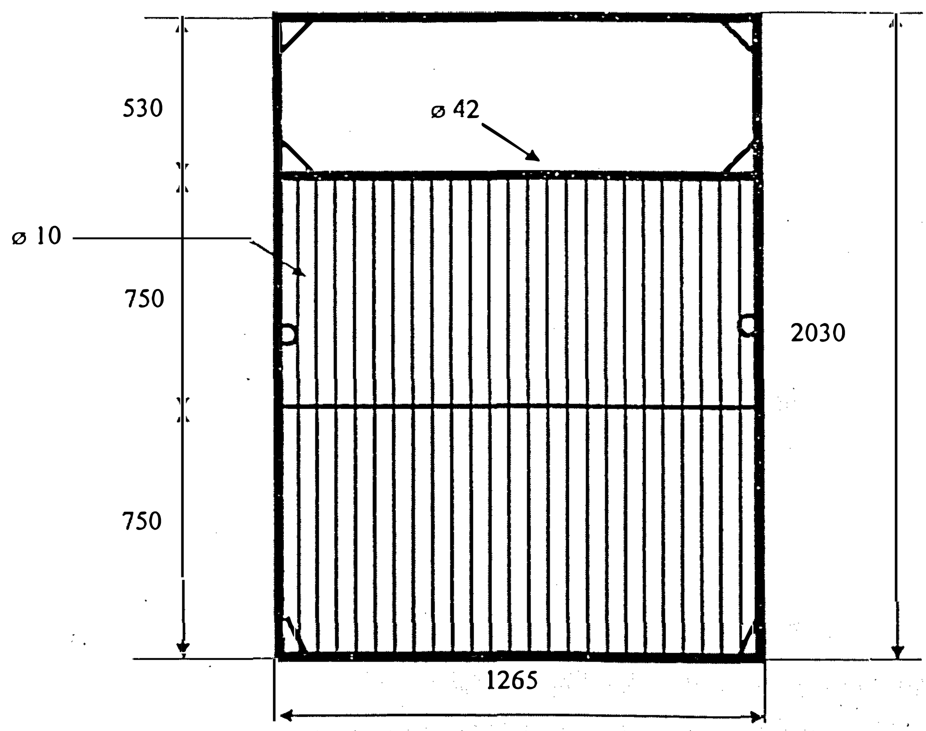
Lateral view of DEJUPA



DEJUPA Grid



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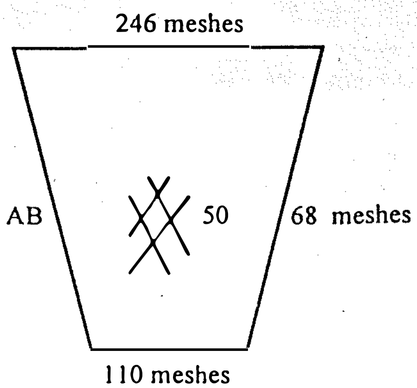

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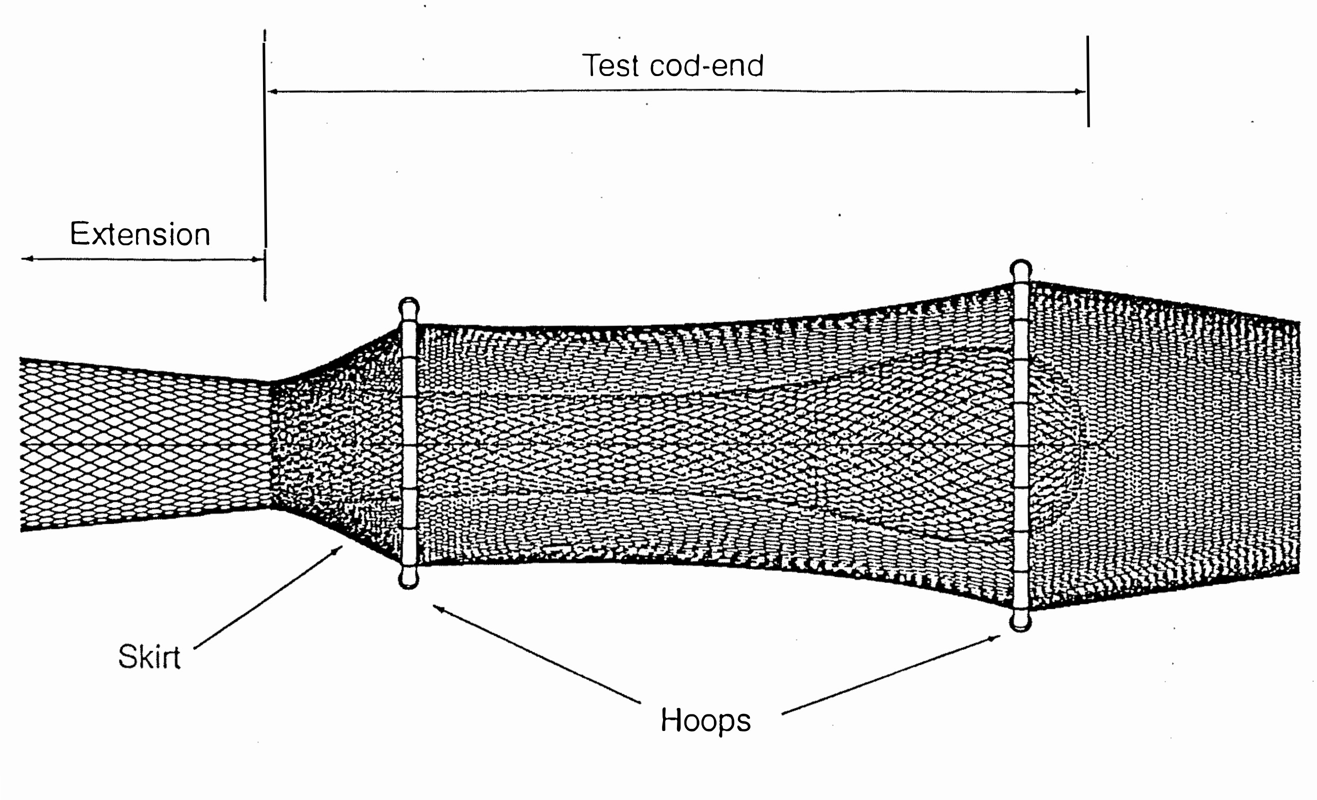

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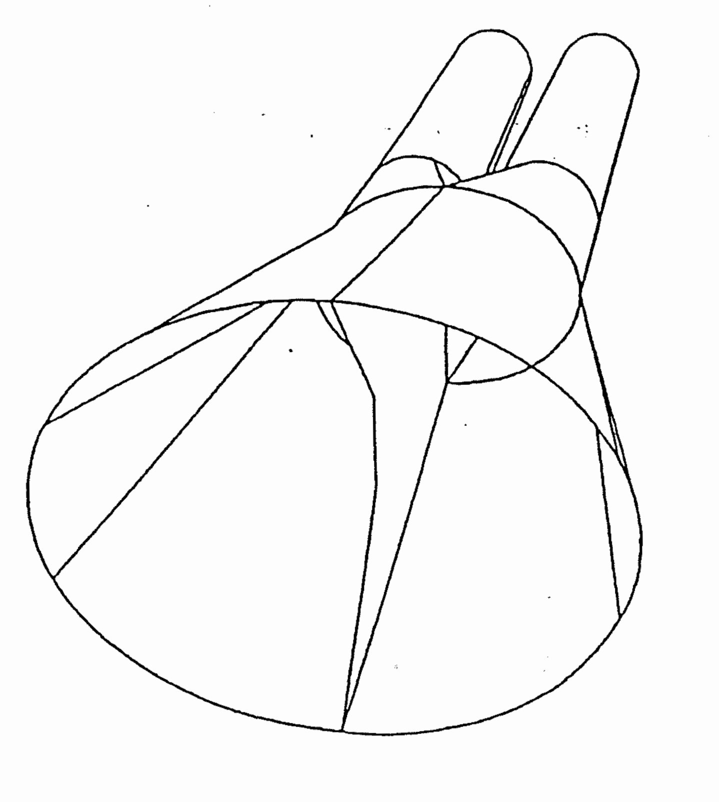


Figure 2.1.5a Schematic diagram of trouser trawl - a single net with a vertical dividing panel and two cod-ends

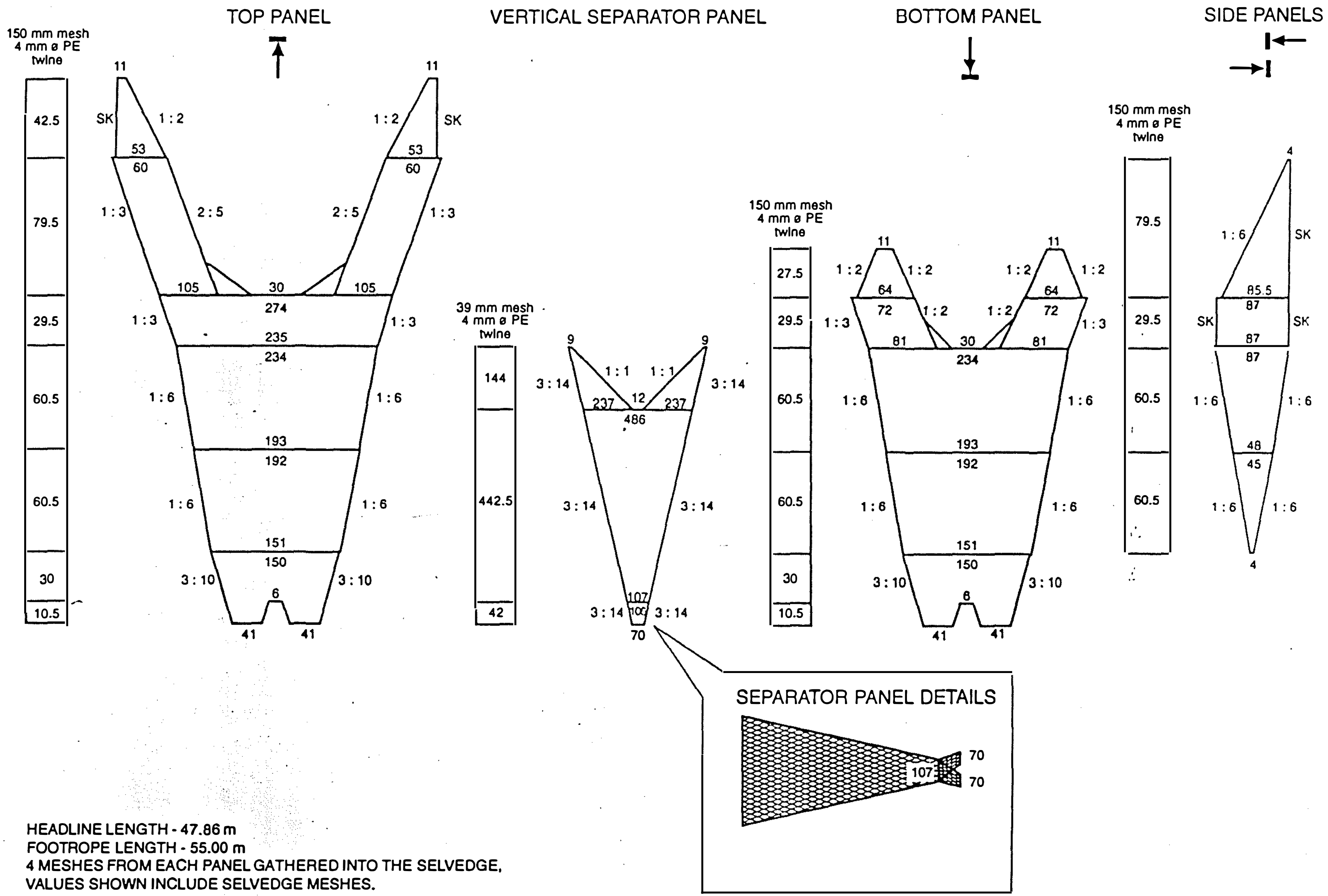
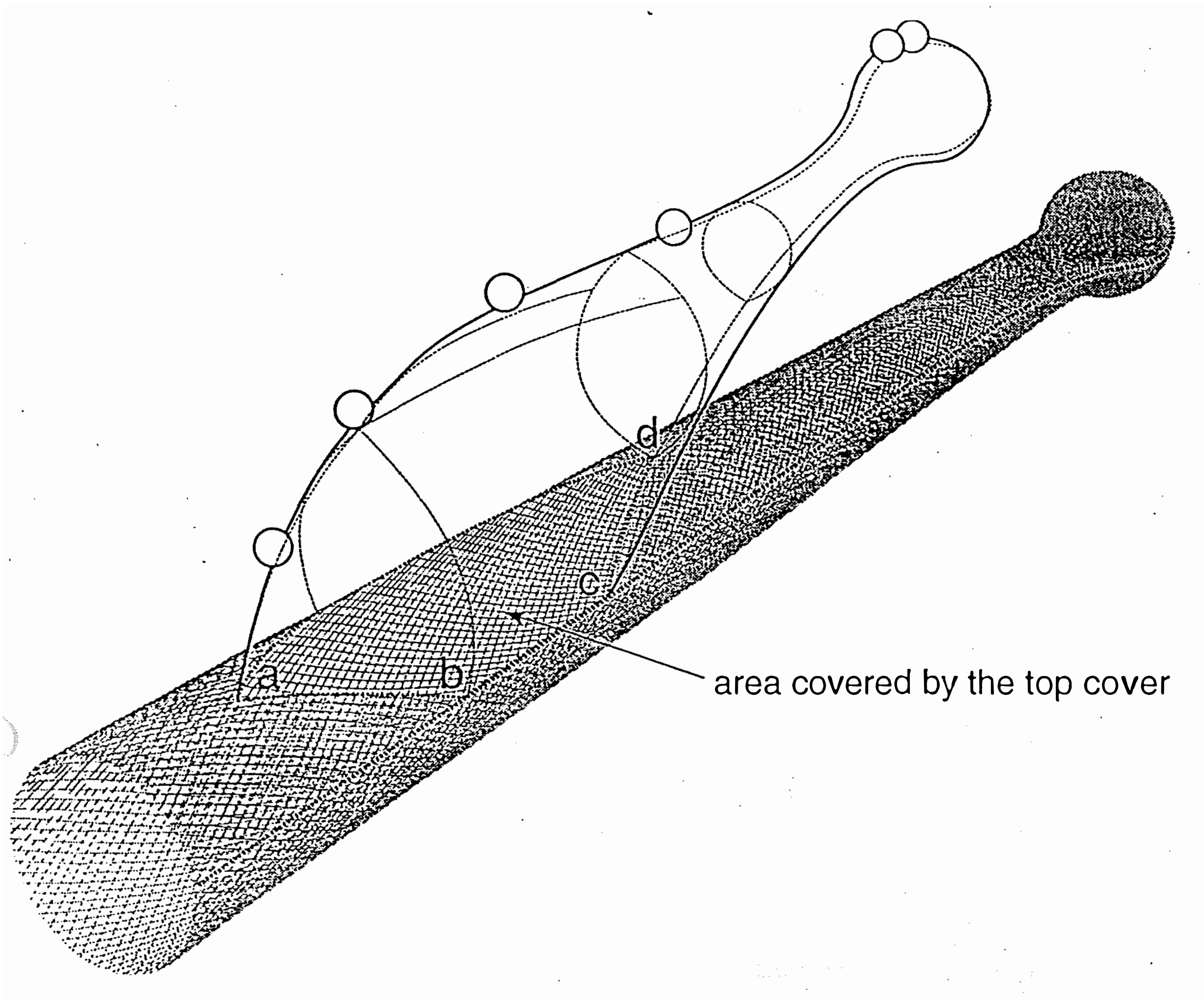


Figure 4.2.5.2 Example of a specification for a trouser trawl with vertical dividing panel



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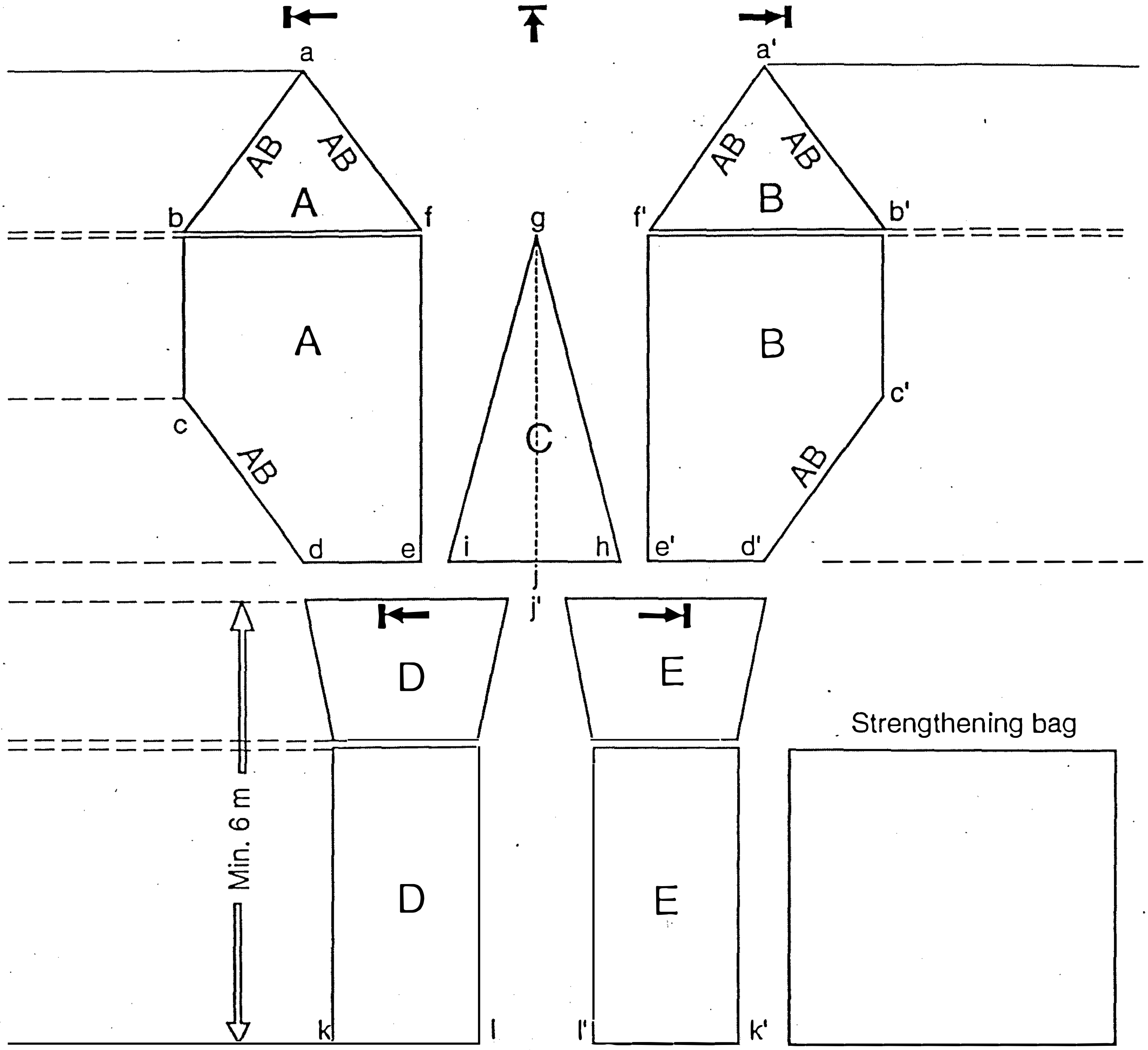

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Maximising yield and reducing discards in the South East Trawl Fishery

Workshop 30-31 July 1998

A few comments on bycatch reduction in the South East Trawl Fishery

Prepared by

Roger Larson

Associate Professor
Norwegian College of Fishery Science
University of Tromso, Norway

The SEF Trawl Bycatch Study

This background paper was prepared by Roger B. Larsen, Associate Professor at the Norwegian College of Fishery Science, University of Tromso, Norway.

Roger Larsen was one of the principal Norwegian scientists instrumental in developing and introducing effective Bycatch Reduction Devices into the Scandinavian trawl fisheries. He recently completed a year's sabbatical study-leave at NSW Fisheries Research Institute, Cronulla where he was involved mainly in bycatch reduction studies in the NSW prawn and estuary fisheries.

The Southern Fish Trawl By-catch Issue

Problems:

i) Mixed species fishery,

ii) Various landing/minimum landing sizes of fish,

iii) Different sizes of Vessels and Gears,

iv) One mesh size in the cod-end,

v) Differences in behaviour, swimming ability and shapes of fish,

vi) The number of species targeted may vary with season and area.

vii) Differences in catch sizes and catch rates

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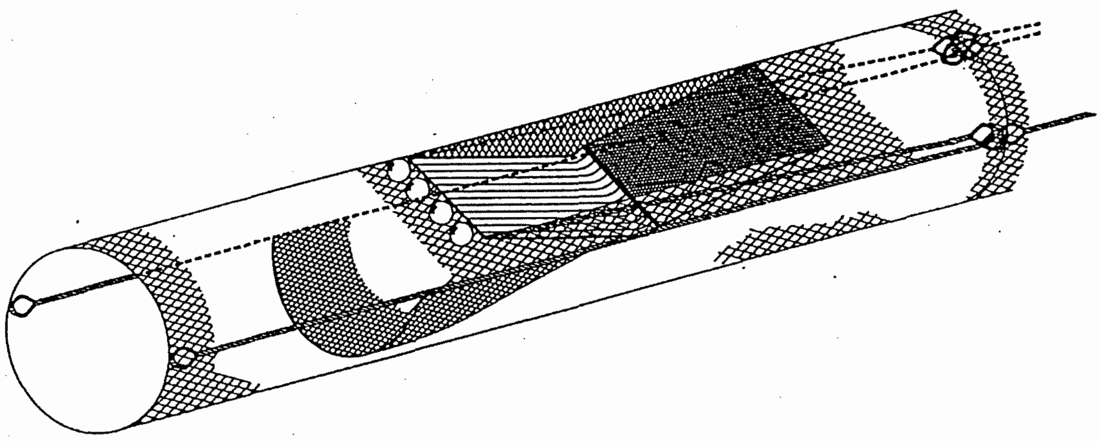
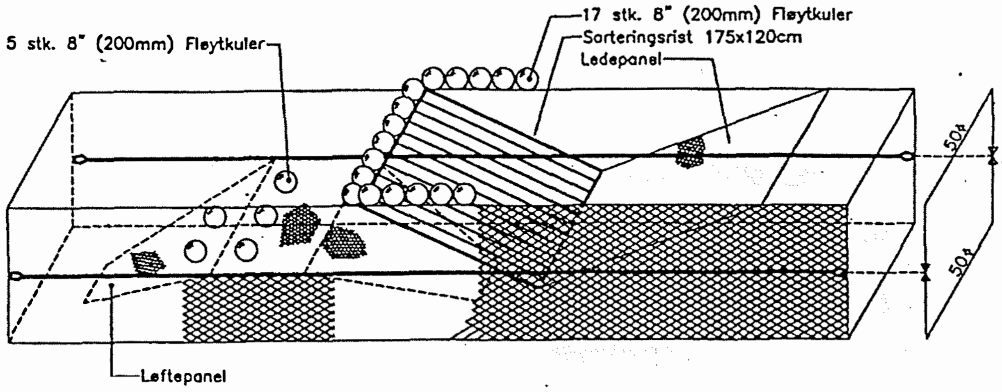
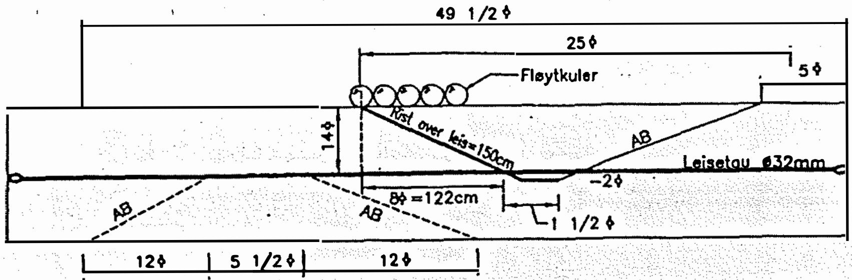
Ristseksjon m/enkel rist (170 x 120 cm)
for tp–panels torsketrål.



Enkel sorteringsrist i topanels torsketrål.
Foreløpig utkast til spesifikasjon – ristseksjon. 07.12.97





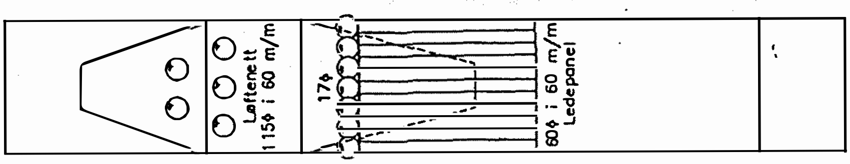
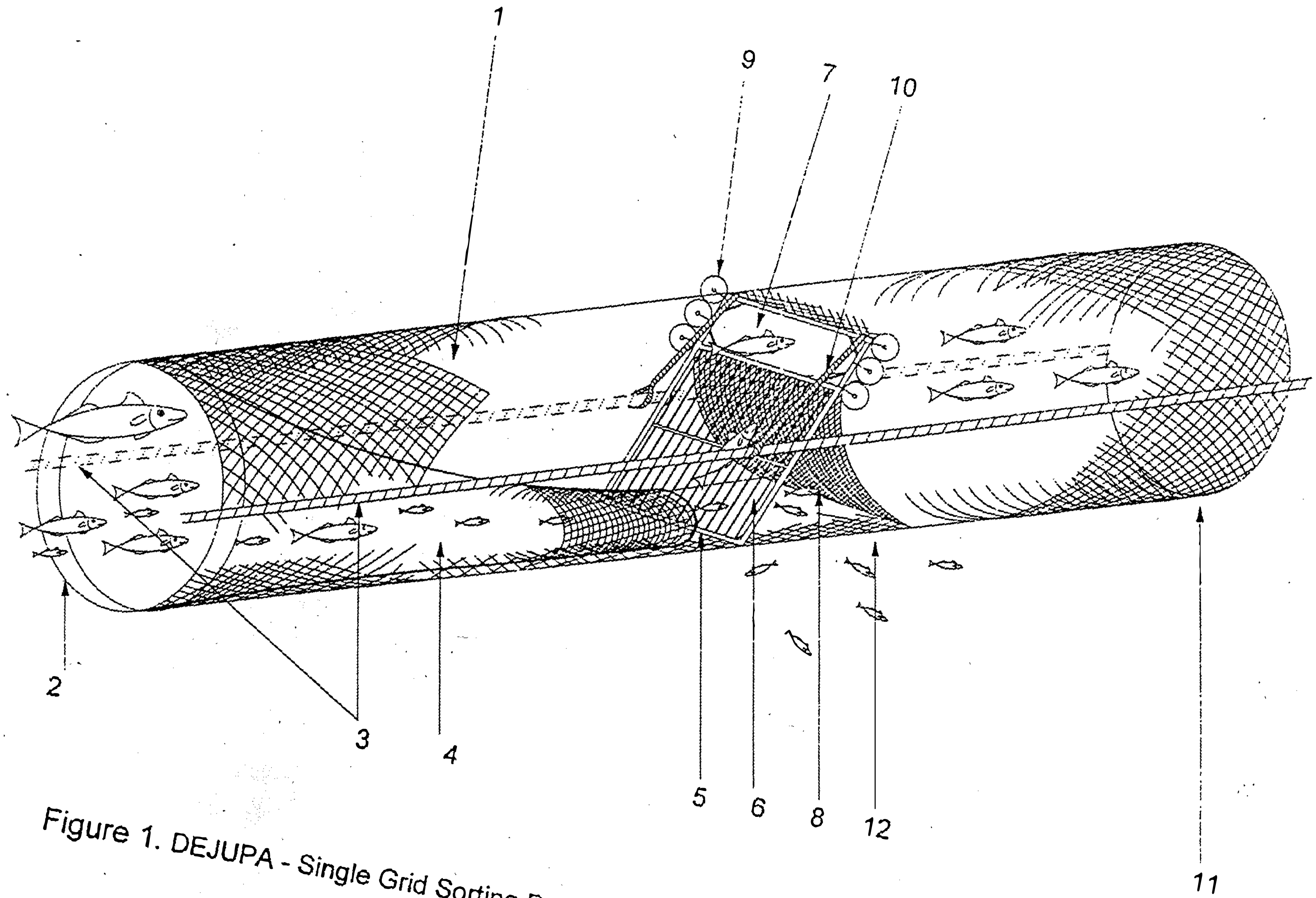


Fig. 1 Skisser av enkelrist



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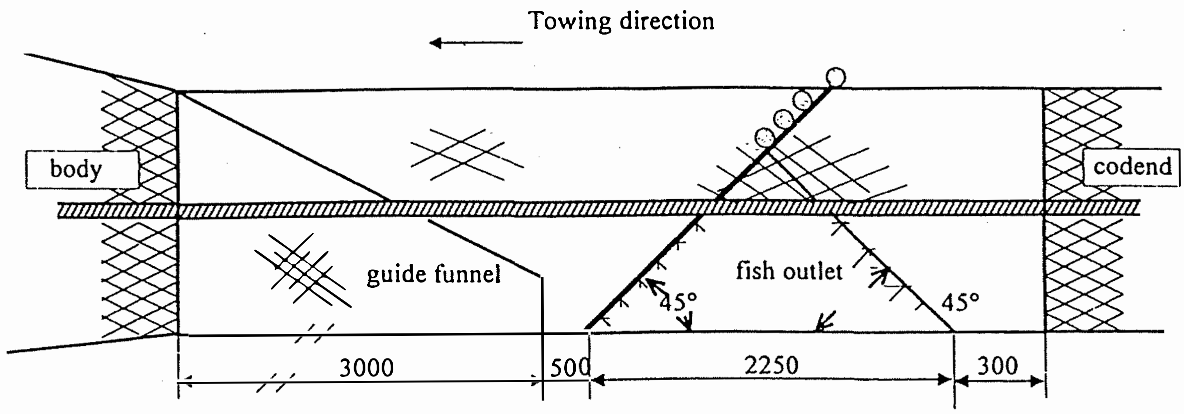
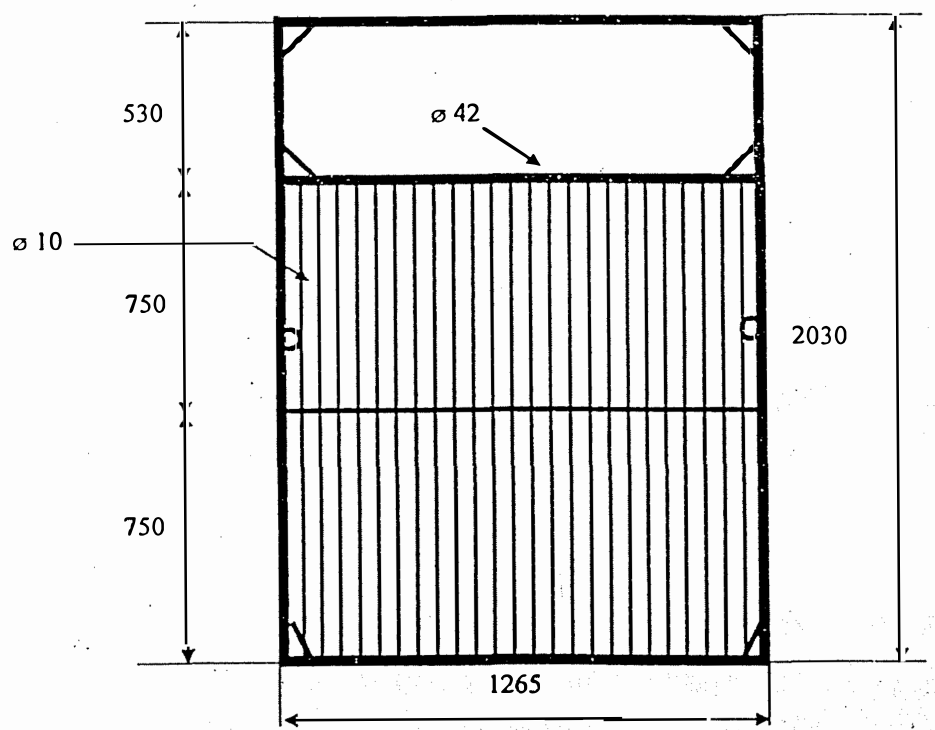
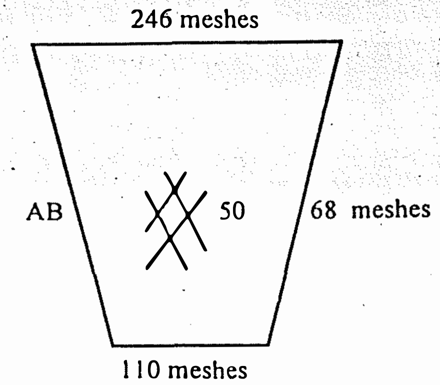


DEJUPA Grid



Guide funnel



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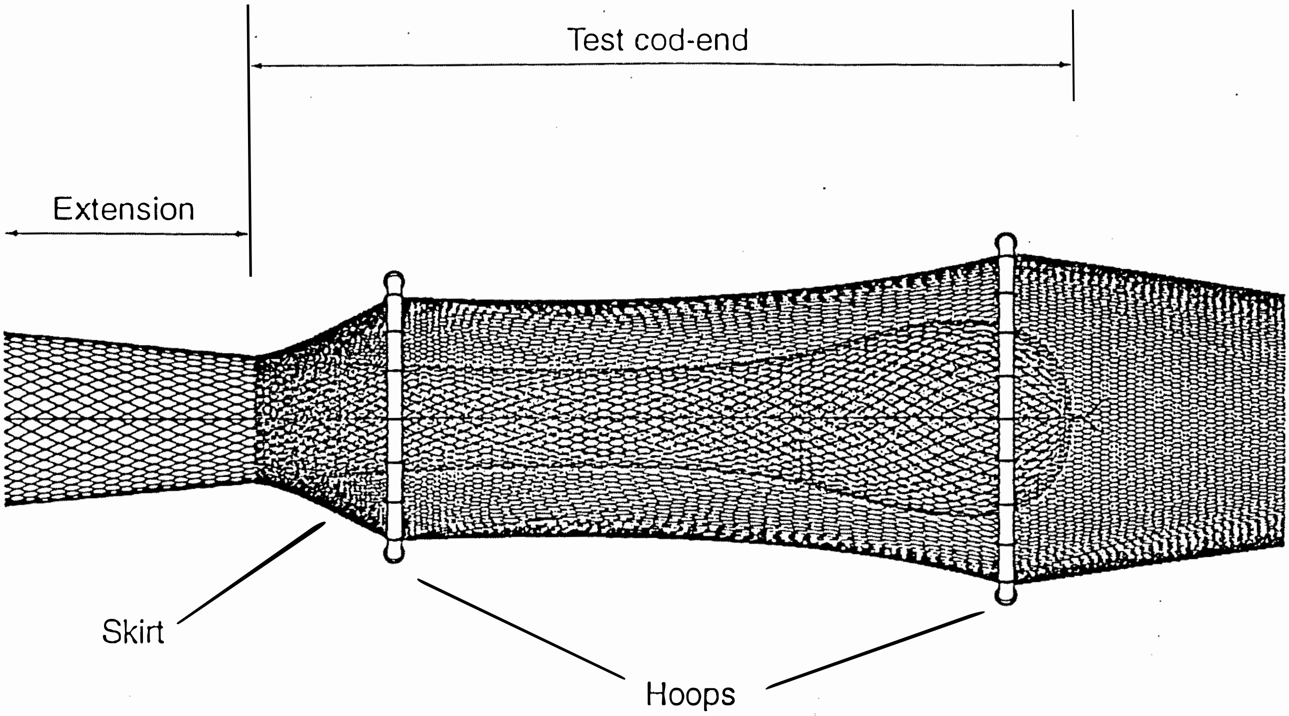

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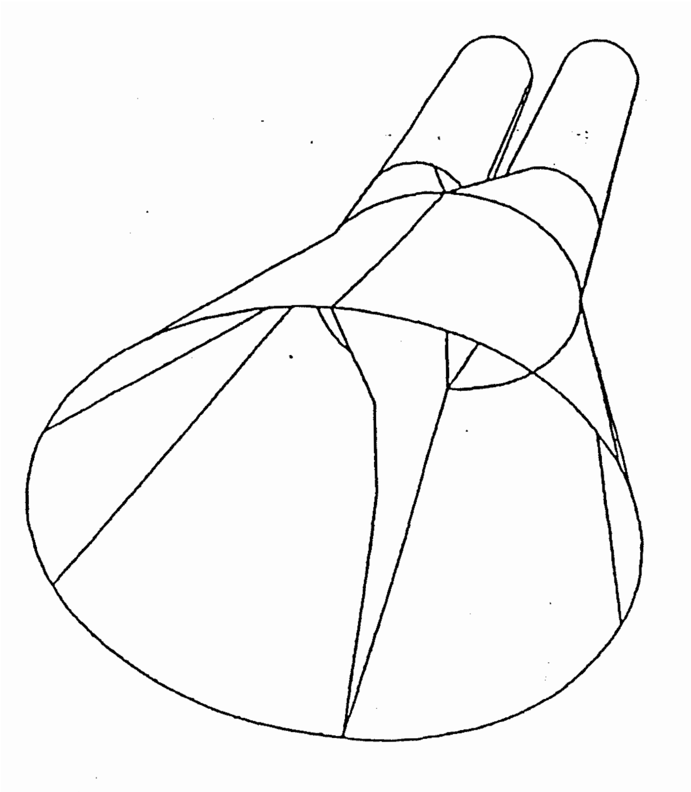

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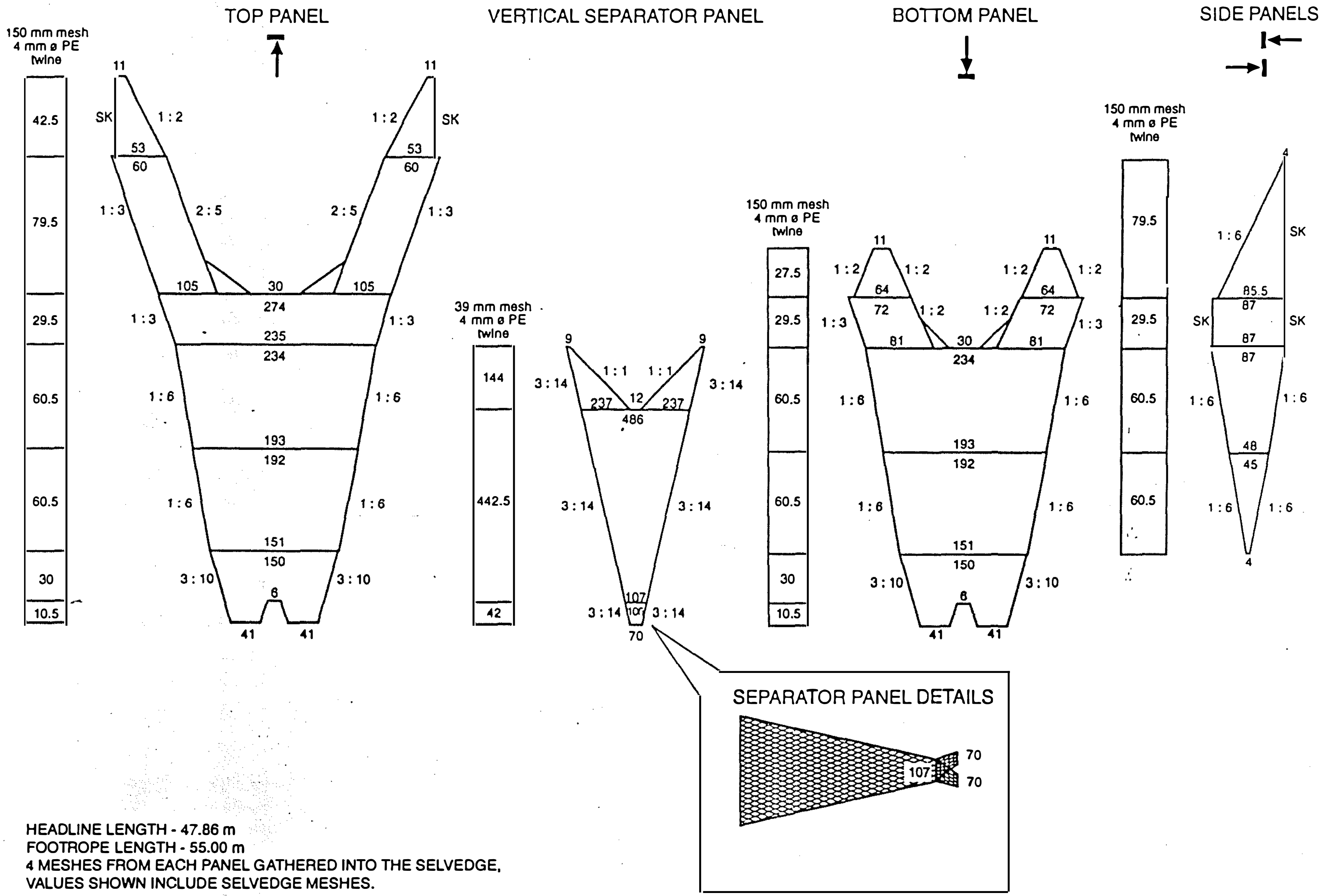

Figure 4.2.5.2 Example of a specification for a trouser trawl with vertical dividing panel

HEADLINE LENGTH - 47.86 m
FOOTROPE LENGTH - 55.00 m
4 MESHES FROM EACH PANEL GATHERED INTO THE SELVEDGE,
VALUES SHOWN INCLUDE SELVEDGE MESHES.

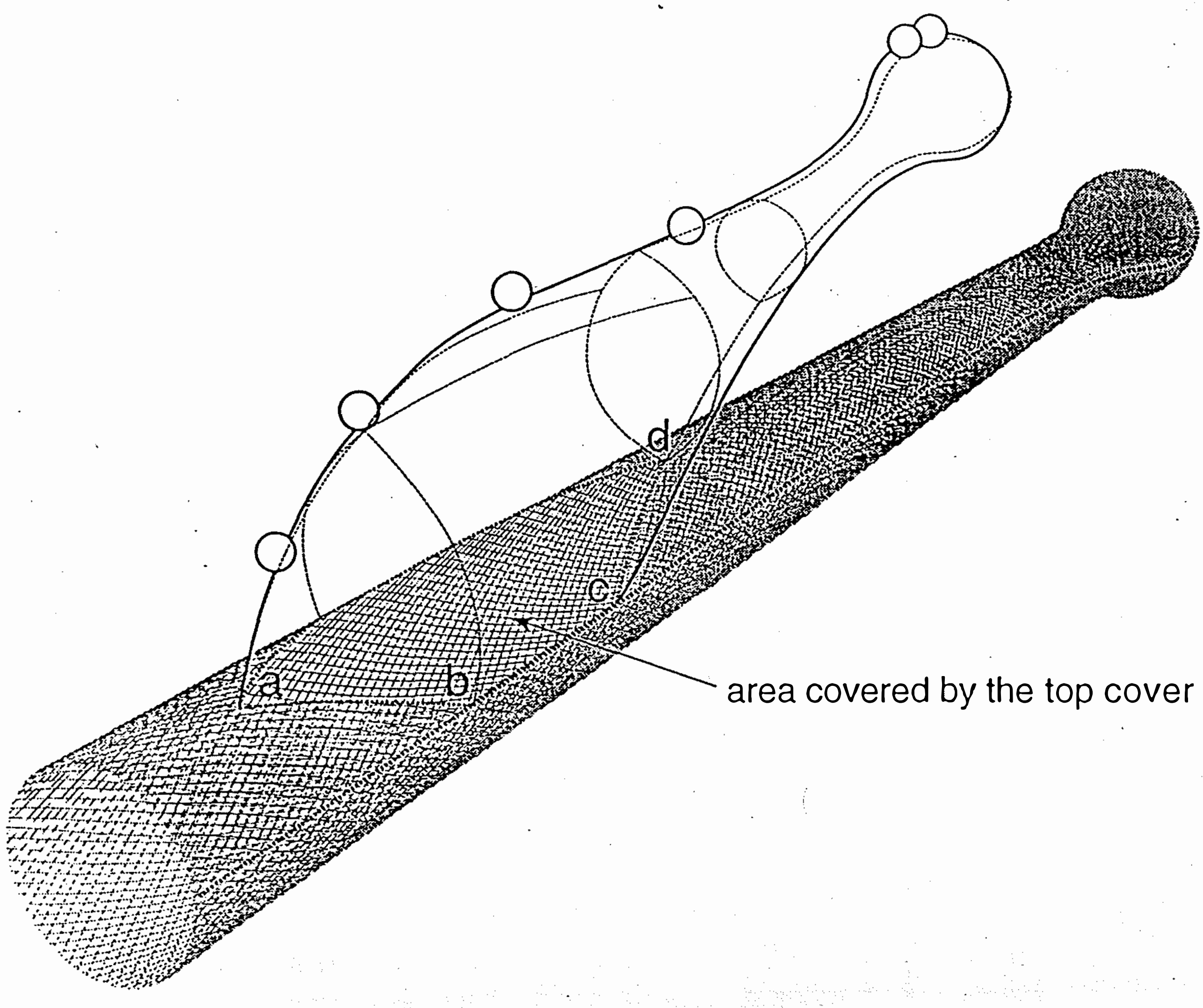

Figure 2.1.6 Schematic diagram of top cover over a window

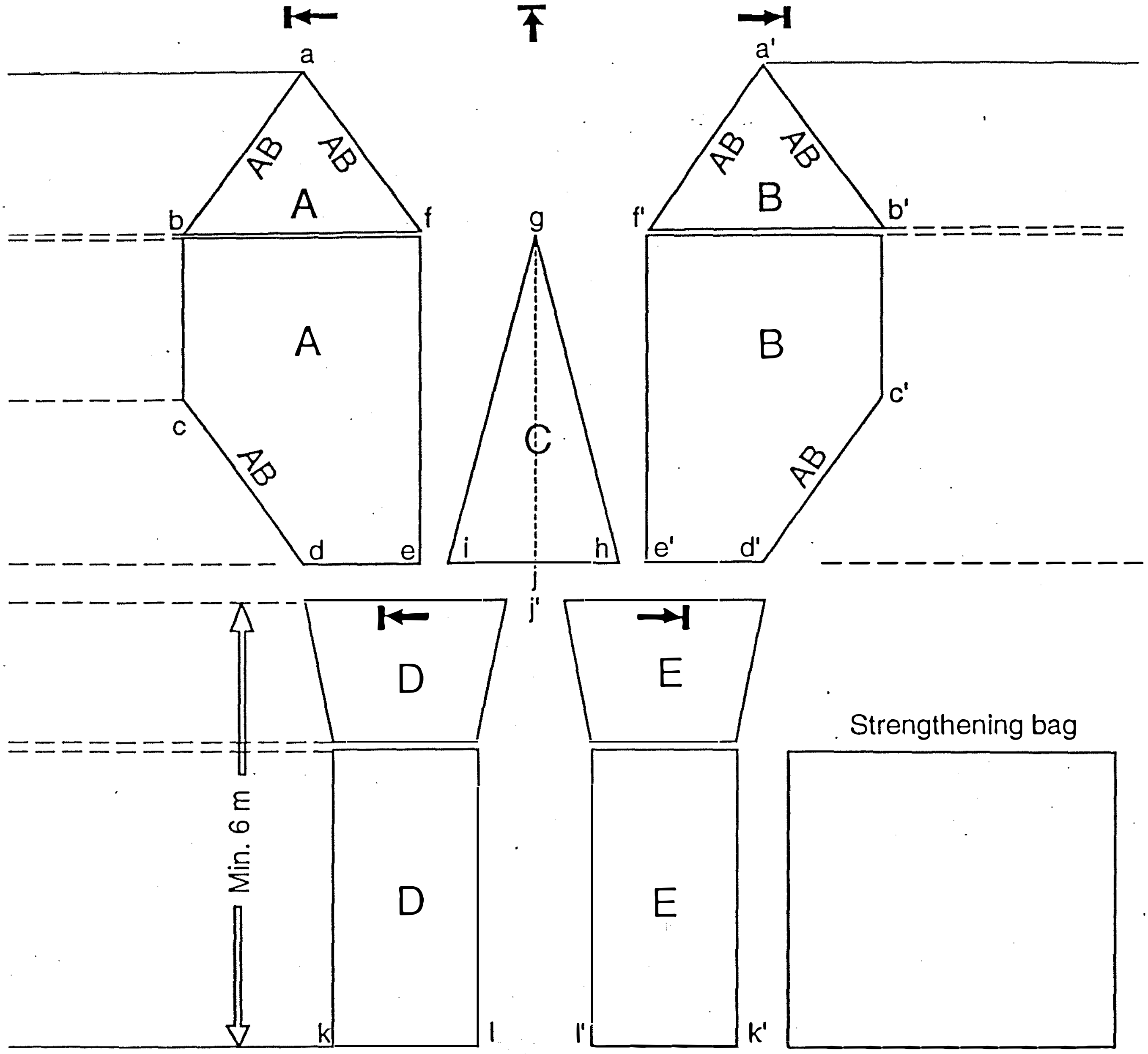

Figure 4.2.6.2 Design of a top cover