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An overview of sea trials with the alternative beam trawl

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1 Summary

The increasing concern about the ecosystem effects of fishing on the marine environment and particularly, the impact of trawling on benthic communities is reflected in numerous publications. The weight of this concern will very likely only increase in management decisions in the near future. Beam trawling has a negative reputation with regard to discarding and seafloor impact and may be confronted with further constraints imposed by the fisheries management.

The fishing industry has, however, the opportunity to anticipate management decisions and to adopt improved fishing gears, i.e. with reduced discarding and reduced environmental impact. A pro-active attitude and a voluntary uptake of improved gears allows the industry to shape the alterations to the specific conditions of the fishery and the fishing grounds.

For the chain matrix beam trawl, many studies have been carried out on a wide variety of technical alterations to the beam trawl to improve the length and species selectivity, to reduce ecosystem effects and to reduce fuel consumption. The ILVO-Fishery institute has carried out many of these experiments and has recently been testing and promoting a combination of successful alterations. The improved trawl has been called the “alternative beam trawl” and has already been commercially tested for two years on a beam trawler. It consists of a number of simple and cheap alterations to the beam trawl.

This report is a compilation of the most successful technical alterations for the beam trawl. The alternative beam trawl is not strictly defined and can consist of any combination of selective devices presented in this report or even new devices that prove to be successful. The basic idea is that each device that has undergone scientific scrutiny can be further developed by the industry in close cooperation with the fishery institute.

Devices like cut-away top panels, square mesh top panels, benthos release panels, T-90 cod-ends, square mesh cod-ends, narrow cod-ends, tunnels in square meshes, selective electric stimulation in the trawl etc. have been or are being tested by ILVO-Fishery. At present, though, sufficient effective selective devices are available to construct an alternative beam trawl with a significantly reduced environmental impact.

2 Introduction

Over 95% of the Belgian fishing fleet practices the beam trawl fishery. A typical mixed fishery that primarily targets sole and plaice but catches and lands a wide variety of commercial fish and shellfish species, including rays, small sharks, gadoids, red mullet, gurnards, flatfish, anglerfish, scallops, whelk, cuttlefish, octopus, squid, Norway lobster, edible crab, etc. Catch statistics indicate that the total number of commercial species taken by the beam trawler fleet is around 40. Towing heavy gear over the seabed at high speeds, to exhibits high catch efficiencies, making the beam trawl fishery very successful in the past. Recently however, decreasing quota and high fuel prices have strongly reduced the profitability of the beam trawl fleet. Next to this, growing public and political awareness on the potentially harmful effects of fishing gear to the marine environment has increased the pressure on the beam trawl fleet by NGOs and retailers.

In this light, there is a strong urge to develop an **alternative beam trawl** that incorporates a series of gear modifications aimed at reducing discards, fuel consumption and environmental impact. The Belgian beam trawl fleet represented by the **Rederscentrale** is well aware of this and has joined forces with the **Stichting Duurzame VisserijOntwikkeling** (SDVO) and the fisheries research institute **Instituut voor Landbouw en VisserijOnderzoek** (ILVO) in the alternative beam trawl task force. With financial support of the Flemish Government (FIVA) and the European Union (FIOV), vessel owners and scientists cooperate in the development and testing of a series of gear modifications.

Possible ways to diminish the adverse environmental impacts of beam trawling are technical gear modifications and the development of alternative fishing methods (Fonteyne and Polet, 2002; van Marlen et al., 2005). Several modifications have been investigated in two EU-funded research projects: SOBETRA (Optimization of a species selective beam trawl) (Fonteyne, 1997) and REDUCE (Reduction of the adverse environmental impact of demersal trawls) (Anon, 2002). The modifications tested in SOBETRA consisted of the use of large escape panels or escape openings in the top panel of the trawls to reduce the bycatch of roundfish species while minimising the effect on the flatfish catch rates. In REDUCE a benthos escape window in the belly of the trawl proved to be successful to reduce the benthos by-catch significantly while maintaining reasonable flatfish catch rates (Fonteyne and Polet, 2002). A consequent series of experiments dealt with improving these technical alterations, testing alternatives and demonstrating the new findings to the industry by trials aboard commercial vessels. These trials were carried out in the frame of the projects IDEV (Innovatiecentrum Duurzame en Ecologische Visserij) (Van Craeynest et al., 2008), ALTERNATIVE BEAM TRAWL (Uittesten van een alternatieve boomkor met het oog op brandstofbesparing en verminderde milieu-impact) (Polet et al., 2008), TOETS (Teruggooi in de boomkorvisserij: Optimalisatie van het onderzoek, Evaluatie van reducerende Technische maatregelen en Sensibilisering van de sector) (Vandendriessche et al. 2008) and IDEVbis (Innovatiecentrum Duurzame en Ecologische Visserij Bis) (Van Craeynest et al., 2008).

The most promising technical alterations have been combined as a concept in the alternative beam trawl, focusing on reduction in fuel consumption and reduction of discards. The key feature is **voluntary uptake** and freedom, within certain margins, to adapt the technical alterations in the gear to specific circumstances of the fishery.

The present paper gives an overview of the most promising technical gear modifications. In the appendix, more detail is given for a series of experiments.

3 Cod-end modifications

3.1 Introduction

The beam trawl fishery is a typical mixed fishery. Although they primarily target plaice and sole, the beam trawlers catch and land a wide variety of commercial fish and shellfish species, including rays, small sharks, gadoids, red mullet, gurnards, flatfish, anglerfish, scallops, whelk, cuttlefish, octopus, squids, Norway lobster, edible crab, etc. Catch statistics indicate that the total number of commercial species taken by the beam trawler fleet is around 40.

Discarding in the North Sea beam trawl fisheries (in general) is considerable. A dedicated STECF Sub-group, who was given the task of reviewing all discard information collected since the implementation of the EU Data Collection Regulation (2002), estimated the overall discard rate of the beam trawlers (for both target and non-target species, but exclusive of non-commercial species) to be between 40 and 60 % in weight (Anon., 2006). Discard rates strongly differ between species, with the lowest values being observed for cod (5-10 % in weight) and sole (10-15 %), and the highest for plaice (45-55 %) and whiting (65-80 %).

The main cause of discarding of commercial species in the flatfish-directed beam trawl fishery is related to the use of the 80 mm cod-end mesh in the sole-directed beam trawl fishery (Grift et al., 2004). This mesh size is appropriate for sole, but too small to accommodate the 50 % retention for plaice. All plaice caught below the minimum landing size of 27 cm (mainly 1- and 2-year olds) are discarded (Grift et al., 2004). Most discards (ca. 90 %) do not survive, either because they are damaged in the net during fishing or during the sorting process on board. So far, data on the non-commercial by-catches in the beam trawl fisheries have mostly been collected within the framework of short-term studies aiming at the impact of beam trawling on benthic and/or demersal assemblages. These studies generally indicate discarding in the flatfish beam trawl fishery as problematic (Lindeboom and De Groot, 1998).

Besides the mesh size in the beam trawl fishery, the mesh shape is also a cause of high discard rates. Diamond meshes have the tendency to close when they are stretched. Stewart and Robinson (1985) showed during underwater observations of trawls that diamond mesh cod-ends get a bulbous shape by the drag force of the accumulated catch in the cod-end. The consequence is that only a few mesh rows in front of the bulge are open and unobstructed. All meshes in front of this zone are stretched and have a reduced mesh opening. The number of meshes through which fish can escape is thus seriously reduced (Wileman et al., 1996). Several modifications have been suggested to resolve this issue: turning the netting over 90° or 45° degrees to obtain T90 meshes or square meshes or reducing the number of meshes in the circumference of the cod-end.

3.2 T90 Cod-end

3.2.1 Introduction

Experimental work (Dahm, 2004) has indicated that turning the diamond mesh netting by 90° (T90) may increase L50, compared to a similar cod-end with normal netting orientation. The shape of the knot makes a T0 mesh close when stretched and allows the T90 mesh to remain open to a certain extent, even when strong forces are applied (Figure 3-1). Herrman et al (2006) made a simulation with both types of meshes and showed that T90 meshes clearly have better selective properties for roundfish. Hansen (2004) extrapolated from flume tank tests that a T90 cod-end has better characteristics in terms of preservation of fish quality, selectivity, survival rate of escapees, efficiency and strength. Based on the apparent positive characteristics of the T90 mesh, it was decided to study the performance of T90 cod-ends in the beam trawl fishery.

Figure 3-1 – T90 cod-end with a posterior sheet of netting (5 rows) with T0 orientation

3.2.2 RV trials and commercial trials with observers

An extensive review of sea trials carried out with T90 cod-ends in beam trawls is presented in Appendix. The review includes both trials on board the research vessel ‘Belgica’ (50.9m LOA, 765 GRT, 1154 kW) and trials on board three commercial beam trawlers O 89 (33.53m LOA, 233 GRT, 1156 HP), Z 48 (32.50 LOA, 246 GRT, 1020 HP) and N 58 (19.35m LOA, 66 GRT, 300 HP). Scientific observers were present on board the commercial fishing vessels during the trials.

3.2.3 Sea trials without observers

Material and methods

In addition to the RV trials, several other vessels have rigged T90 cod-ends. Among these the Z 63 (20.04m LOA, 68 GRT, 298 HP) tested a T90 cod-end on a series of fishing trips from February to April 2007. The crew reported environmental conditions, technical data and sole catches (weight and numbers) per haul and per side, allowing a catch comparison to be made.

Results

Table 2-1 shows the differences in sole catches on board Z 63 during the experimental trials. For eacht trip, only limited differences were observed both in weight and in number. Statistical analysis (Wilcoxon, $p<0.05$) of the per haul data yielded no significant differences between the standard trawl and the trawl with T90 cod-end.

Table 3-1 – Catch differences for sole (% weight and % number) with T90 cod-end on board commercial vessel Z 63

Trip	Catch difference (% weight)	Catch difference (% number)	No of hauls
1	+2.2%	+2.3%	21
2	+1.3%	+1.8%	53
3	-1.6%	-2.0%	48
4	+0.1%	+0.7%	55
All	0.0%	+0.5%	177

3.2.4 Conclusion

The T90 cod-end has interesting selective properties for the most important commercial species for the Belgian beam trawl fleet, i.e. sole. It allows more undersized fish to escape and more marketable fish to be caught. For other flatfish (including plaice), selective properties are worse with T90 retaining more undersized fish. Roundfish species and non-commercial fish appear to escape more easily from a T90 mesh than from a diamond mesh in a typical beam trawl cod-end. The picture is less clear for benthic invertebrates, RV trials showed a significant reduction whereas in commercial trials, little differences were observed.

One important issue raised by skippers participating in the trials is that the T90 netting appeared to be shrinking faster than traditional diamond netting.

3.3 Square mesh cod-end

3.3.1 Introduction

Research by Fonteyne and M’Rabet (1992) and Walsh et al. (1992) has shown that square meshes are less selective for flatfish compared to diamond meshes. The rationale behind it was that diamond meshes have a shape similar to the body shape of flatfish. For roundfish on the other hand, the selective properties of square meshes are better than those of diamond meshes. Given the present concerns with the state of cod stocks and the implications of the cod recovery measures on the beam trawl fleet. It was decided to evaluate the performance of a square mesh cod-end in the beam trawl fishery.

Figure 3-2 – Square mesh cod-end with a posterior sheet of diamond mesh

3.3.2 RV trials

Material and methods

A sea trial was carried out on board the research vessel 'Belgica' (50.9m LOA, 765 GRT, 1154 kW) in November 2007. A 4m chain matrix beam trawl was rigged with a square mesh cod-end (80mm nominal mesh size). A small mesh cover was rigged over the cod-end. Catches of the cod-end and cover were collected separately. For both, total weight, commercial catch length distributions and bycatch compositions were recorded.

Results

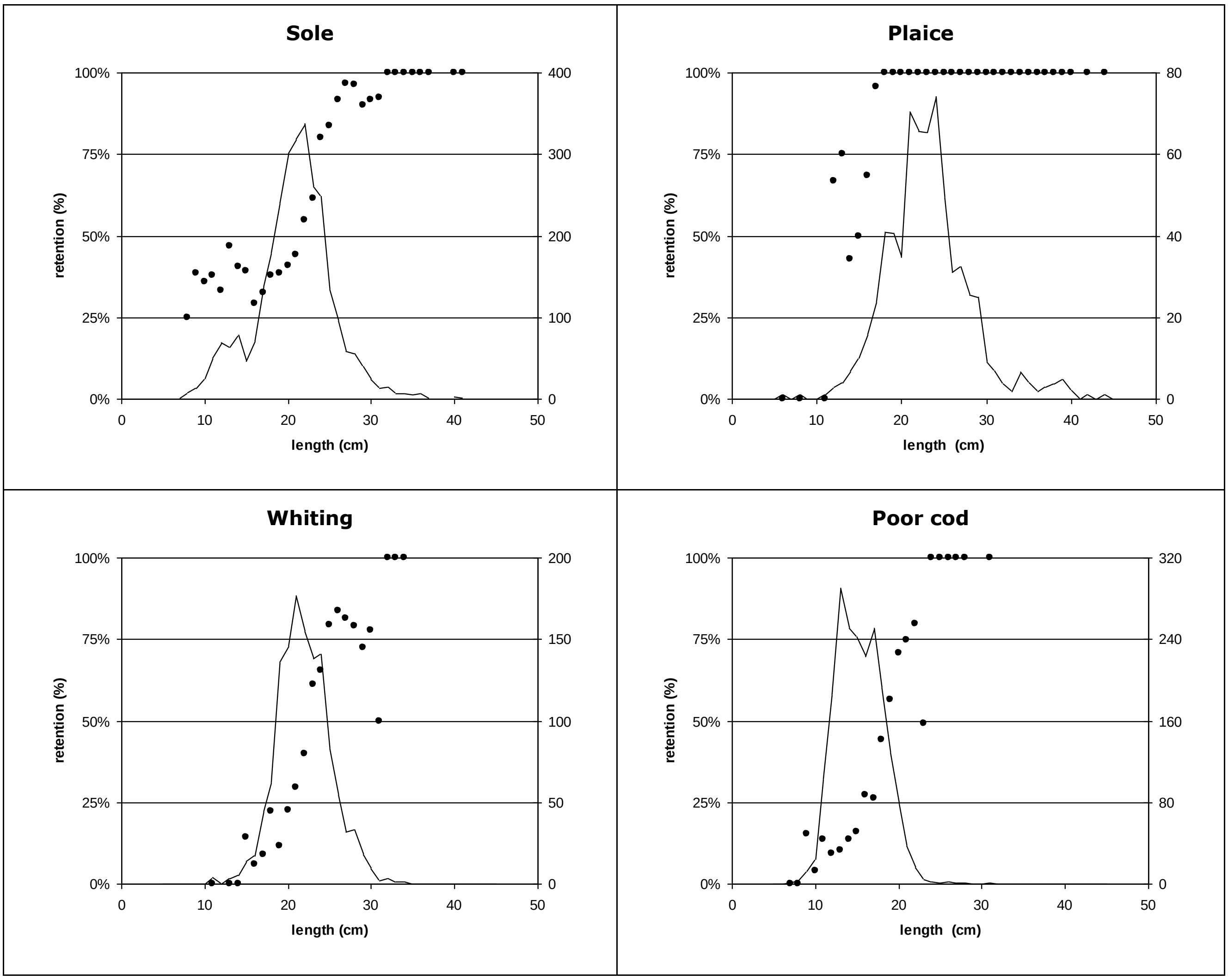

Figure 3-3 – Retention of fish in a square mesh cod-end (dotted line), total number of fish caught in both cod-end and cover (full line)

Figure 3-3 shows the catch retention (% cod-end to total catch ratios) and total catch numbers per length class for four commercial fish species that were caught in sufficient numbers. The experimental retention graphs for sole, plaice and poor cod may be compared with selection ogives and L50 values (length at which 50% of the catch is retained by the cod-end) determined for diamond mesh and T90 mesh cod-ends (80mm) (Appendix).

- L50 for sole is 21.3mm for diamond and 22.3mm for T90 mesh, comparable to the 21 to 22mm observed in the sea trials with a square mesh cod-end.
- L50 for plaice is 15.3mm for T90 mesh, it appears to be somewhat smaller in the sea trials with a square mesh cod-end.

- L50 for poor cod is 12.9mm for diamond and 19.6 for T90 mesh, a value between 18 and 19 mm was observed during the sea trials with a square mesh cod-end.

All retention curves appear to be quite steep in comparison to selectivity ogives calculated for diamond mesh cod-ends.

The covered cod-end approach is not well suited to evaluate the effect on benthic invertebrates.

3.3.3 Commercial trials

Several commercial vessels (Z 121, Z 39) have experimented with a square mesh cod-end. However, due experimental flaws, insufficient data are available for a catch comparison analysis.

3.3.4 Conclusion

Limited results are available on the performance of square mesh cod-ends in the beam trawl fishery. Selective properties for sole appear to be comparable to those of the T90 cod-end, slightly better than those of traditional diamond mesh. Similar to conclusions made by Fonteyne and M'Rabet (1992) and Walsh et al. (1992), it was observed that the selectivity of a square mesh cod-end is worse for plaice and better for roundfish. This may be explained by the shape of the mesh opening in comparison to the natural shape of flatfish (similar to stretched diamond mesh) and roundfish (similar to an opened square mesh).

Catch comparison experiments and commercial trials are needed to further evaluate the performance of a square mesh cod-end, especially with regards to bycatch of benthic invertebrates.

3.4 Narrow cod-end

3.4.1 Introduction

Diamond meshes have the tendency to close when they are stretched. Stewart and Robinson (1985) showed during underwater observations of trawls that diamond mesh cod-ends get a bulbous shape by the drag force of the accumulated catch in the cod-end. The consequence is that only a few mesh rows in front of the bulge are open and unobstructed. All meshes in front of this zone are stretched and have a reduced mesh opening. The number of meshes through which fish can escape is thus seriously reduced (Wileman et al., 1996). By reducing the number of meshes in the circumference of the cod-end, it is expected that the meshes in front of the accumulated catch will remain more opened.

3.4.2 RV trials

Material and methods

A sea trial was carried out on board the research vessel 'Belgica' (50.9m LOA, 765 GRT, 1154 kW) in November 2007. A 4m chain matrix beam trawl was rigged with a narrow diamond mesh cod-end (80mm nominal mesh size) having a circumference of only 40 meshes in comparison to the standard 50 meshes. A small mesh cover was rigged over the cod-end. Catches of the cod-end and cover were collected. For both, total weight, commercial catch length distributions and bycatch compositions were recorded.

Results

Figure 3-4 shows the catch retention (% cod-end to total catch ratios) and total catch numbers per length class for four commercial fish species (sole, plaice, whithing and poor cod) that were caught in sufficient numbers. The experimental retention graphs for sole, plaice and poor cod may be compared with selection ogives and L50 values (length at which 50% of the catch is retained by the cod-end) determined for diamond mesh and T90 mesh cod-ends (80mm) (Appendix).

- L50 for sole is 21.3mm for diamond and 22.3mm for T90 mesh, a value around 25mm was observed during the sea trials with a narrow cod-end.
- L50 for plaice is 15.3mm for T90 mesh, comparable to the 15 to 16mm observed in the sea trials with a narrow cod-end.
- L50 for poor cod is 12.9mm for diamond and 19.6 for T90 mesh, a value between 20 and 21 mm was observed during the sea trials with a narrow cod-end.

Retention curves observed in the narrow cod-end experiments are less steep than those observed in experiments with the square mesh cod-end.

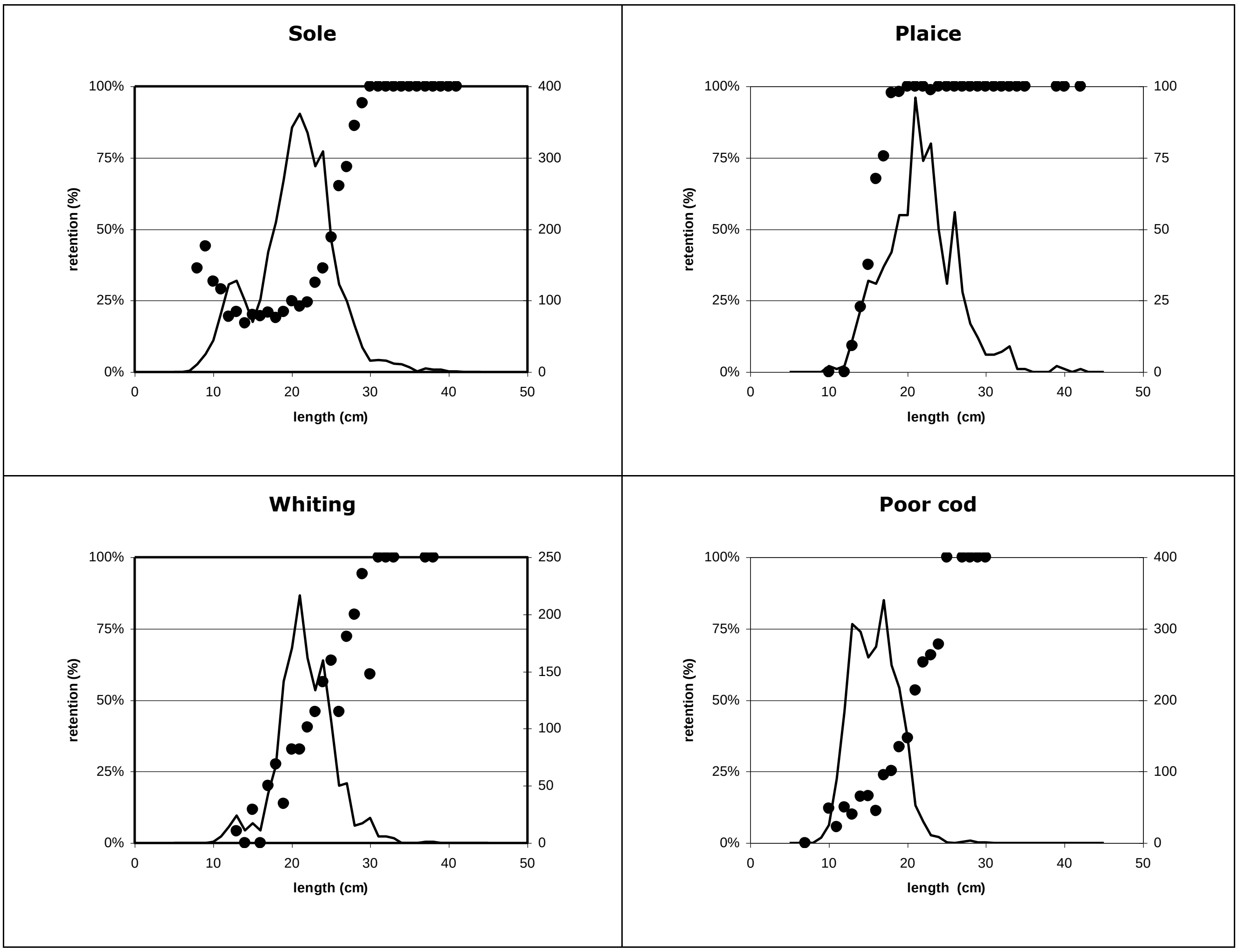

Figure 3-4 – Retention of fish in a narrow cod-end (dotted line), total number of fish caught in both cod-end and cover (full line)

The covered cod-end approach is not well suited to evaluate the effect on benthic invertebrates.

3.5 Conclusion

Limited results are available on the performance of narrow cod-ends in the beam trawl fishery. For sole, an L50 value above the minimum landing size was observed (25cm in comparison to the 24cm minimum landing size). For roundfish, selective properties appear slightly better than those obtained with the traditional diamond mesh cod-end.

In general, the performance of the narrow cod-end appears worse than the performance of the T90 and square mesh cod-end.

4 Benthos release panels

4.1 Introduction

The increasing concern about the ecosystem effects of fishing on the marine environment and particularly, the impact of trawling on benthic communities is reflected in numerous publications (Hall, 1999 ; Kaiser and De Groot, 2000 ; Kaiser et al., 2006 ; Løkkeborg, 2005). The effects of bottom trawling on benthic ecosystems in the North Sea and Irish Sea were intensively studied during an international research project (Lindeboom and De Groot, 1998). In the North Sea flatfish beam and otter trawl fisheries the by-catch weight of invertebrates was estimated at several times the amount of marketable fish. The mortality of the invertebrates discarded from flatfish beam trawls was found to be species dependent and varied from less than 10% (starfish and brittle stars) to almost 90% (the bivalve *Arctica islandica*). Due to the low catch efficiency of beam trawls for these species, this mortality is low when expressed as a percentage of the initial density. Nevertheless, repeated trawling will affect the structure of benthic communities, leading to a replacement of sensitive slow growing and slow reproducing species by opportunistic, fast growing and fast reproducing species. One possible way for reducing the adverse effects of trawling on benthic communities is to reduce the direct mortality by developing alternative fishing methods and through technical modifications of existing fishing gears. Adaptations to the bottom panel of the trawl may reduce bycatch of benthic invertebrates. The application of a benthos release panel (square mesh panel) in front of the cod-end aimed at reducing bycatch of benthic invertebrates was tested (Figure 4-1).

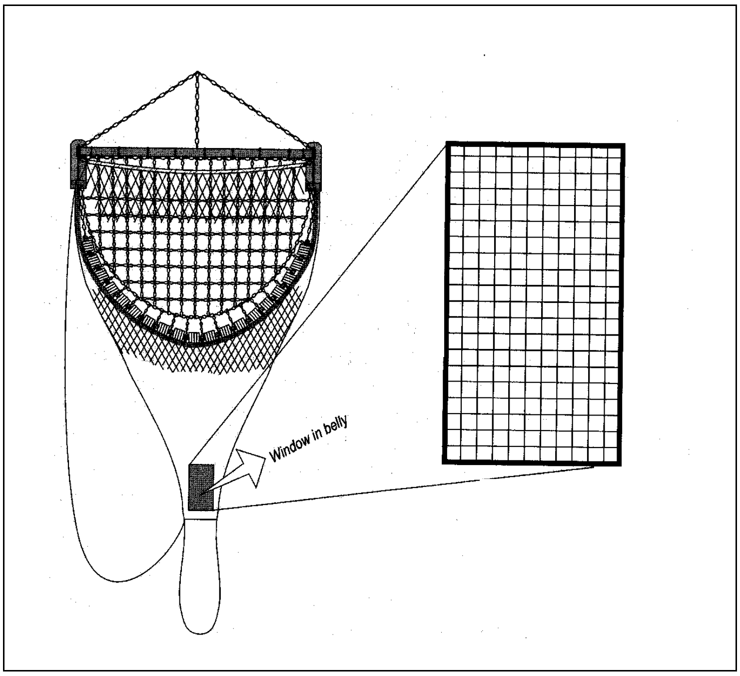

Figure 4-1 – Benthos release

4.2 RV trials

An extensive review of sea trials with benthos release panels in beam trawls carried out on board the research vessel 'Belgica' (50.9m LOA, 765 GRT, 1154 kW) is presented in Appendix.

4.3 Commercial trials with observers

An extensive review of sea trials with benthos release panels in beam trawls carried out on board the commercial fishing vessels O 89, Z 48 and N 58 is presented in Appendix. Since then, further trials have been carried out on board Z 121 in January 2008. The focus of these trials was on discard reduction.

4.3.1 Material and methods

During the sea trials, Z 121 was rigged with a benthos release panel on one side. The panel is constructed of doubly braided 120mm square mesh netting and inserted 10 meshes in front of the cod-end. Total catches, weight and length distribution of commercial species and weight and composition of the bycatch were recorded. This approach allows a catch comparison analysis to be made.

4.3.2 Results

Discards during the experimental sea trip consisted of 40 species of invertebrates and 40 species of fish. The benthos release panel appeared to have little effect on the discard composition. Starfish made up the bulk of the invertebrate discards and haddock, poor cod, lemon sole made up the bulk of the fish discards.

Figure 4-2 shows the number of invertebrates and fish in the discards, Table 4-1 shows the the discard reduction (in numbers) for individual species. For three species of starfish and for the total number of invertebrates, a significant reduction in the number of discards could be observed.

Figure 4-3 shows the total weight of discards compared to the commercial catch weight, the weight of different fractions in the non-commercial catch and the weight of selected species (sole, scallops, gadoids) in the commercial catch. Table 4-2 shows the effect of the benthos release panel on the weight of different commercial and non-commercial species and fractions in the total catch. Catch weights were significantly lower for one species of starfish, inert material, scallops and total commercial catch. It was established that loss of scallops occurred due to improper rigging of the benthos release panel that caused a slack in the bottom panel of the net in front of the panel. No significant catch losses were observed for sole or other commercial species.

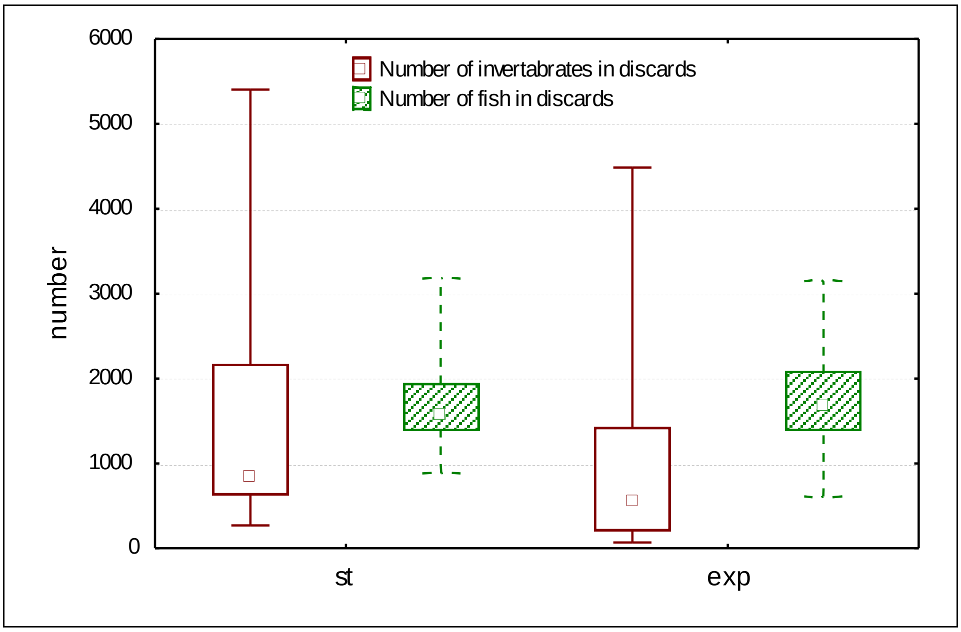

Figure 4-2 – Number of fish and invertebrates in discards for the standard trawl and the trawl with benthos release panel on board Z 121

Table 4-1 – Effect of benthos release panel on discards (numbers) of different species (* significant, Wilcoxon, p<0.05)

	# hauls	Wilc p	median # st	median # exp	hauls with reduction (%)	median difference (%)
Asterias rubens*	**20**	**0.05**	**92.3**	**39.4**	**70**	**-70.4%**
Astropecten irregularis*	**20**	**0.05**	**157.0**	**52.9**	**75**	**-64.7%**
Cancer pagurus	20	0.83	9.9	11.3	45	0.0%
Crossaster papposus*	**20**	**0.02**	**16.3**	**7.3**	**65**	**-32.1%**
Inachus sp.	20	0.39	0.0	0.0	40	0.0%
Liocarcinus holsatus	20	0.53	25.7	45.6	35	17.6%
Luidia sp. (L. ciliaris + L. sarsi)	20	0.40	15.6	12.5	45	0.0%
Maja squinado	20	0.74	18.0	14.3	60	-18.9%
Marthasterias glacialis	20	0.09	263.8	239.1	65	-33.8%
Necora puber	20	0.40	26.2	13.0	55	-10.7%
Pecten maximus	20	0.11	34.2	15.4	60	-29.0%
Aspitrigla cuculus	20	0.16	14.7	29.8	25	40.5%

Buglossidium luteum	20	0.19	0.0	11.8	25	7.8%
Callionymus lyra	20	0.91	130.0	113.9	50	6.1%
Eutrigla gurnardus	20	0.57	11.8	12.5	30	2.0%
Glyptocephalus cynoglossus	20	0.69	9.7	6.3	35	0.0%
Limanda limanda	20	0.72	153.9	95.4	50	-0.5%
Lophius piscatorius	20	0.84	12.1	13.0	45	0.0%
Melanogrammus aeglefinus	20	0.68	319.9	350.4	50	2.6%
Merlangius merlangus	20	0.26	159.4	189.3	35	19.0%
Microstomus kitt	20	0.63	198.7	239.1	55	-3.8%
Pleuronectes platessa	20	0.25	26.2	15.5	55	-18.1%
Raja brachyura	20	0.97	4.3	5.4	30	0.0%
Scyliorhinus canicula	20	0.31	170.7	148.8	60	-11.0%
Trisopterus luscus + T. minutus	20	0.50	201.3	155.3	55	-19.0%
Total number of invertebrates in discards*	***20***	***0.03***	***832.5***	***542.8***	***85***	***-45.8%***
Total number of fish in discards	*20*	*0.79*	*1569.0*	*1673.9*	*50*	*4.1%*

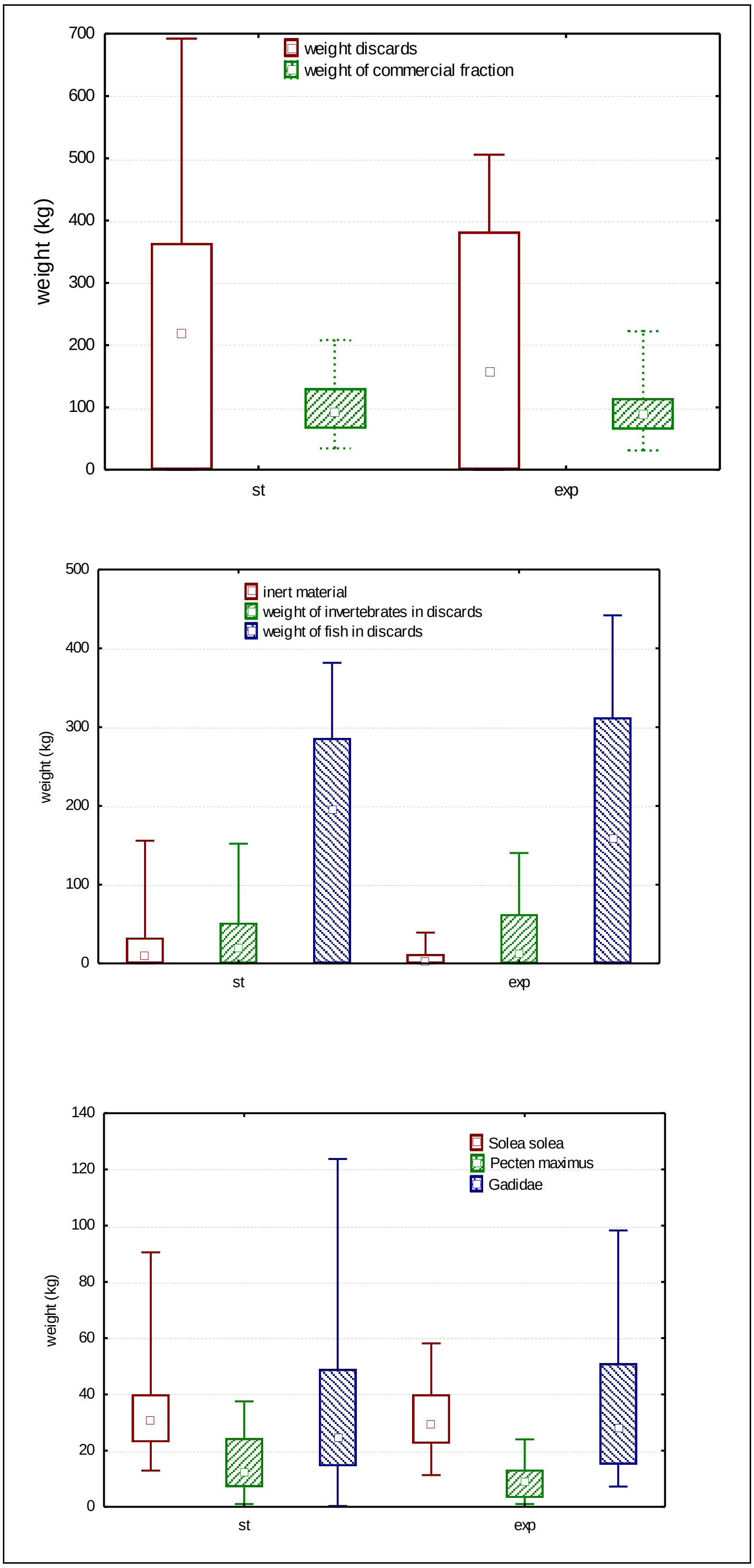

Figure 4-3 – Effect of benthos release panel on weight of discards and commercial fraction (top), weight of different fractions of the non-commercial catch (center), weight of selected commercial species (bottom)

Table 4-2 – Effect of benthos release panel on weight of different species (kg) and catch fractions (* signigicant, Wilcoxon, p<0.05)

	# hauls	Wilc p	median weight st	median weight exp	hauls with reduction (%)	median difference (%)
Asterias rubens	20	0.26	1.24	1.08	45.5%	0.0%
Astropecten irregularis*	**20**	**0.01**	**2.47**	**1.07**	**63.6%**	**-46.5%**
Cancer pagurus	20	0.94	4.35	4.38	40.9%	0.0%
Crossaster papposus	20	0.14	0.00	0.00	31.8%	0.0%
Liocarcinus holsatus	20	0.60	0.00	0.00	13.6%	0.0%
Luidia sp. (L. ciliaris + L. sarsi)	20	0.46	0.00	0.00	13.6%	0.0%
Maja squinado	20	0.94	11.13	10.70	45.5%	0.0%
Marthasterias glacialis	20	0.56	21.64	20.01	54.5%	-6.0%
Necora puber	20	0.22	1.08	0.00	36.4%	0.0%
Pecten maximus	20	0.12	3.66	0.25	45.5%	0.0%
Aspitrigla cuculus	20	0.08	1.47	2.26	18.2%	5.6%
Buglossidium luteum	20	0.17	0.00	0.00	13.6%	0.0%
Callyonimus lyra	20	0.74	8.85	9.45	45.5%	0.0%
Eutrigla gurnardus	20	0.41	2.18	1.47	22.7%	1.5%
Glyptocephalus cynoglossus	20	0.83	0.00	0.00	36.4%	0.0%
Limanda limanda	20	0.31	8.64	9.09	31.8%	3.1%
Lophius piscatorius	20	0.95	2.17	2.96	36.4%	0.0%
Melanogrammus aeglefinus	20	0.60	69.37	85.58	45.5%	0.0%
Merlangius merlangus	20	0.22	16.64	25.14	40.9%	5.3%
Microstomus kitt	20	0.82	24.34	28.59	50.0%	-5.1%
Pleuronectes platessa	20	0.16	3.33	1.44	50.0%	-4.7%
Raja brachyura	20	0.61	0.00	2.53	31.8%	0.0%
Scyliorhinus canicula	20	0.79	81.49	73.62	50.0%	-2.2%
Trisopterus luscus + T. minutus	20	0.46	9.91	10.52	40.9%	0.7%
Inert fraction*	**20**	**0.01**	**26.25**	**10.67**	**77.3%**	**-48.6%**
Total weight invertebrates	20	0.68	48.89	50.98	50.0%	-3.9%
Total weight fish in discards	20	0.71	275.45	302.39	50.0%	-0.4%
Total weight discards	20	0.63	372.46	388.14	50.0%	-0.4%
Solea solea (comm)	35	0.29	31.00	29.60	42.9%	3.4%
Pecten maximus* (comm)	**35**	**<0.001**	**12.40**	**8.00**	**88.6%**	**-44.6%**
Gadidae sp. (comm)	35	0.83	24.30	28.00	45.7%	11.4%
Total weight commercial fraction*	**35**	**0.02**	**90.90**	**88.90**	**68.6%**	**-6.9%**
Efficiency (comm/total)	20	0.79	25.3%	23.0%	55.0%	-1.1%

4.4 Conclusion

RV trials and commercial trials have shown that the application of a benthos release panel in front of the cod-end can drastically reduce bycatch of inert material and benthic invertebrates. This may improve fish quality and reduce catch handling time. The reduction of benthic invertebrates appears to be strongly species specific, with relatively heavy and small species and individuals yielding the best results.

The observations for commercial species give a mixed picture. On eurobeamers, there appears to be an unacceptable loss of commercial sole (similar observations were made on board the research vessel that is rigged with trawls of comparable size). Whereas the benthos release panel performs better on large beam trawlers. This may be due to the length of the trawl which is needed for the catch to settle after the chain matrix or the tickler chains or it may be due to the length of the panel in comparison to the length of the trawl.

5 Alterations to the top panel (commercial trial

s
)

The use of short large mesh sections in the front part of the top panel is obligatory in the beam trawl fishery. Several vessels are voluntarily rigging a longer large mesh section than required in order to reduce drag and save fuel.

A review of sea trials with square mesh top panels and cutaway covers in beam trawls aimed at reducing gadoid bycatch that were carried out on board commercial fishing vessels is presented in Appendix.

From these trials, it was concluded that roundfish species like haddock and whiting, which stay in the middle or upper part of a trawl when they are caught can escape through escape openings in the top panel of a beam trawl. The efficiency depends on the size of the escape opening and consequently they are only efficient when inserted in the larger beam trawls. Cod, however, a species remaining close to the belly of the trawl when caught, takes no or little advantage of these escape openings.

6 Separator panels (commercial trials)

6.1 Introduction

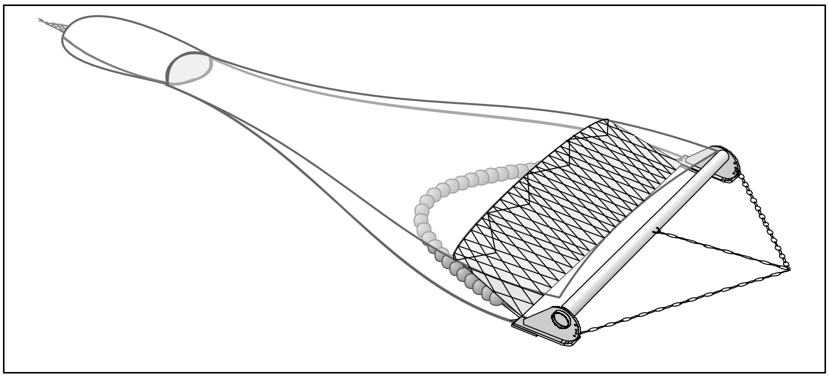

Figure 6-1 – Inclined separator panel

Sea trials with cutaway covers and square mesh top panels aimed at reducing bycatch of cod in beam trawl fisheries have yielded little success (6 Separator panels (commercial trials)) since cod tend to remain close to the bottom. An inclined separator panel, rigged from the chain matrix to the cover (Figure 6-1), combined with a cutaway cover was tested to reduce the bycatch of cod. The separator panel guides the cod to the opening in the top of the trawl.

An inclined separator panel was tested on board the commercial fishing vessel Z 39 Zuiderzee (32.5m LOA, 251 GRT, 750 kW). During three fishing trips in ICES Area IVc (May to July 2008), cod catches were recorded per haul and per side, enabling a catch comparison. Limited data was recorded for other species.

6.2 Results

Figure 6-2 shows the cod bycatch reduction (%) during the three experimental trips. Over all trips, a consistent and significant (Wilcoxon) reduction of cod catches was observed (-26% trip 1, -42% trip 2, -42% trip 3).

Limited catch data was available for other species, showing no significant (Wilcoxon) difference in the catch between both sides (Table 6-1).

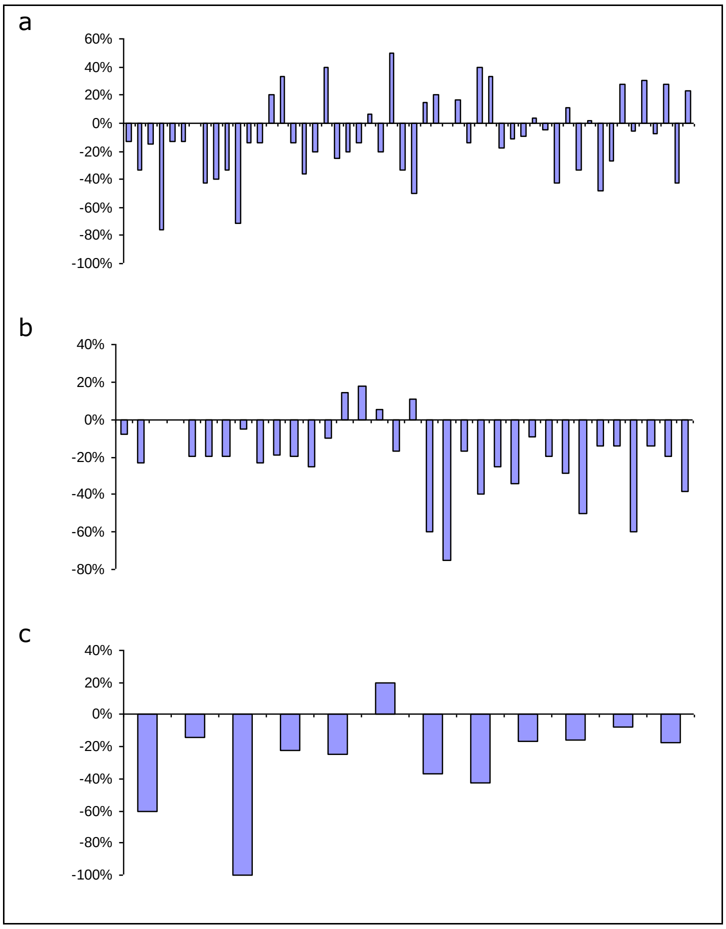

Figure 6-2 – Cod bycatch reduction (%) using an inclined separator panel on board Z 39, trip 1 (a), trip 2 (b), trip 3 (c)

Table 6-1 – Catch differences (%) observed with an inclined separator panel on board Z 39 (combined data for 3 fishing trips)

Species	**Catch difference (% weight)**
Cod	**-39%**
Sole	+0.4%
Plaice	- 6%
Mixed ray	-3%
Whiting	+5%

6.3 Conclusion

Application of an inclined separator panel in a beam trawl can significantly reduce unwanted bycatch of cod (**-39%**). The limited data available on other species showed no significant catch reduction. In a previous experiment carried out in 2005 within the framework of the REDUCE project (Anon. 2002), a 20% catch reduction was observed for cod. Catch reductions were also observed for whiting (20%) and haddock (30%). The differences observed may be explained by differences in rigging.

7 T90 extension (commercial trials)

7.1 Introduction

Occasional catches of sand can greatly increase the weight and drag of a trawl in the beam trawl fishery. This may occur quite frequently on certain fishing grounds. In flume tank studies, it has been observed that T90 netting allows an enhanced water flow through the net and wider opening of the meshes than traditional diamond meshes. In this light, commercial skippers suggested that application of T90 extension might reduce the bycatch of sand in the beam trawl fishery, reducing fuel consumption and enhancing fish quality. An additional result might be a reduced catch of benthic invertebrates.

T90 extensions were rigged on board the commercial vessels Z 98 and Z 483 for a series of sea trials. Commercial catches were recorded per haul and per side, allowing a catch comparison analysis. Next to this, total catches were evaluated visually and warp loads were collected from force cells installed on board the Z 98.

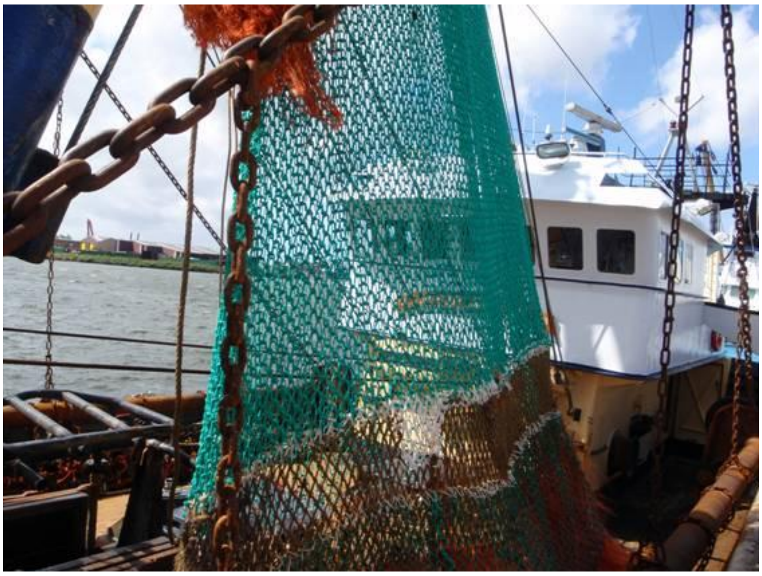

Figure 7-1 – T90 extension rigged on board Z 98

7.2 Results

7.2.1 Total catch and warp loads

On board Z98, average warp loads per haul ranged from 3.5 tonnes to 4.6 tonnes per gear. No significant differences in warp load could be observed between the standard configuration and the trawl with T90 extension. However, the warp load gauges installed on the vessel are not calibrated on a regular basis and no baseline data was available from previous trips. The crew observed higher catches of benthic invertebrates and sand in the standard trawl (Figure 7-2).

Figure 7-2 – Sand caught in the standard trawl

7.2.2 Commercial catch

A paired Wilcoxon analysis of commercial catch weights (per haul and per configuration) showed significant catch losses for cod (-36%), brill (-22%) and sole (-9%). Table 7-1 shows catch differences for 10 species over the whole trip.

Table 7-1 - Catch differences (% weight) observed for trawl with T-90 extension on board Z 98 (* significant, Wilcoxon, p<0.05)

Species	Catch difference (% weight)	Total weight (kg)	No of hauls
Cod	**-36%***	432	21
Brill	**-22%***	408	35
Sole	**-9%***	1918	41
Turbot	-2%	313	39
Mixed gurnards	+1%	402	26
Plaice	+3%	2638	37
Cuttlefish	+4%	1232	22
Mixed ray	+8%	1110	18
Dogfish	+17%	249	8

Figure 7-3 shows the length frequency distribution of sole caught in the standard trawl and the trawl with T90 extension. There is a loss of small commercial sole (24 to 29 cm). No differences are observed for sole below the minimum landing size or for larger sole.

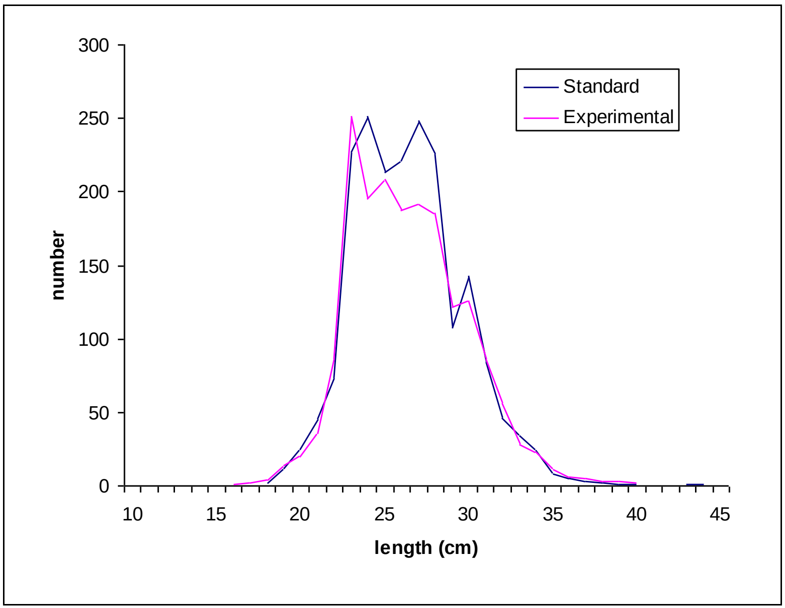

Figure 7-3 – Length frequency distribution of sole caught in standard trawl and trawl with T90 extension on board Z 98

On board Z 483 only a limited number of hauls were performed before the T90 extension was ripped and replaced with a diamond mesh extension. These hauls yielded a slightly higher commercial sole catch (+3%).

7.3 Conclusion

According to the crew of the commercial vessel Z 98, the T90 extension succeeded in reducing bycatch of sand and benthic invertebrates without grave losses of commercial catches.

Baseline data on warp loads and further sea trials on fishing grounds where bycatch of sand is more frequent are required to further evaluate the potential effect of a T90 extension on fuel consumption.

8 Trawls in Dyneema™ netting (commercial trials)

8.1 Introduction

The traditional nylon netting material in a tickler chain beam trawl was replaced with Dyneema™. This material exhibits a higher breaking force and a higher abrasion resistance. Hence, smaller diameter twine can be used and the trawl will consist of less netting material (70% weight reduction in netting material). This results in a reduction of the hydrodynamic drag of the netting material and in lower fuel consumption. The Dyneema™ trawls were tested on board the commercial fishing vessel O 231.On a series of four trips in the North Sea and the Celtic Sea (August 2008 to September 2008). Data on fuel consumption, warp load and vessel speed were collected and compared to data from the previous year.

8.2 Results

Baseline data was gathered from 18 different trips to three different fishing grounds (Irish Sea, Celtic Sea, Liverpool Bay, North Sea and Bay of Biscay) over a one year period (August 2007 to July 2008). An average fuel consumption of 5420 l/day with a standard deviation of 5% was observed over all trips. There were some differences between fishing grounds: 5315 l/day in Liverpool Bay, 5450 l/day in the Celtic Sea and 5590 l/day in the Bay of Biscay. Average warp loads were 6.7 tonnes with a standard deviation of 7% (per gear).

After replacing the nylon netting with Dyneema™, the average fuel consumption per day dropped to 4940 l/day with average warp loads of 5.9 tonnes with a standard deviation of 6%, a drop of **11.9%**. There was no significant difference in fishing speed between the baseline trips and the Dyneema™ trips. If all baseline trips are included, a reduction of **8.8%** in fuel consumption is observed.

The skipper did not observe any differences in catch volume or catch composition.

8.3 Conclusion

Replacement of the traditional nylon netting material in a tickler chain trawl with Dyneema™ results in a reduction of fuel consumption of 8.8%. It is expected that the effect of using Dyneema™ in a chain matrix trawl will be smaller. As this gear is fished at lower speeds, the relative importance of hydrodynamic drag is smaller than in a tickler chain trawl. Bottom resistance will be more important in the total resistance of a chain matrix beam trawl.

9 Wheeled trawl shoes (commercial trials)

9.1 Introduction

The sliding resistance of the trawl shoes of a beam trawl makes up an important part of the total resistance of the gear (especially at lower fishing speeds). If the trawl shoes in are fitted with or replaced by wheels (Figure 9-1), the sliding resistance is replaced with a (theoretically) lower rolling resistance of the wheels.

Figure 9-1 – wheeled trawl shoes tested in chain matrix beam trawl (left) and tickler chain beam trawl (right)

9.2 Material and methods

Different configurations (single large wheel, large wheel with one or two smaller wheels, two large wheels) of wheeled trawl shoes have been tested on board commercial vessels. This is an overview of vessels that have experimented with wheeled trawl shoes: O 33, O 89, O 105, O 231, Z 19, Z 45, Z 46, Z 47, Z 55, Z 69, Z90, Z98, Z 121, Z 196, Z 243.

In most sea trials, the vessels were rigged with 2 sets of wheeled beam trawls. This setup does not allow a catch comparison or a warp load comparison. Results from these experiments are mainly limited to anecdotal information gathered from the crew and the skipper. Only one series of experiments performed on board the tickler chain beam trawler O 231 was set up as a catch comparison experiment. One side was rigged with a wheeled beam trawl in which the trawl shoes were replaced by one large wheel. Commercial catches and warp loads (from force cells installed on the vessel) were recorded during these experiments.

9.3 Results

On board O 231, lower warp loads were observed for the wheeled beam trawl (6 tonnes) in comparison to the traditional gear (7.1 tonnes) when fishing on hard soils (a difference of 15.5%). Theoretically, this reduction in drag should result in a 16% reduction of fuel consumption for a vessel operating two wheeled beam trawls. On soft soils, it was observed that resistance is higher. This may be explained by the wheels sinking deeper into the mud than the traditional sole plates that have a larger surface area. Catch comparison analysis showed different catch losses for different fish species: sole (-10%); plaice, turbot and brill (-5%); ray (no loss).

These findings are supplemented with anecdotal information from chain matrix beam trawlers that have tested wheeled beam trawls. The wheeled beam trawls appeared to be performing well on hard soils, giving similar to even slightly higher catches. Skippers reported only minor fuel savings in the range of 5% on hard soils. Another advantage reported was that repair and maintenance costs for the wheels appear to be lower than for the trawl shoes.

All participants complained about the poor performance of the wheeled beam trawl on soft soils. Different configurations (single large wheel, large wheel with one or two smaller wheels, two large wheels) of wheeled trawls were tested to resolve this issue, with limited success.

9.4 Conclusion

Fuel savings attained with wheeled trawl shoes appear to be minimal and limited to hard soils. Under these conditions the wheeled beam trawls appear to yield slightly higher catches and give some savings on repair and maintenance.

One important issue that remains unresolved is the poor performance of the wheeled beam trawl on soft fishing grounds.

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12 Appendix

A compilation of length and species selectivity improving alterations to beam trawls

Depestele, Polet, Van Craeynest and Vandendriessche

Instituut voor Landbouw- en Visserijonderzoek

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A compilation of length and species selectivity improving alterations to beam trawls

22 April 2011

Authors: Jochen Depestele, Hans Polet, Kris Van Craeynest, Sofie Vandendriessche

13 Introduction

Fishing has direct and indirect effects on the marine environment (Hall, 1999). Direct effects include fish mortality, changes of food availability and alteration of the physical environment, such as fish habitats. Fish mortality originates either from removal of target and non-target fish species, direct fish mortality during the fishing process without actually retaining the fish and damage to fish, which makes them more vulnerable to scavengers and other predators. By removing biomass, fisheries change the food base for other biota, change predation pressure, change the population structure of species and may even remove certain species from the ecosystem. Changes of food availability come from fish mortality as well as from the discards of unwanted fish, fish offal and benthos. The alteration of fish habitats can be divided in the effects on the substrate, as structural component of the habitat and the short- and long-term effects on benthic communities (Auster and Langton, 1999). Indirect effects of fishing are the knock-on effects that follow from a direct effect, i.e. the reaction of the ecosystem on fishing.

The possible effects of fishing gear on the marine environment are increasingly gaining international public, political and scientific attention (Linnane et al., 2000). The impact of bottom trawling in particular has been subject of many studies (e.g. Jennings and Kaiser, 1998; Paschen et al., 1999; Collie et al., 2000; Fonteyne, 2000; Kaiser and De Groot, 2000; Linnane et al., 2000; Kaiser et al., 2002; Schratzberger et al., 2002). The biological impact of bottom trawling reveals itself in the direct affection of benthic organisms and the by-catch of undersized target fish, non-target fish and benthic invertebrate species (Hall, 1999; Lindeboom and de Groot, 1998; Kaiser and de Groot, 2000). Rijnsdorp et al. (1996) found that of 19 North Sea demersal fish species recorded, 18 were found to have decreased between the beginning of the 20th century and the 1990s, for several down to 1% or less of the original densities. The susceptibility of populations to fisheries impact is assumed to be associated with some life history characteristics including large ultimate body size, slow growth rates, high age at maturity and low fecundity. This is confirmed by the IMPACT II study (Lindeboom and de Groot, 1998) that found significant changes in community structure in the North Sea due to fishing activities, with a dominance of opportunistic short-lived species and a decrease of long-living sessile organisms. This was confirmed by the study on long-term trends in the North Sea by Clark and Frid (2001) who also found that non-commercial fish species increased in density, while commercial species decreased. Schratzberger et al. (2002) states that the reduction of biomass and production is especially true for macro-infaunal invertebrate communities, but suggest that meiofauna are more resistant to disturbance by beam trawling than macrofauna. The studies indicate that beam trawling plays an important role in the fishery impact.

The beam trawl fishery is a typical mixed fishery. Although they primarily target plaice and sole, the beam trawlers catch and land a wide variety of commercial fish and shellfish species, including rays, small sharks, gadoids, red mullet, gurnards, flatfish, anglerfish, scallops, whelk, cuttlefish, octopus, squid, Norway lobster, edible crab, etc.

Catch statistics indicate that the total number of commercial species taken by the beam trawler fleet is around 40.

Discarding in the North Sea beam trawl fisheries (in general) is considerable. A dedicated STECF Sub-group, who was given the task of reviewing all discard information collected since the implementation of the EU Data Collection Regulation (2002), estimated the overall discard rate of the beam trawlers (for both target and non-target species, but exclusive of non-commercial species) to be between 40 and 60 % in weight (Anon., 2006). Discard rates strongly differ between species, with the lowest values being observed for cod (5-10 % in weight) and sole (10-15 %), and the highest for plaice (45-55 %) and whiting (65-80 %). Discarding mostly concerns fish below the Minimum Landing Size, but the analysis by the aforementioned STECF Sub-group also showed evidence of high-grading and landing of under-sized fish.

The main cause of discarding in the flatfish-directed beam trawl fishery is related to the use of the 80 mm cod-end mesh in the sole-directed beam trawl fishery (Grift et al., 2004). This mesh size is appropriate for sole, but too small to accommodate the 50 % retention for plaice. All plaice caught below the minimum landing size of 27 cm (mainly 1- and 2-year olds) are discarded (Grift et al., 2004). Most discards (ca. 90 %) do not survive, either because they are damaged in the net during fishing or during the sorting process on board.

So far, data on the non-commercial by-catches in the beam trawl fisheries have mostly been collected within the framework of short-term studies aiming at the impact of beam trawling on benthic and/or demersal assemblages and no systematically collected time series exist.

Several studies on the selectivity of flatfish beam trawls have been conducted, the results of which have been used in management decisions. The research often is internationally coordinated through EU research projects or through the ICES Working Group on Fishing Technology and Fish Behaviour (WGFTFB). Research in recent years was mainly directed towards improving species selectivity, ranging from the rather crude separation between fish and benthic invertebrate species to improved fish-species selection. The European Cod Recovery Plan has led to some research project on flatfish and roundfish separation. A summary of most of the Dutch, British and Belgian research of the last two decades to improve beam trawl selectivity can be found in CEFAS (2003), Fonteyne & Polet (2002), Fonteyne et al. (2005), Revill & Jennings (2005), van Marlen (2000; 2003) and van Marlen et al. (2005).

Possible ways to diminish the adverse environmental impacts of beam trawling are technical gear modifications and the development of alternative fishing methods (Fonteyne and Polet, 2002; van Marlen et al., 2005). Several modifications have been investigated in two EU-funded research projects: SOBETRA (Optimization of a species selective beam trawl) (Fonteyne, 1997) and REDUCE (Reduction of the adverse environmental impact of demersal trawls) (Anon, 2002). The modifications tested in SOBETRA consisted of the use of large escape panels or escape openings in the top panel of the trawls to reduce the bycatch of roundfish species while minimising the effect on the flatfish catch rates. In REDUCE a benthos escape window in the belly of the trawl proved to be successful to reduce the benthos by-catch significantly while maintaining reasonable flatfish catch rates (Fonteyne and Polet, 2002). A consequent series of experiments dealt with improving these technical alterations, testing alternatives and demonstrating the new findings to the industry by trials aboard commercial vessels. These trials were carried out in the frame of the projects IDEV (Innovatiecentrum Duurzame en Ecologische Visserij) (Van Craeynest et al., 2008) and ALTERNATIVE BEAM TRAWL (Uittesten van een alternatieve boomkor met het oog op brandstofbesparing en verminderde milieu-impact) (Polet et al., 2008).

The most promising technical alterations have been combined as a concept in the so called “alternative beam trawl”, focusing on reduction in fuel consumption and reduction of discards. One commercial vessel has been fishing with this gear for over two years, on a voluntary basis and there is interest of other vessel owners to adopt this gear as their standard trawl. The key feature is “voluntary uptake” and freedom, within certain margins, to adapt the technical alterations in the gear to specific circumstances of the fishery. The present paper gives an overview of the most promising technical gear modifications.

14 Benthos release panel – RV trials

Based on:

Fonteyne, R. and Polet, H., 2002. Reducing the benthos by-catch in flatfish beam trawling by means of technical modifications. Fisheries Research, 55 (1-3) (2002) pp. 219-230

14.1 Introduction

The increasing concern about the ecosystem effects of fishing on the marine environment and particularly, the impact of trawling on benthic communities is reflected in numerous publications (Hall, 1999 ; Kaiser and De Groot, 2000 ; Kaiser et al., 2006 ; Løkkeborg, 2005). The effects of bottom trawling on benthic ecosystems in the North Sea and Irish Sea were intensively studied during an international research project (Lindeboom and De Groot, 1998). In the North Sea flatfish beam and otter trawl fisheries the by-catch weight of invertebrates was estimated at several times the amount of marketable fish. The mortality of the invertebrates discarded from flatfish beam trawls (Fig. 14-1) was found to be species dependent and varied from less than 10% (starfish and brittle stars) to almost 90% (the bivalve *Arctica islandica*). Due to the low catch efficiency of beam trawls for these species, this mortality is low when expressed as a percentage of the initial density. Nevertheless, repeated trawling will affect the structure of benthic communities, leading to a replacement of sensitive slow growing and slow reproducing species by opportunistic, fast growing and fast reproducing species. One possible way for reducing the adverse effects of trawling on benthic communities is to reduce the direct mortality by developing alternative fishing methods and through technical modifications of existing fishing gears. The present chapter focuses on the Belgian beam trawl experiments with benthos release panels (BRPs).

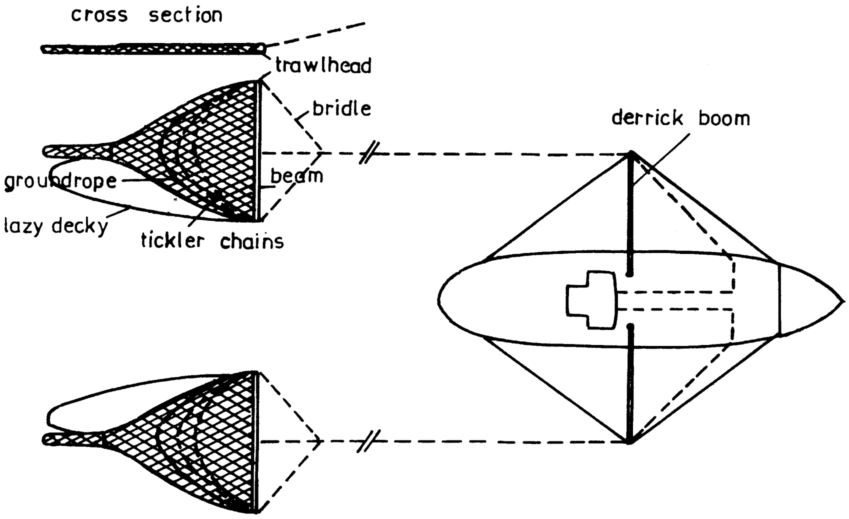


Fig. 14-1 – A double rig beam trawler

14.2 Material and methods

The benthos escape devices were inserted in a standard 4m beam trawl equipped with a chain matrix. Both the standard and the experimental net used in the comparative fishing experiments were made of 120mm polyethylene netting. The belly was constructed of double yarn netting and provided with bottom chafers made of polyethylene ropes. The double braided polyethylene cod-ends had a nominal mesh opening of 80mm. The mesh sizes were regularly measured with an ICES mesh gauge operated at 4kg. The difference in mean mesh size never exceeded 0.3mm.

Several types of escape zones, just behind the footrope, were tested but due to the high loss of commercial fish, the trials were not continued. Detailed information is given in Fonteyne and Polet (2002). The focus of the article lies on the benthos release panel rigged just in front of the footrope, for which three different mesh sizes were tested, i.e. 120mm, 150mm and 200mm. The windows were 1.80m long and 1.20m wide and were inserted at a distance of about 1.2m (10 x 120mm meshes) from the cod-end. The 200mm window was made of braided polyethylene netting of R10800tex; the 120 and 150mm windows were made of braided polyethylene netting of R9600tex.

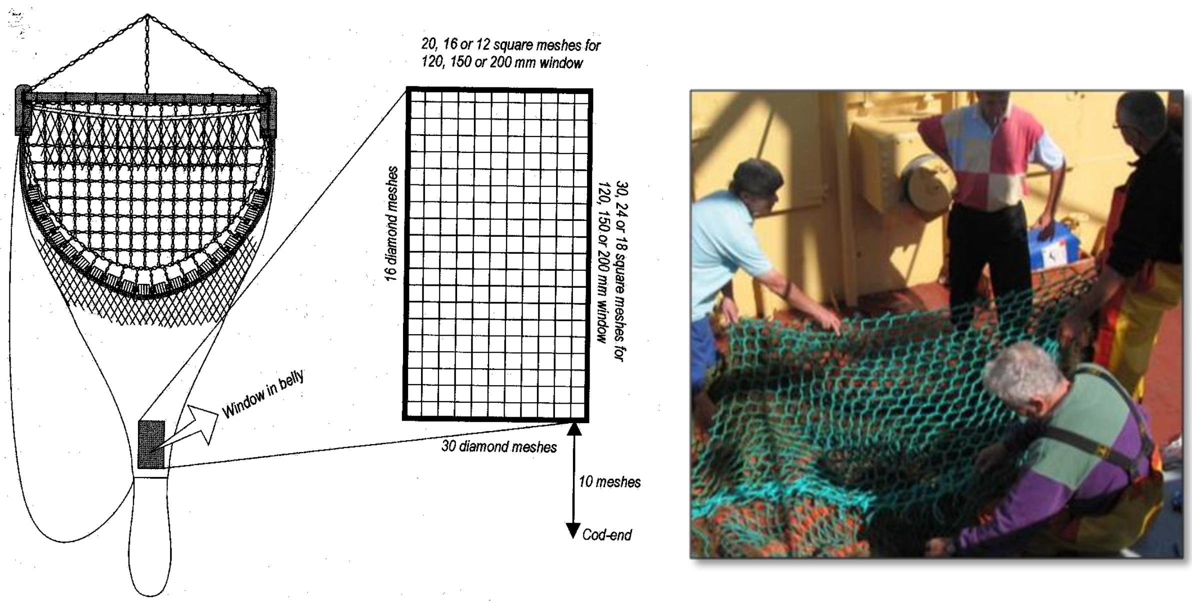


Fig. 14-2 – The benthos release panel

The trials were carried out aboard RV BELGICA (50.9m L.O.A., 765 GRT, 1154 kW engine power). To enable simultaneous towing of the standard and the experimental gear, two 4m beam nets were attached to each other in an 8m twin beam trawl set-up. The two gears were identical, except for the BRP. The trials took place end of 1999 and early 2000 in the Southern North Sea. The haul duration was between 2 and 2.5 hours, covering roughly 75.000m² with each net in water depths between 20 and 50m.

After each haul the total catch weights were recorded and all fish species were sorted out of the catch. The rest of the catch was separated in a benthos fraction and a debris fraction. These were weighed separately to determine the overall benthos and debris reduction in the experimental net. The catches were analysed in detail and all commercial fish, non-commercial fish and invertebrate species were measured. All fish and benthos species were measured to the cm below. The percentage catch reductions were calculated for the overall benthos and debris weight and for the numbers of fish and benthos on a species basis. Paired t-tests were performed to judge whether the differences in catch were statistically significant.

14.3 Results

The average reduction in benthos weight was 83, 70 and 64 % for the 200, 150 and 120 mm square mesh windows respectively. These differences were statistically significant. The average reduction in weight of debris was 56 and 34 % for the 200 and 150 mm windows respectively. The experimental net with a 120 mm square mesh window caught 7 % more debris than the standard net. Only the catch reduction with the 150 mm was statistically significant. The numbers of commercial fish and benthos species for each configuration are given in Table 14-1.

The 200 mm window showed an important loss of commercial fish catch. The catches of sole (*Solea solea*), the most valuable commercial species were reduced by an unacceptable 45 %. Almost all benthos species showed reduced catches, for 4 species the reduction was statistically significant. A reduction in commercial fish catch was also noted with the 150 mm window for most species, but none of these reductions was significant. All 19 benthos species observed showed a reduced catch in the experimental net, of which 11 were significant. The highest reductions, about 90 %, were found for hermit crab (*Pagurus bernhardus*), queen scallop (*Aequipecten opercularis*) and whelk (*Buccinum undatum*). The results for fish were contradictory with the 120 mm window. For some species the experimental net caught less, for the others the catch was higher. The low number of hauls and low number of fish were probably the reason for these inconclusive results.

Thirteen benthos species analysed appeared in reduced numbers in the catch. For 6 species the reduction was significant. The catch reduction at length is given in Fig. 14-3.

Table 14-1: Total numbers of commercial fish and benthos species and percentage reduction in experimental net (statistically significant reductions in bold italics)

Species	200 mm window 6 valid hauls			150 mm window 16 valid hauls			120 mm window 5 valid hauls		
	Stan	Exp	Red	Stan	Exp	Red	Stan	Exp	Red
Commercial fish									
Pleuronectes platessa	53	34	36	77	94	-22	21	32	-52
Limanda limanda	23	12	48	103	77	25	4	3	25
Solea solea	330	182	***45***	495	407	18	223	255	-14
Merlangus merlangus	127	98	***23***	536	458	15	38	80	***-***
Gadus morhua	7	8	-14	11	13	-18	5	8	***111***
Raja spp.	104	90	13	372	360	3	119	99	-60
Scyliorhinus canicula	47	53	-13	24	20	17	41	39	17
Microstomus kitt									5
	11	10	9	18	9	50	5	10	
									-100
Benthos									
Agonus cataphractus	12	4	67	6	2	67	-	-	-
Callyonimus lyra	10	8	20	16	8	***50***	6	6	0
Anthozoa spp.	6	0	100	16	12	26	0	0	
Aphrodite aculeata	283	32	89	3082	1028	***67***	120	99	18
Atelecyclus rotundatus	25	0	100	14	0	100	6	3	58
Cancer pagarus	9	12	-27	23	19	16	20	17	12
Pagurus benhardus	851	23	***97***	1590	159	***90***	341	73	***78***
Hyas araneus	65	5	***92***	258	230	19	57	33	42
Liocarcinus depurator	146	37	75	432	194	***55***	96	20	79
Liocarcinus holsatus	307	81	74	322	194	***40***	118	65	***45***
Necora puber	54	33	39	181	119	***34***	51	71	-40
Macropodia rostrata	155	5	97	318	100	***69***	148	8	***95***
Aequipecten opercularis	723	41	94	80	8	***90***	1611	429	***73***
Psammechinus miliaris	31878	1206	96	62003	18138	***71***	32435	7218	***78***
Crossaster papposus	21	7	67	21	16	24	39	39	-1
Spatangus purpureus	27	27	0	8	3	62	5	5	0
Asterias rubens	6266	420	***93***	16290	6597	***60***	5300	1708	***68***
Buccinum undatum	486	34	***93***	2600	274	***89***	832	135	84
Ophiria ophiura	0	0		3	0	100	40	15	63

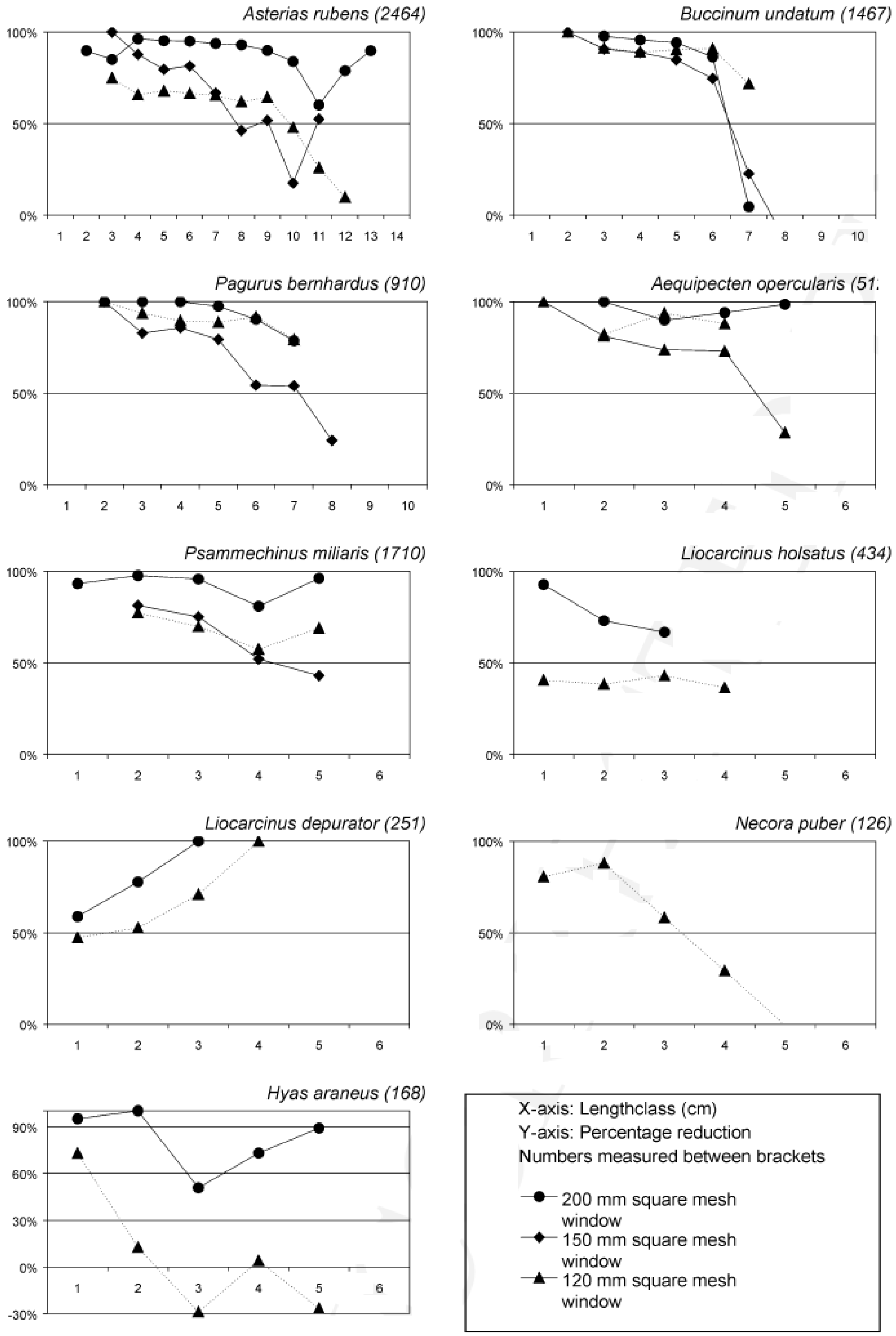


Fig. 14-3 – The percentage catch reduction by the BRP, at length, of a selection of benthic species

14.4 Conclusions

A square mesh window in the aft of the belly seems to be a good solution to release benthos from a flatfish beam trawl. The choice of the mesh size should balance the reduction in benthos catch and the loss of commercial fish. Based on the RV trials, a mesh size of 150 mm seems to be the better choice. This was confirmed by Revill (2005) who applied 150 mm square mesh benthos release panels on board of British commercial beam trawlers. A similar study is going on Belgian trawlers.

15 T90 cod-end – RV trials

15.1 Introduction

The beam trawl fishery is a typical mixed fishery. Although they primarily target plaice and sole, the beam trawlers catch and land a wide variety of commercial fish and shellfish species, including rays, small sharks, gadoids, red mullet, gurnards, flatfish, anglerfish, scallops, whelk, cuttlefish, octopus, squids, Norway lobster, edible crab, etc. Catch statistics indicate that the total number of commercial species taken by the beam trawler fleet is around 40.

Discarding in the North Sea beam trawl fisheries (in general) is considerable. A dedicated STECF Sub-group, who was given the task of reviewing all discard information collected since the implementation of the EU Data Collection Regulation (2002), estimated the overall discard rate of the beam trawlers (for both target and non-target species, but exclusive of non-commercial species) to be between 40 and 60 % in weight (Anon., 2006). Discard rates strongly differ between species, with the lowest values being observed for cod (5-10 % in weight) and sole (10-15 %), and the highest for plaice (45-55 %) and whiting (65-80 %).

The main cause of discarding in the flatfish-directed beam trawl fishery is related to the use of the 80 mm cod-end mesh in the sole-directed beam trawl fishery (Grift et al., 2004). This mesh size is appropriate for sole, but too small to accommodate the 50 % retention for plaice. All plaice caught below the minimum landing size of 27 cm (mainly 1- and 2-year olds) are discarded (Grift et al., 2004). Most discards (ca. 90 %) do not survive, either because they are damaged in the net during fishing or during the sorting process on board. So far, data on the non-commercial by-catches in the beam trawl fisheries have mostly been collected within the framework of short-term studies aiming at the impact of beam trawling on benthic and/or demersal assemblages. These studies generally indicate discarding in the flatfish beam trawl fishery as problematic (Lindeboom and De Groot, 1998).

Besides the mesh size in the beam trawl fishery, the mesh shape is also a cause of high discard rates. Diamond meshes have the tendency to close when they are stretched. Stewart and Robinson (1985) showed during underwater observations of trawls that diamond mesh cod-ends get a bulbous shape by the drag force of the accumulated catch in the cod-end. The consequence is that only a few mesh rows in front of the bulge are open and unobstructed. All meshes in front of this zone are stretched and have a reduced mesh opening. The number of meshes through which fish can escape is thus seriously reduced (Wileman et al., 1996). Experimental work (Dahm, 2004) has indicated that turning the diamond mesh netting by 90° (T90) may increase L50, compared to a similar cod-end with normal netting orientation. The shape of the knot makes a T0 mesh close when stretched and allows the T90 mesh to remain open to a certain extent, even when strong forces are applied (Fig. 15-1). Herrman et al (2006) made a simulation with both types of meshes and showed that T90 meshes clearly have better selective properties for roundfish. Hansen (2004) extrapolated from flume tank tests that a T90 cod-end has better characteristics in terms of preservation of fish quality, selectivity, survival rate of escapees, efficiency and strength. Based on the apparent positive characteristics of the T90 mesh, it was decided to study the performance of T90 cod-ends in the beam trawl fishery.

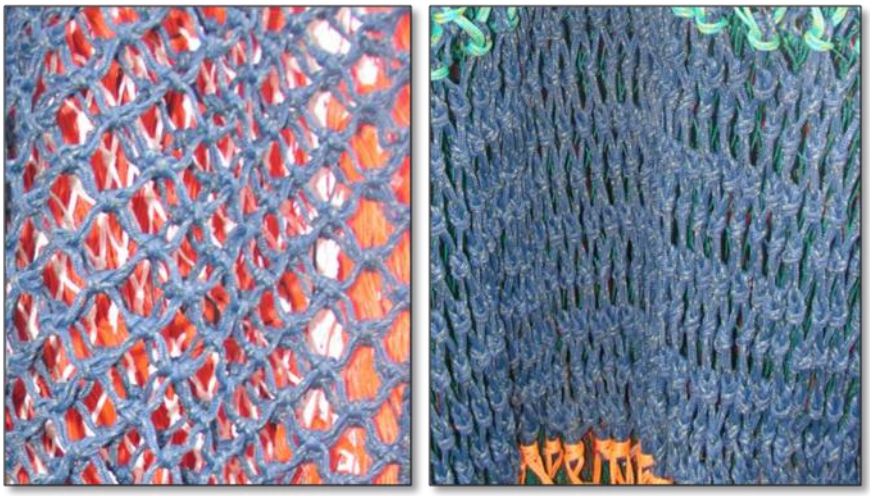


Fig. 15-1 – T90 and diamond meshes (top) and a T90 cod-end with a posterior sheet of netting (5 rows) with T0 orientation.

15.2 Materials and methods

15.2.1 Vessel and gears

The sea trials were carried out on board of the RV "Belgica" which has an overall length of 50.9 m, a GRT of 765 t and an engine power of 1154 kW. A commercial skipper was hired to select the fish tracks and to guide the fishing operations in order to match commercial conditions as closely as possible. The towing speed was on average 4 knots and the warp length was three times the water depth. The trials took place from 4 to 15 September 2006.

The gear studied was a commercial beam trawl with a beam length of 4m and a vertical net opening of 0.5 m. These gears are often used by Eurocutters, small double rig beam trawlers allowed to fish within the 12-miles zone under certain conditions. The lengths of the headline and the groundrope were 3.7m and 9.4m respectively. The groundrope consisted of rubber bobbins. The net was made of knotted polyethylene netting with a nominal mesh size of 120mm. To reduce wear, the belly was constructed of double yarn netting and provided with bottom chafers made of polyethylene ropes. The double braided cod-ends had a nominal mesh opening of 80mm and a twine diameter of 4mm. The cod-end mesh sizes were regularly measured with the OMEGA-gauge, according to the ICES protocol (Fonteyne, 2005).

In contrast with commercial beam trawlers, RV Belgica is not equipped with derrick booms for towing two beam trawls at the same time. To enable simultaneous fishing with a standard and an experimental cod-end, two 4m beam trawls were attached next to each other to an 8m beam with an extra trawlhead in the middle. The two gears were identical, except for the cod-ends.

The standard cod-end was constructed along commercial practice. The experimental cod-end was constructed in diamond meshes turned by 90°, i.e. the so-called T90 mesh. A total of 14 and 21 valid hauls were carried out respectively for the standard and the T90 cod-end.

15.2.2 Catch analysis

The catches of the standard and experimental cod-ends and covers were collected in baskets and the total catch weights were recorded. All commercial fish species were sorted out of the catch. The fish were measured to the cm below. The rest of the catch was weighed to determine the non-commercial fraction of cod-end and cover catches. Of a selection of hauls, a sample was taken of the non-commercial fraction for further analysis in the lab. There, each species was counted and weighed.

The percentage "total catch" and "non-commercial catch" released by both the standard and the experimental cod-ends was calculated for each haul. The significance of the difference was estimated by the Mann-Whitney test. For each of the non-commercial species of which at least 50 animals were present in each cod-end, the percentage animals (in no's) escaping from both cod-ends was calculated.

The cod-end selectivity was investigated for five commercial and one non-commercial fish species. The SELECT model was chosen to describe the selectivity. The standard methodology for selectivity of fishing gears is described in Wileman et al. (1996). Based on the deviance residuals obtained when calculating the selection curves, the logistic function was chosen as a link function to fit the retention points for each species and fitted the data very well. This function is the cumulative distribution function of a logistic random variable and is specified by the following equation:

$$RR(TL) = \exp(a + b \bullet TL) / (1 + \exp(a + b \bullet TL))$$

where RR(TL) is the probability that an animal of length TL (Total Length) is retained in the cod-end. a and b, which are the two parameters to be estimated, represent the intercept and the slope, respectively, after a logit transformation. These parameters were estimated with the maximum likelihood method by the CC software (Constat, Denmark). L25, L50 and L75 are the body lengths at which 25%, 50% and 75% of the shrimps are retained in the cod-end. SF is the selection factor and is the L50 divided by the mesh size. SR is the selection range and is equal to the difference between L75 and L25 and gives an idea of the slope of the curve. Single hauls were combined by the variance component analysis method of Fryer (1991) by the CC software. 95% confidence limits of the selection parameters are given in brackets.

15.3 Results

A standard 80mm beam trawl cod-end releases about 25% of the total catch weight entering the cod-end (Fig. 15-2). For the non-commercial species this is almost 35%. The T90 cod-end releases about 45% and 60% of respectively the total and non-commercial catch weight. The Mann-Whitney U-tests indicated a highly significant difference ($p < 0.001$).

The selection ogives for both cod-ends, for sole, plaice, dab, lemon sole, poor cod and cod, are given in Fig. 15-3 and the selection parameters in Table 15-1. For sole, the L50 is not significantly higher for the T90, but the selection range is. For plaice, no selection at all was observed for the standard cod-end. The T90 did allow plaice to escape, with an L50 of 15.3cm. For lemon sole and dab, the L50 is the same for both cod-ends. The selection range shows the same pattern as for sole, although no significant difference could be demonstrated. For roundfish, the T90 cod-end clearly performs much better than the standard cod-end. For cod, the L50 increases significantly from 14.7cm to 22.6cm. For poor cod, the increase goes from 12.9cm to 19.6cm.

Fig. 15-4 gives the percentage of the total number of animals entering the cod-end that were released through mesh selection and were collected by the cod-end cover. The T90 cod-end proves to be superior in releasing non-commercial catch for all species observed. Due to the low number of hauls sampled for non-commercial species, no significance could be calculated.

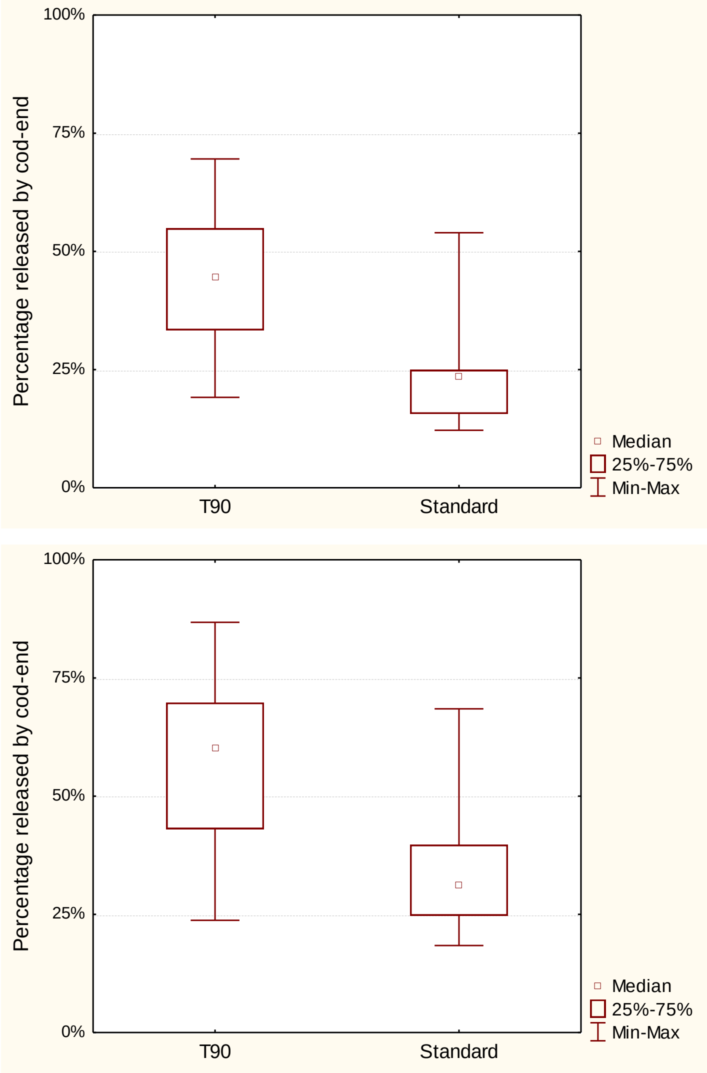


Fig. 15-2 – The percentage of "total catch"(top) and "non-commercial catch" (bottom)

Table 15-1: The selectivity parameters for a standard 80mm commercial cod-end and an 80mm T90 cod-end for five commercial and one non-commercial species.

		SF	L50	SR
Sole	Diamond mesh 80mm	0,27	21,3 (20,7 - 21,9)	5,9 (5 - 6,8)
	T90 mesh 80mm	0,28	22,3 (21,6 - 23,1)	3,6 (2,9 - 4,3)
Plaice	Diamond mesh 80mm	no selection	-	-
	T90 mesh 80mm	0,19	15,3	1,9
Lemon sole	Diamond mesh 80mm	0,20	15,9 (14,7 - 17,1)	3,6 (2,8 - 4,5)
	T90 mesh 80mm	0,19	15,7	1,6
dab	Diamond mesh 80mm	0,19	15,1 (14,3 - 16)	2,8 (1,7 - 4)

	T90 mesh 80mm	0,19	15,4 (14,9 - 15,8)	1,8 (1,3 - 2,2)
cod	Diamond mesh 80mm	0,18	14,7 (13,9 - 15,5)	2,3 (1,5 - 3)
	T90 mesh 80mm	0,28	22,6 (19,8 - 25,3)	4,1 (2,3 - 5,8)
poor cod	Diamond mesh 80mm	0,16	12,9	2,9
	T90 mesh 80mm	0,24	19,6	4,7

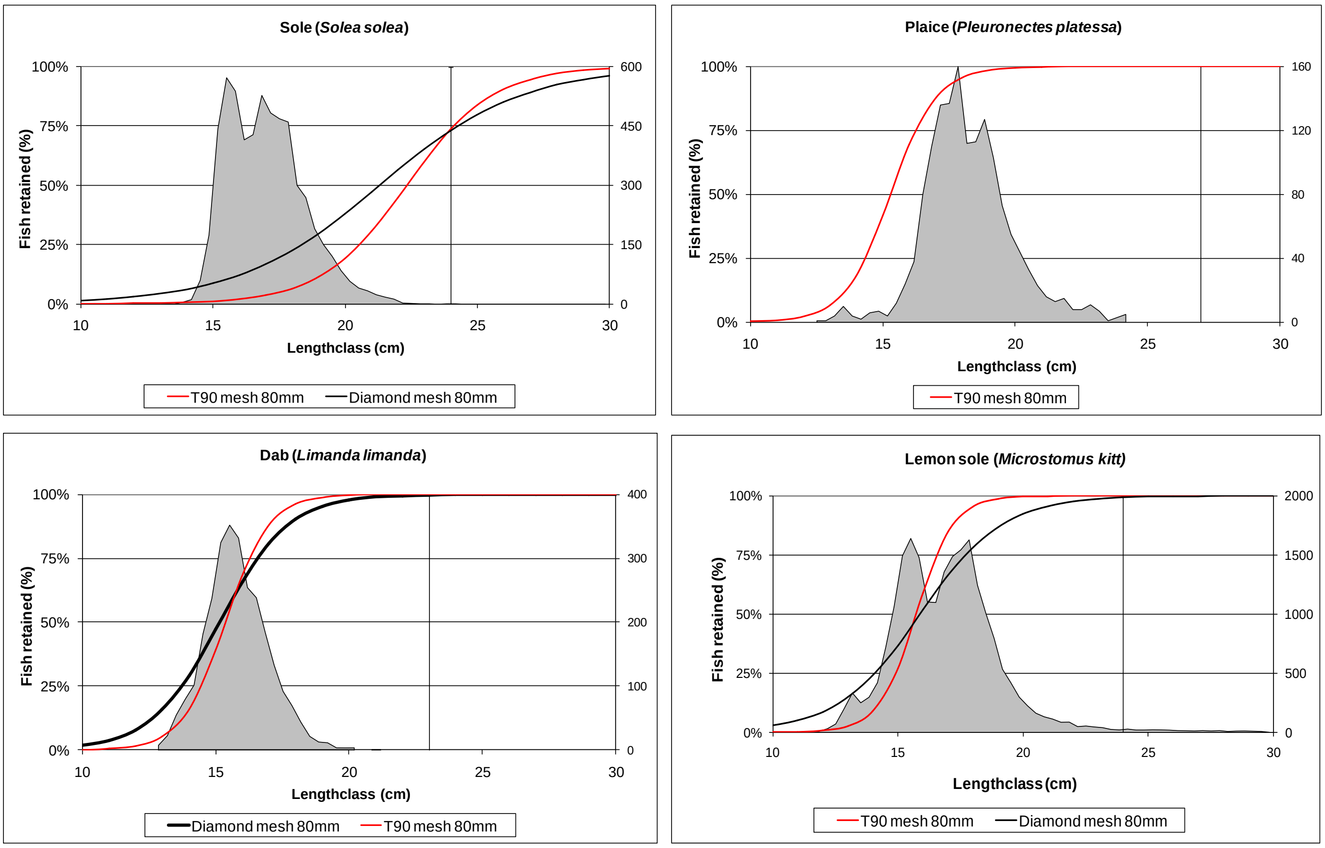


Fig. 15-3 – The selection ogives for a standard 80mm commercial cod-end and a 80mm T90 cod-end for five commercial and one non-commercial species. For each species the length frequency distribution for the total catch (cod-end + cover) is given.

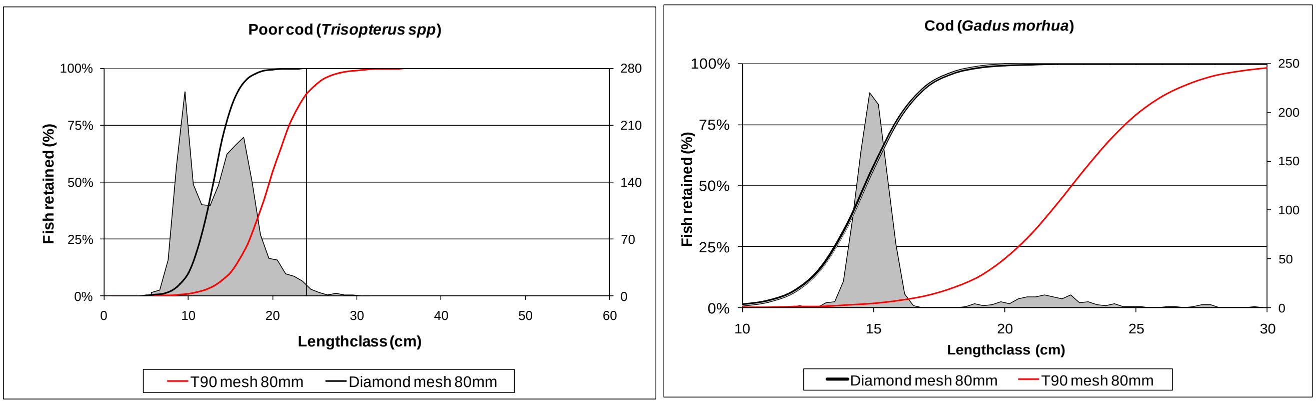


Fig. 15 3 (continued) – The selection ogives for a standard 80mm commercial cod-end and a 80mm T90 cod-end for five commercial and one non-commercial species. For each species the length frequency distribution for the total catch (cod-end + cover) is given.

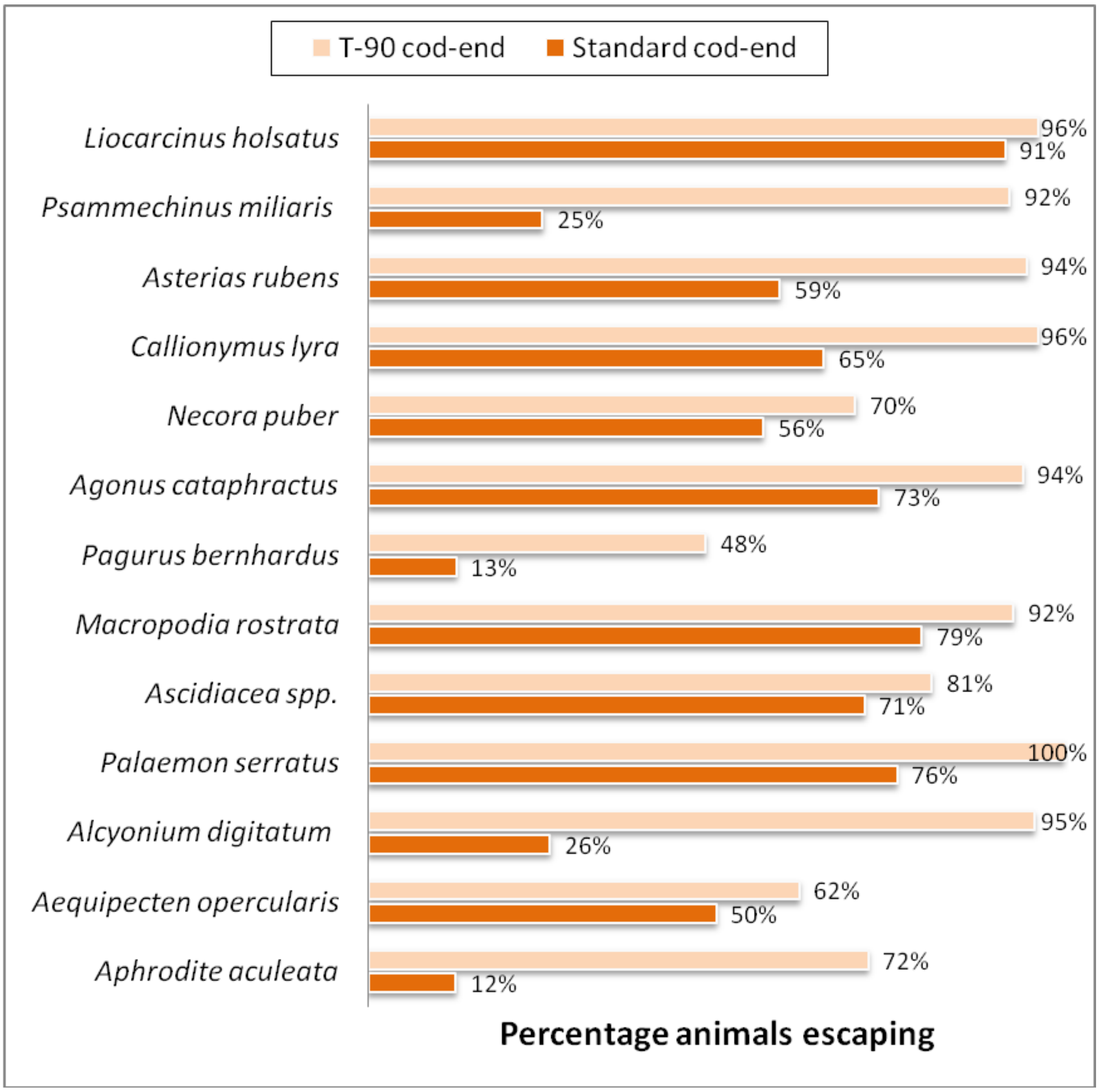


Fig. 15-4 - The percentage of the total number of animals entering the cod-end that were released through mesh selection and were collected by the cod-end cover

15.4 Discussion

Fonteyne and M'Rabet (1992) and Walsh et al. (1992) have shown that square meshes are less selective for flatfish compared to diamond meshes. The rationale behind it was that diamond meshes have a shape similar to the body shape of the flatfish, thus allowing an easier passage through the mesh compared to the square mesh. A similar rationale could apply for the T90 mesh because this mesh has less similarity with the flatfish body compared to the diamond mesh. The present trials have, however, indicated that the T90 mesh only leads to a sharper selection ogive with the ogive's center of rotation between L50 and L75. This is the case for dab, lemon sole and sole. Particularly for sole, the most important commercial species for the beam trawl, this center of rotation lies exactly on MLS. The consequence is that the application of T90 leads to an increased release of undersized fish and increased catch of fish just above MLS.

For roundfish there is no doubt that the T90 cod-end outperforms the standard cod-end. For benthos, the success rate of T90 is species dependent but for each of the species more animals escape through the T90 mesh. With a better retention of the most important commercial species, sole, and the release of many undersized commercial fish and many non-commercial animals, the T90 cod-end seems to be a good alternative for the standard diamond mesh cod-end.

It has to be noted, though, that these trials have been carried out on a research vessel. The results cannot as such be extrapolated to the commercial fishery. Commercial trials are essential for further evaluation of this cod-end. The disadvantage of commercial trials aboard beam trawlers, however, is the difficulty to work with a cod-end cover and the lack of controlled conditions. Detailed catch measurement is also often problematic.

15.5 Conclusions

The T90 cod-end has interesting selective properties for the most important commercial species for the beam trawl, i.e. sole. It allows more undersized fish to escape and more marketable fish to be caught. Roundfish species and non-commercial fish and invertebrates escape much more easily from a T90 mesh than from a diamond mesh in a typical beam trawl cod-end. It can thus be expected that the application of a T90 cod-end will result in less discards and cleaner catches.

16 Alterations to the top panel – commercial tria

Based on:

Fonteyne, R., 1997. Optimization of a species selective beam trawl (SOBETRA). Final Project Report EU-Project AIR2-CT93-1015.

16.1 Introduction

Many fisheries are in danger because of overcapacity in their fleets and resource waste by discarding (e.g. Kelleher, 2005). Shrimp trawls are known to generate the highest quantities of discards, followed by bottom trawls. The need for selective trawls is recognised at many levels. At the time of the study presented in this chapter (Fonteyne, 1997), the midterm review of the Common Fisheries Policy (Anon., 1991) stressed the importance of reducing discards and the need for more research and acceptance of selective gears by fishermen. Special concern existed for overexploited roundfish stocks like cod and haddock. These species were important by-catch species in the beam trawl fishery. The problem could not be resolved by a general increase in minimum mesh size as this would have a serious drawback on the catch of the flatfish target species. Sorting the catch during the catching process, however, could drastically increase the survival of the unwanted by-catch and contribute to the recovery of the stocks.

The present research project is presented in Fonteyne (1997) and had following specific goals:

- to improve the species selective beam trawls developed under FAR project TE2.554
- to construct models of the modified gears and to test these models in a flume tank
- to construct selected designs at full scale and to validate the technical performance of these gears
- to carry out comparative sea trials on defined subfleets
- to evaluate the economic impact of replacing the traditional gears by species selective gears
- to introduce the new gears to the fishing industry

16.2 Materials and methods

In the frame of the SOBETRA project (Optimization of a species selective beam trawl) (Fonteyne, 1997) ILVO-Fishery tested a number of gear modifications aiming at the reduction of the roundfish by-catches in the Belgian flatfish beam trawl fishery. These designs consisted of the creation of large escape zones for roundfish in the top panel of the trawl without affecting the catch of flatfish. Two types of escape openings were tested, viz. square mesh top panels and cutaway covers.

The square mesh top panels (Fig. 16-1) were made of traditional diamond mesh netting with a mesh opening of 120 mm. The remaining diamond mesh sections also had a mesh opening of 120 mm. The netting was stretched in the direction of the bars and heat-set prior to the construction of the cover.

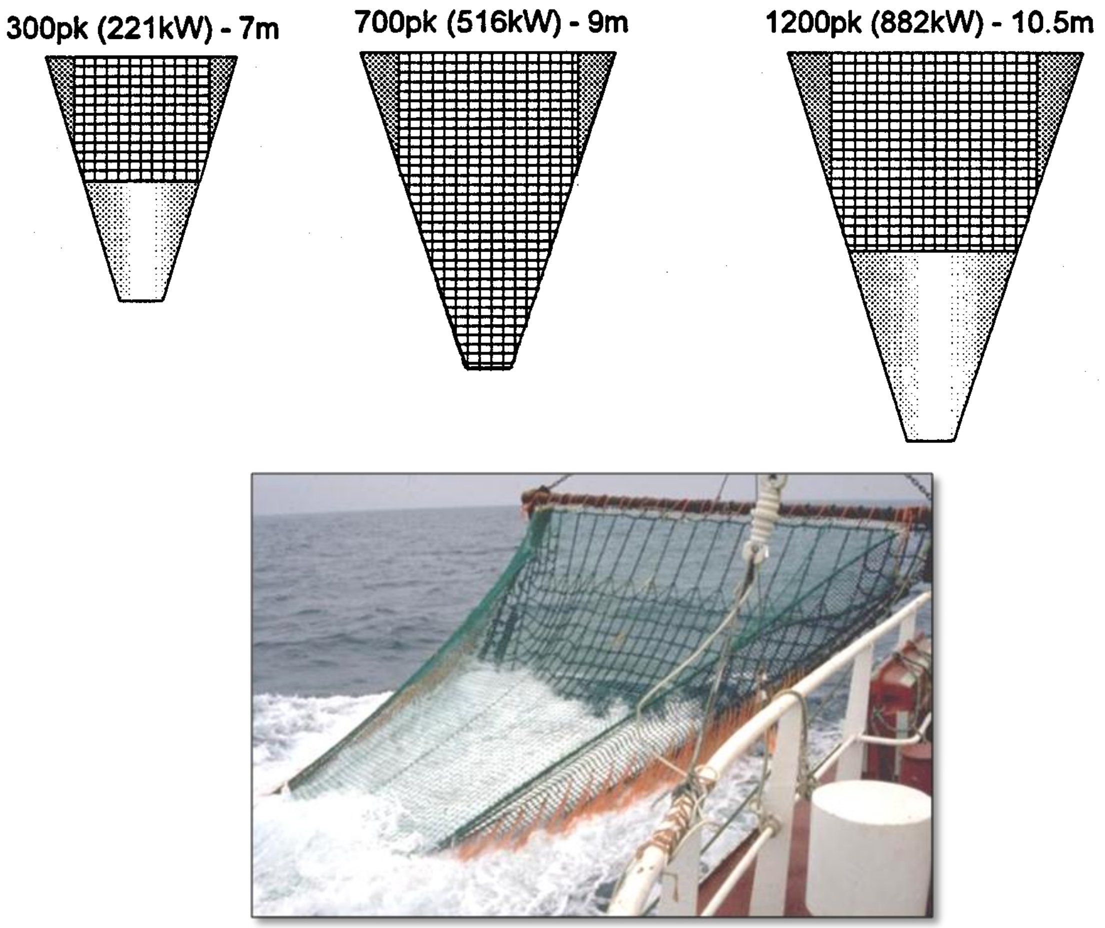


Fig. 16-1 - Square mesh top panels for 7, 9 and 10.5 m beams

The cutaway covers (Fig. 16-2) were easily constructed from the conventional top panels by cutting away the excess netting and reinforcing the new front edge. On a number of occasions the cutaway covers were provided with a square mesh window in the aft part of the top panel. The mesh side was 200 mm; the size of the window was 9x15 meshes.

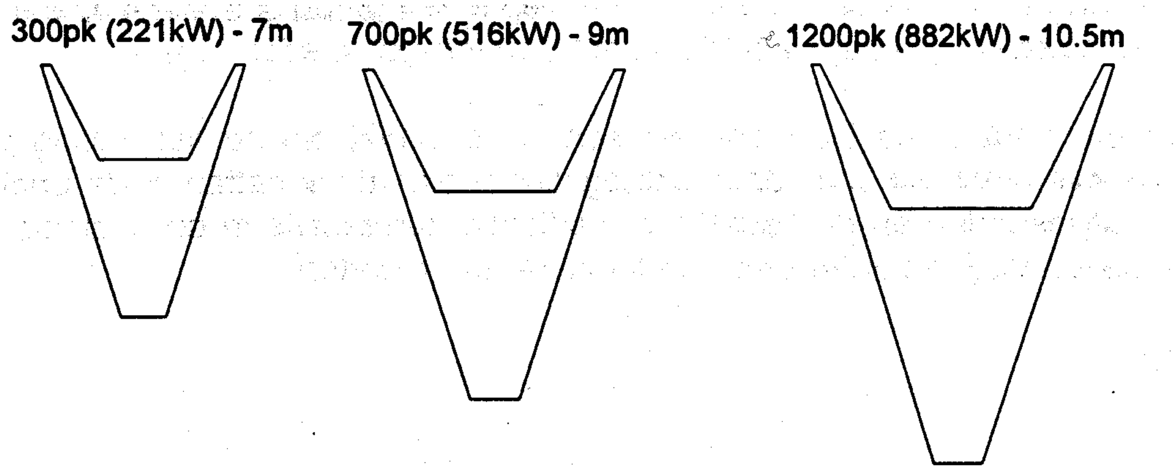


Fig. 16-2 - Cutaway covers 7, 9 and 10.5 m beams

Several representative categories of vessels were chosen to test the new designs extensively under commercial conditions. The method used was to compare the performance of each experimental gear with a conventional gear fished simultaneously on the other side of the ship. Scientific staff monitored catch data from each haul. They measured the length of various species of fish and recorded the weight of the catches.

The project was set up according to the following scheme:

- design of the selective gears
- flume tank trials
- validation of technical performance
- determination of subfleets
- comparative fishing experiments
- economic assessment
- technical transfer

16.3 Results

The net designs from a former project and new ideas were evaluated and a selection of the most promising designs was made. These were constructed as 1:5 models and tested and optimised in the flume tank in Hull. The selective devices chosen on the basis of the model tests were tested at full scale with underwater video observation and an initial catch comparison of the modified and standard gears.

The most important beam trawler sub fleets were determined in order to choose the most representative vessels for the large scale catch comparison experiments. This was based on landing and effort data and on area based discard practices. Three important sub fleets were determined for Belgium, i.e. 270-300 hp, 600-100 hp and >1100 hp.

Consequently, vessels were selected and the comparative experiments were carried out. The trials showed a mixture of results. The catch reductions obtained with the various configurations are given in the Table 16-1.

Table 16-1: Catch reductions obtained with the various configurations

Vessel	Beam length	Configuration	Cod	Whiting	Haddock	Sole	Plaice
221 kW	7 m	Cutaway cover	[-6%]	-13%	No catch	+1%	-6%
		Square mesh top	[+6%]	-8%	[-3%]	-2%	-8
516 kW	9 m	Square mesh top	-5%	-5%	No catch	-18%	-18%
		Cutaway cover with SQW	-4%	-47%	No catch	[-5%]	-13%
684 kW	9m	Square mesh top	-6%	[-30%]	no catch	-5%	0%
		Cutaway cover with SQW	+3%	[-27%]	-41%	[+12%]	+6%
882 kW	10 m	Cutaway cover	+5%	-38%	-24%	+2%	-2%
		Cutaway cover with SQW	[-16%]	-20%	-22%	+1%	-3%
		Square mesh top	-12%	-48%	-43%	-6%	0

In general the species selectivity of the beam trawls could be improved for whiting and haddock, but much less for cod. This is in accordance with underwater observations showing that roundfish species stay in different levels in a trawl with haddock in the upper level, whiting in the middle and cod in the lower level (Main and Sangster, 1982). Hence, the animals closest to the escape zone in the upper level have more chance to swim out of the trawl before entering the cod-end.

Cutaway covers or square mesh top panels may be applied; the degree of success depends on the vessel size and gear size. The reason is that on the smaller vessels using smaller nets the escape opening cannot be made sufficiently large to allow adequate escape of roundfish without incurring losses of flatfish. For the 221 kW vessels the results do not justify the use of the species selective devices.

16.4 Conclusions

Roundfish species like haddock and whiting, which stay in the middle or upper part of a trawl when they are caught can escape through escape openings in the top panel of a beam trawl. The efficiency depends on the size of the escape opening and consequently they are only efficient when inserted in the larger beam trawls. Cod, however, a species remaining close to the belly of the trawl when caught, takes no or little advantage of these escape openings.

17 Benthos release panel and T90 cod-end – commerc

ial trials “eurocutter”

17.1 Introduction

Based on an initial evaluation of different potential alterations to the beam trawl on board of the research vessel ‘Belgica’, two measures that showed promise in reducing its ecological impact by limiting by-catch and thus discards were selected for trials on board a commercial vessel. In the spring of 2007 the Eurobeamer N 58 ‘Pascin’ was rigged with a T-90 cod end and a benthic release panel.

17.2 Materials and methods

17.2.1 Vessel

The experiments were performed on board N 58 ‘Pascin’ (Fig. 17-1), a typical eurobeamer (length 19,35 m, width 6,20 m, tonnage 66 GT). The vessel was constructed in 1985 and is equipped with a 300 HP engine.

Fig. 17-1 - N 58 in alongside the Nieuwpoort fish auction

The vessel is operated by BVBA Rederij Pascin and sails with a crew of three. Its main fishing grounds are at the Thames estuary and the main target species is Dover sole. On a seasonal basis, shrimp is targeted in Belgian coastal waters.

17.2.2 Gear

For the sole fishery, N 58 is rigged with a 4 m beam, 4 tickler chains and a standard round net with an 80 mm cod end (combined weight of 1500 kg). During the experiments, the port configuration was adjusted with an 80 mm T-90 cod end. Furthermore, a benthic release panel (BRP) was inserted in front of the cod end (120 mm square mesh, single braided).

17.2.3 Experimental trips

During May and June 2007, three experimental trips were organized to evaluated the performance of the T-90 cod end and the BRP on board of a eurobeamer (Table 17-1).

Table 17-1: Experimental trips

Nr.	Date	Tested configuration	Number of hauls (not retained)
1	20/05/2007 - 26/05/2007	T-90 cod end	45 (8)
2	31/05/2007 - 5/06/2007	T-90 cod end and BRP	35 (7)
3	19/06/2007 - 24/06/2007	BRP	38 (6)

Vessel and crew performed their usual fishing operations, targeting Dover sole in the vicinity of Long Sand at the Thames estuary (Fig. 17-2). This approach offers a realistic picture of the performance of the adaptations during commercial fishing operations.

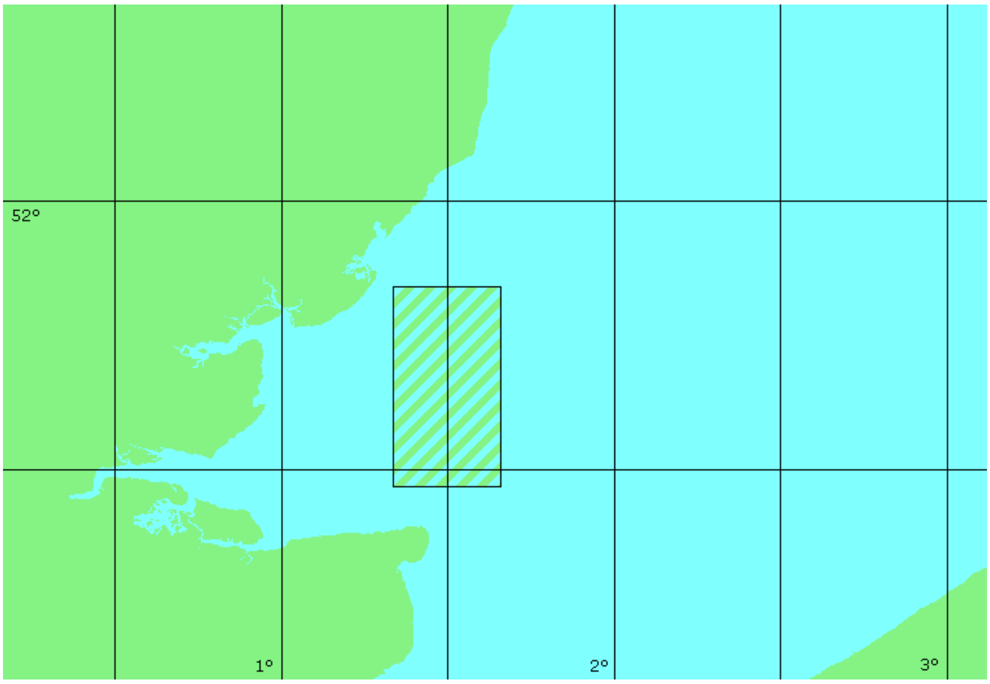


Fig. 17-2 - Fishing area during experimental trips

17.2.4 Catch comparison

The performance of the T-90 cod end and the BRP were evaluated by means of a catch comparison between the starboard and port catches (standard and experimental rigging). Two employees of ILVO-Fisheries joined the crew to record technical data and environmental conditions (e.g. time, location, depth, speed, weather condition, current) during hauls. Commercial catch and bycatch (discards) were weighed and commercial fish was counted and measured for each haul. For a limited number of hauls, benthic invertebrates were identified and counted.

17.3 Results and discussion

17.3.1 Bycatch (discards)

17.3.1.1 Weight of non-commercial catch

Fig. 17-3 shows the difference in weight of the non-commercial catch (catch – commercial fish) between standard and experimental rigging. Further analysis (Wilcoxon test) of the data shows a significant reduction of non-commercial catch during trips 2 (T-90 cod end and BRP) and 3 (BRP) (58% and 48% respectively).

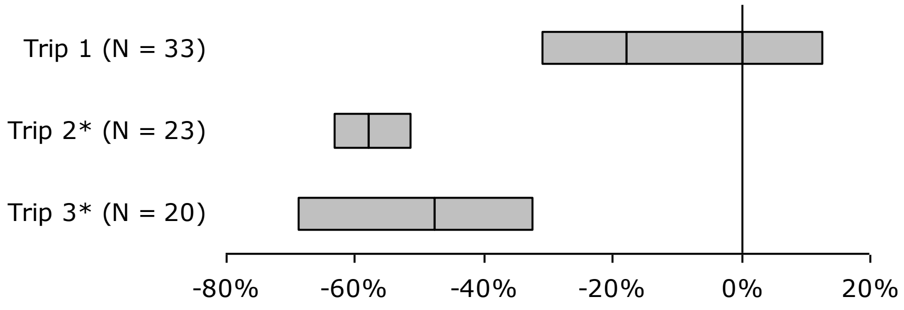


Fig. 17-3 - Weight difference (percentage) of non-commercial catch, experimental versus standard rigging (median and quartiles); Trip 1: T-90 cod end; Trip 2: T-90 cod end and BRP; Trip 3: BRP

The results show that the application of a BRP on board a eurobeamer results in a major reduction of by-catch (discards) in beam trawl fisheries. Experiments on board the research vessel 'Belgica' and large commercial beam trawlers yielded similar (albeit more limited) results. Furthermore these results proved highly dependent on the fishing grounds. During the experiments on board N 58 only one fishing ground was visited (Thames estuary). This fishing ground was not visited during previous experiments with large beam trawlers.

17.3.1.2 Benthic invertebrates

For a limited number of hauls, benthic invertebrates were identified and counted in a subsample of the non-commercial catch. Some 20 invertebrates were identified during the experimental trips but only 7 were caught in sufficient numbers to allow further analysis (Wilcoxon test). Fig. 17-4, Fig. 17-5 and Fig. 17-6 illustrate the distribution of the catch of these 7 invertebrates between the experimental and the standard configuration during each trip. Similar to the results for the total non-commercial catch, application of the T-90 cod end (trip 1) appeared to have little effect on the catch of individual invertebrates. Fig. x and x give more insight into the clear effect of the BRP that was observed on the total non-commercial catch. On the one hand, there is a distinct effect on the by-catch of hermit crabs, whelks and brittle stars. During application of the T-90 cod end combined with BRP and BRP, respectively 9%/12%, 4%/0%, 12%,9% of the total catch was present in the experimental configuration. On the other hand, the effect on the by-catch of sea mice, starfish and sea urchins is limited. During application of the T-90 cod end combined with BRP and BRP, respectively 42%/40%, 37%/30%, 35%,46% of the total catch was present in the experimental configuration. The results for masked crabs were inconclusive.

Apparently, the effect of the BRP is highly species dependent. Only species with a sufficiently high weight escape (fall) through the BRP.

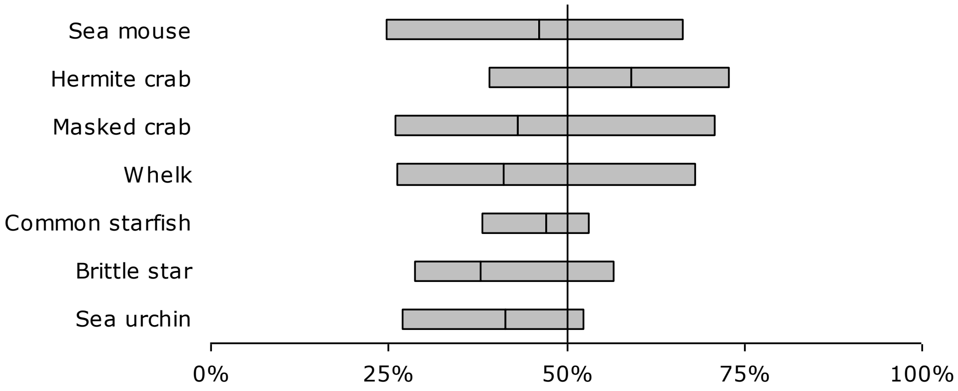


Fig. 17-4 - Percentage distribution of invertebrates (by number) between standard and experimental configuration during trip 1 (T-90 cod end) (median and quartiles)

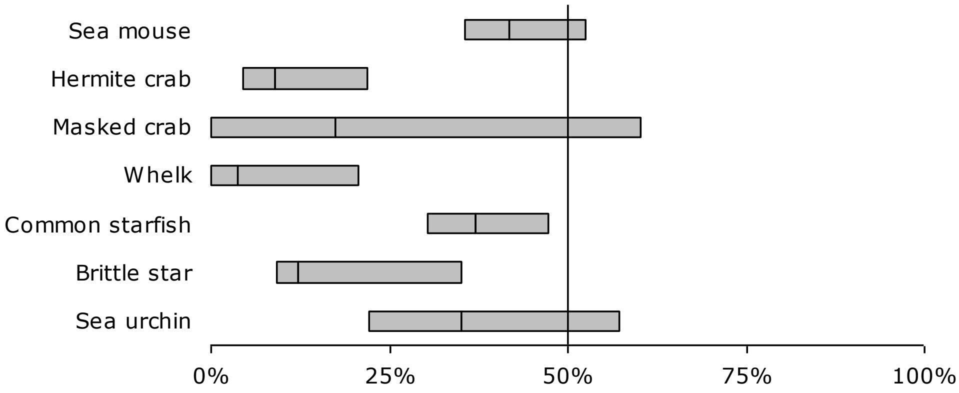


Fig. 17-5 - Percentage distribution of invertebrates (by number) between standard and experimental configuration during trip 2 (T-90 cod end and BRP) (median and quartiles)

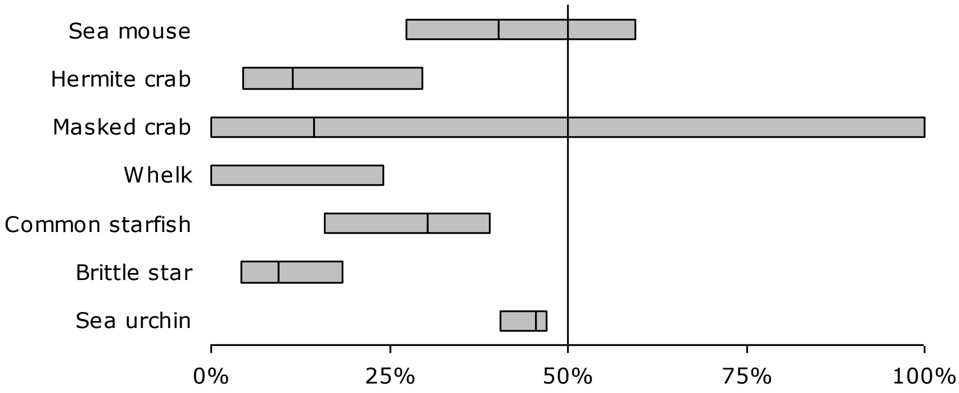


Fig. 17-6 - Percentage distribution of invertebrates (by number) between standard and experimental configuration during trip 3 (BRP) (median and quartiles)

17.3.1.3 Commercial catch

During trip 2 and the first 26 hauls of trip 3, a standard cod end with a larger mesh size (87 mm) was employed. The difference in mesh size strongly affected the catch of commercial fish. Due to damage, this cod end was replaced with an 80 mm cod end at the end of trip 3. During further analysis, the commercial catch data of trip 3 is divided and treated as trip 3a and trip 3b.

Dover sole

Dover sole is the main target for Belgian eurobeamers, this is also the case for N 58. Fig. 17-7 shows the effect of the adaptations made during the experimental trips on the commercial sole catch.

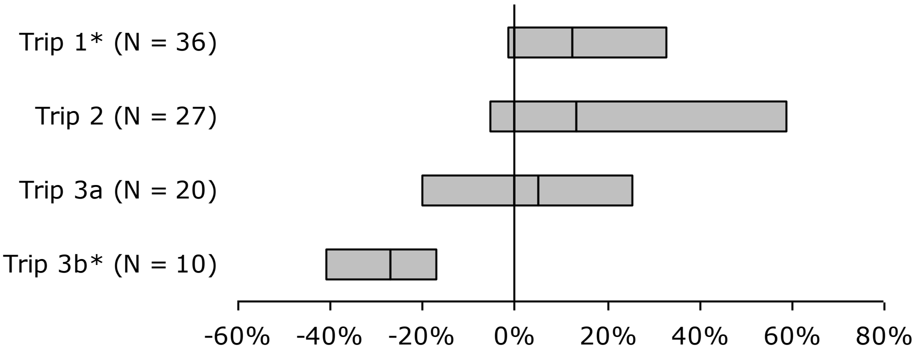


Fig. 17-7 - Weight difference (percentage) of sole catch, experimental versus standard rigging (median and quartiles); Trip 1: T-90 cod end; Trip 2: T-90 cod end and BRP (large mesh standard cod-end); Trip 3a: BRP (large mesh standard cod-end); Trip 3b: BRP

Further analysis (Wilcoxon) of the results shows that applying the T-90 cod end yields a significantly higher catch of commercial sole (13%). Application of the BRP (trip 3b), on the other hand, yields a significant loss of commercial sole (27%). During trip 2 and 3a, no significant difference could be observed. Possibly, the loss of sole through the BRP (experimental rigging) was compensated by the loss of sole through the larger mesh cod-end (standard rigging).

Fig. 17-8, Fig. 17-9, Fig. 17-10 and Fig. 17-11 illustrate the length distributions of the sole caught during the experimental trips. Fig.8 shows that application of the T-90 cod-end results in a better selectivity around the minimum landing size (MLS) of sole (24 cm). More commercial sole is caught and less undersized sole is discarded. During previous experiments on board a large beam trawler and the research vessel 'Belgica', similar observations were made. The data of trip 2 (T-90 cod-end) and 3a (BRP) are clearly corrupted by the large mesh cod-end in the standard configuration. However, the loss of large sole that is observed for trip 2 and 3a can not be explained by the large mesh cod-end. This loss may be due to the application of the BRP. This is confirmed by the results of trip 3b (Fig. 11) that compare the BRP with a normal mesh cod end. The results show a loss of sole over the entire length range. Apparently both small and large sole are lost through the BRP.

This loss of sole through the BRP was not observed during previous experiments with large beamers. On the research vessel 'Belgica', loss of sole was observed with a 150 mm BRP but not with a 120 mm BRP. Further experiments are needed to determine these different observations.

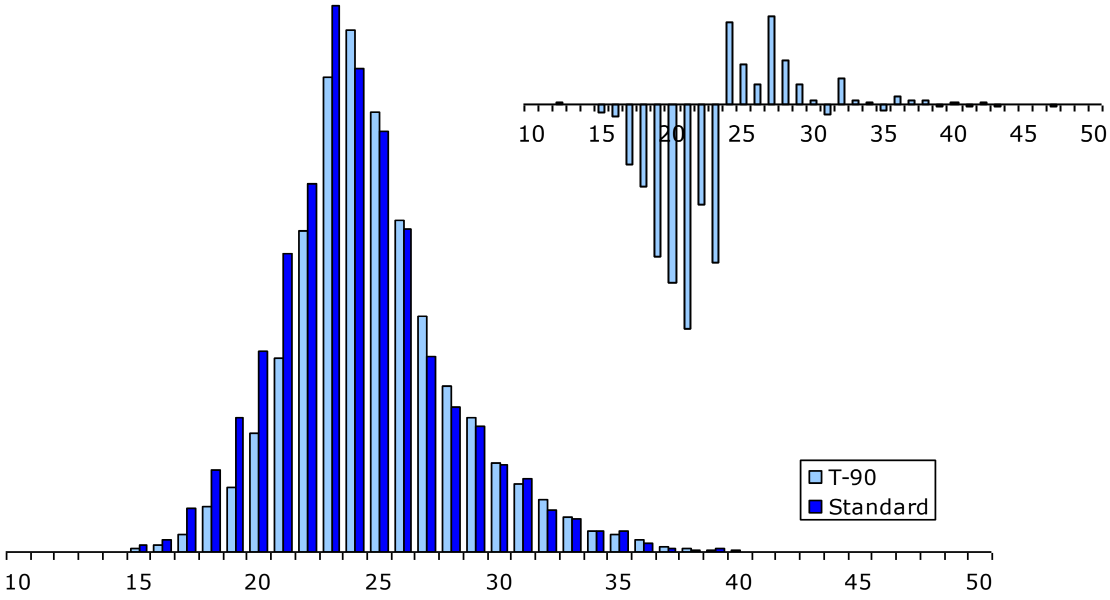


Fig. 17-8 - Length distribution of sole catch with experimental (T-90 cod end) and standard configuration (Trip 1); small graph shows catch difference (by number)

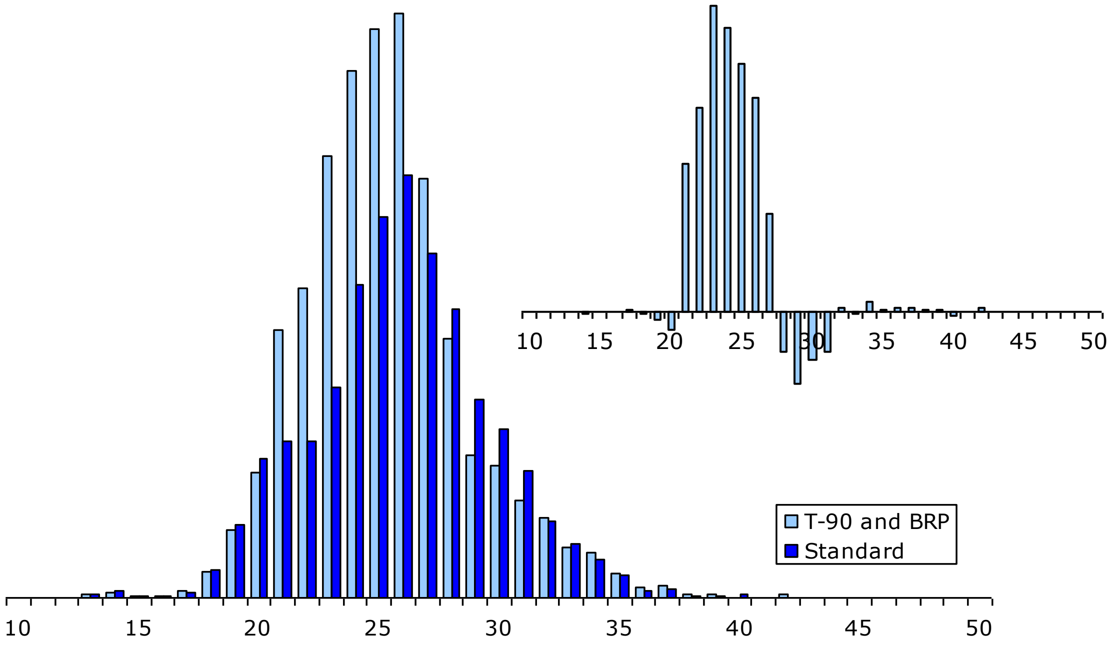


Fig. 17-9 - Length distribution of sole catch with experimental (T-90 cod end and BRP) and standard configuration (large mesh cod end) (Trip 2); small graph shows catch difference (by number)

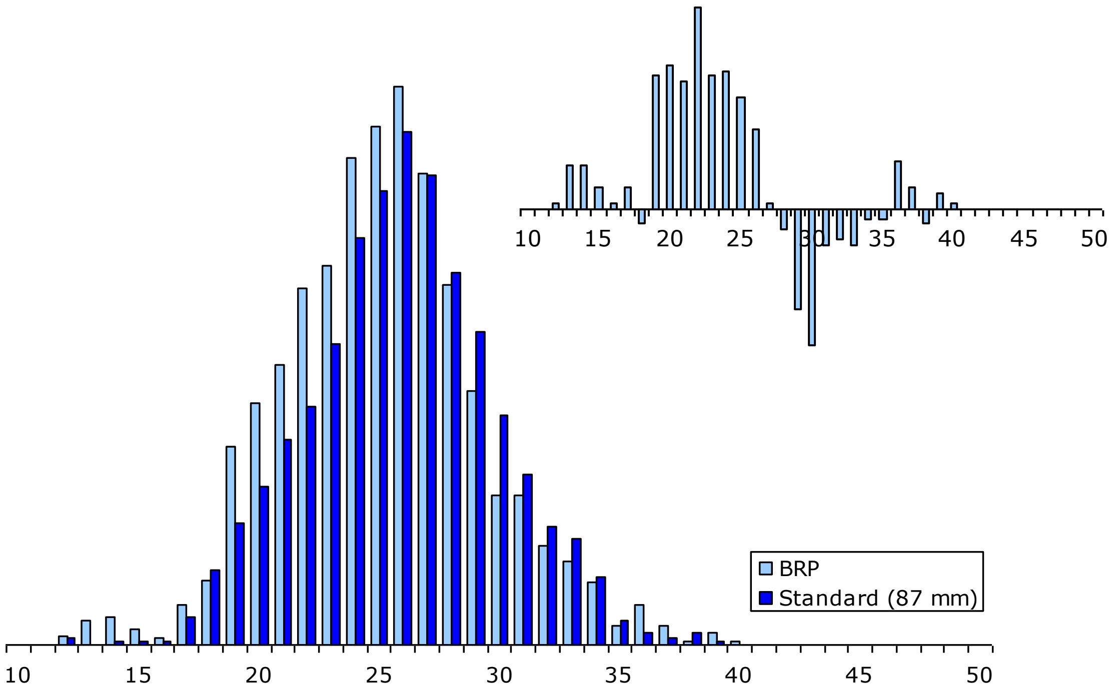


Fig. 17-10 - Length distribution of sole catch with experimental (BRP) and standard configuration (large mesh cod end) (Trip 3a); small graph shows catch difference (by number)

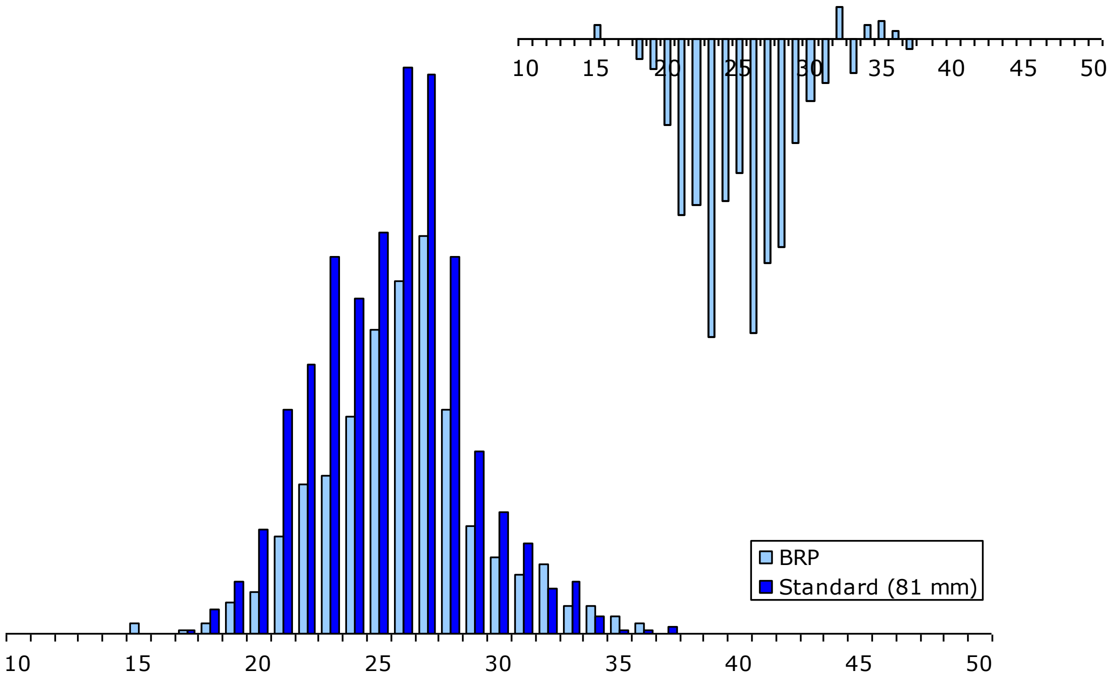


Fig. 17-11 - Length distribution of sole catch with experimental (T-90 cod end and BRP) and standard configuration (Trip 3b); small graph shows catch difference (by number)

Plaice

Next to sole, ray and plaice make up an important part of the revenues of Belgian eurobeamers. For practical reasons, ray were not measured during the experimental trips. Plaice, however, was measured. In contrast to the results for sole, use of the T-90 cod end results in a worse selectivity for plaice. Similar observations were made on board large beam trawlers and the research vessel ‘Belgica’. The T-90 cod end with its open meshes is more appropriate to reduce the bycatch of small roundfish rather than stiff flatfish (like plaice) that escape more easily through the stretched diamond meshes from a standard cod end. The same observation could be made during the experiments with the T-90 cod end and the BRP (Trip 2). Application of the BRP without the T-90 cod end (Trip 3a and 3b) appeared to have little effect on the catch of plaice.

The high loss of sole through the BRP was not observed for plaice and the length selectivity for plaice is lower with the T-90 cod end.

17.4 Conclusion

Experiments with the T-90 cod end and the BRP on board of the eurobeamer N 58 ‘Pascin’ largely confirm previous observations on board the research vessel ‘Belgica’ and large beam trawlers:

- Reduction of total non-commercial catch with the BRP (48% to 58%)
- No loss of commercial sole with the T-90 cod end (13% extra)
- Improved length selectivity for sole when using the T-90 cod end
- No loss of commercial plaice with the T-90 cod end
- Reduced length selectivity for plaice when using the T-90 cod end

In contrast to previous observations, application of the BRP on board the eurobeamer N.58 ‘Pascin’ resulted in a high loss of commercial sole (27%). Further experiments are needed to determine the cause of this loss and why it was not observed during earlier experiments. Possible explanations may be the use of a single braided BRP, difference in towing speed, position and size of BRP in relation to the size of the trawl.

A more in depth analysis of benthic invertebrates in the non-commercial bycatch shows that the performance of the BRP is highly species dependent (most effective in reducing the bycatch of hermit crab, whelk and brittle star).

The results of trip 2 and 3a were corrupted by the use of a large mesh cod end in the standard configuration (strongly effecting the catch of sole). The data from these trips requires further statistical analysis (based on selectivity data from other experiments) to allow a better interpretation.

18 Benthos release panel and T90 cod-end – commerc

ial trials “large segment”

Based on:

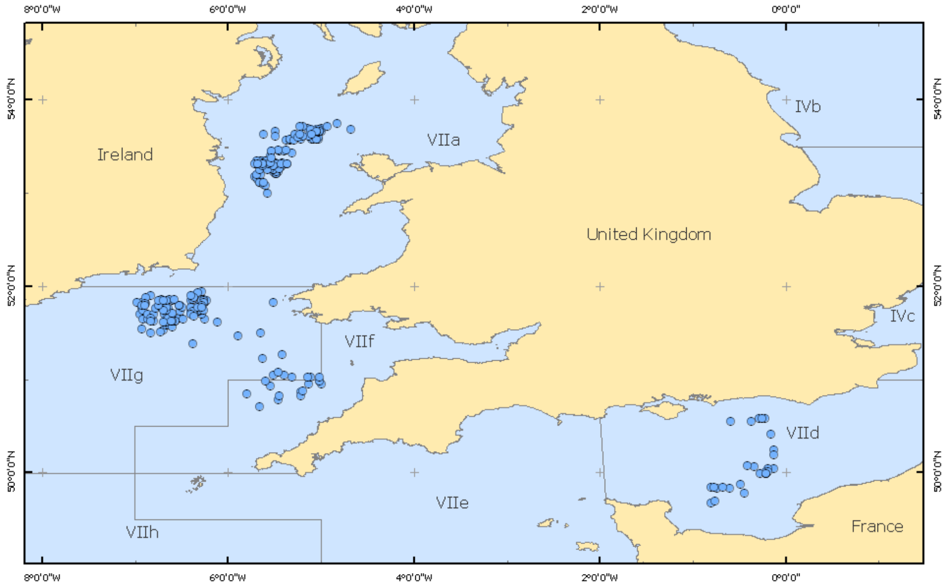
New data collected in the FIOV-project (FIFG, Financial Instrument for Fisheries Guidance) “Innovatiecentrum Duurzame en Ecologische Visserij”. Project VIS/02/B/05/DIV

18.1 Introduction

In the general introduction and chapters 3 and 4, it has been pointed out that a benthos release panel (BRP) and a T90 cod end have the potential to significantly reduce the unwanted by-catch of beam trawls. However, RV trials are usually conducted in optimized conditions (a single vessel and a limited spatial and temporal scale), which do not match the conditions aboard commercial vessels. Hence, RV results should be verified by data from commercial catches in order to assess the applicability of the modifications for commercial trawlers. The present chapter focuses on the results from trials with vessels from the “large segment”, i.e. vessels with more than 221kW engine power.

18.2 Material and methods

The commercial trials were carried out in the period August 2005 – April 2006 during 6 trips done by 2 different vessels. In some cases, trips were subdivided due to changes in the configuration of the treatments. Table 7.1 gives an overview of the tested treatments per trip and the date of the trials; visited fishing grounds are represented in the map below.



Map showing coordinates of tows conducted during the trips in which the alternative beam trawl configurations were tested.

On each vessel, one of the standard beam trawls was modified rigging a BRP, a T90 cod end, or both. In the RV trials (see chapter 3), a BRP with a mesh size of 150 mm yielded the best results regarding a reduction of benthic species and a minimal loss of commercial catch. However, a BRP with a 120mm mesh (4mm double polyethylene twine) was used during commercial trials to ensure a minimization of sole loss, since this is an essential factor to obtain a voluntary application of the adaptations by fishermen. In the experimental beam trawl, the BRP (1.8m by 1.2m) was inserted in the belly in front of the cod end at a distance of about 1.2m (Polet & Fonteyne, 2001). The cod end had a standard configuration or was replaced with an 80mm cod end mesh (4mm double polyethylene twine), which had been turned 90°.

Table 18-1: List of trips with specification of experimental setup, trip code and date

Treatment	Vessel	Trip code	Date
T90	1	A	24/8/05-5/9/05 part I Invalid due to net defect; excluded
		B	24/8/05-5/9/05 part II
		C	8/8/05-22/8/05
	2	D	31/3/06-14/4/06
BRP	1	C	8/8/05-22/8/05
T90+BRP	1	AB	24/8/05-5/9/05
		C1	8/8/05-22/8/05 part I
		C2	8/8/05-22/8/05 part II
		E	17/11/05-25/11/05
	2	D	31/3/06-14/4/06
		F	20/3/06-25/3/06

For both the standard and alternative beam trawl, catches of sole, plaice, cod, haddock and whiting were analysed in terms of numbers, individual lengths and weight per species, for both marketable and undersized individuals. For other fish species, these data were gathered opportunistically, depending on the species composition of the catch and the available time for processing. For some less commercially important fish species, information about the marketable fraction is mostly lacking (e.g. rays and skates; see results). After the processing of the commercial catch, the weight of the discards was estimated separately for both treatments.

The graphs in the results section display various aspects of catch comparisons with a full line always representing results from the standard beam trawl and an interrupted line representing results from the experimental beam trawl. Box plots represent median with percentiles in the box and minimum/maximum in the whiskers.

Statistical analyses of the effects of beam trawl modifications were done with the non-parametrical Wilcoxon matched pairs test for dependant samples; $p<0.05$ is considered as significant and is shown in red throughout the results.

18.3 Results

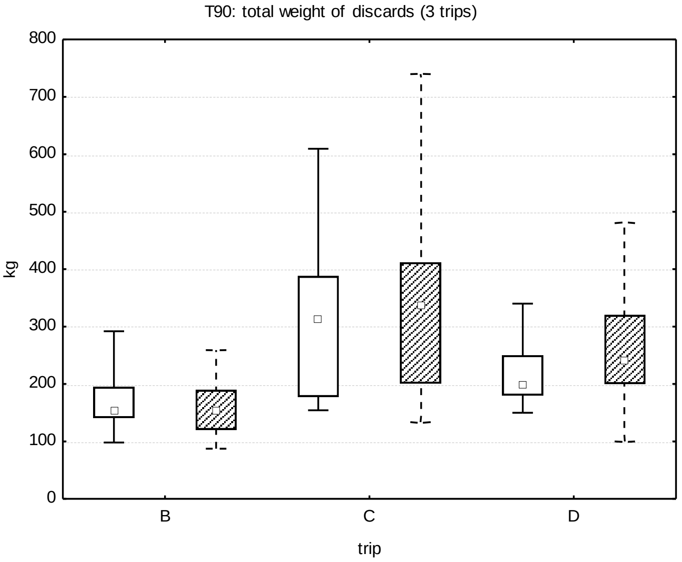
18.3.1 Effect T90, BRP and T90+BRP on the total weight of discards

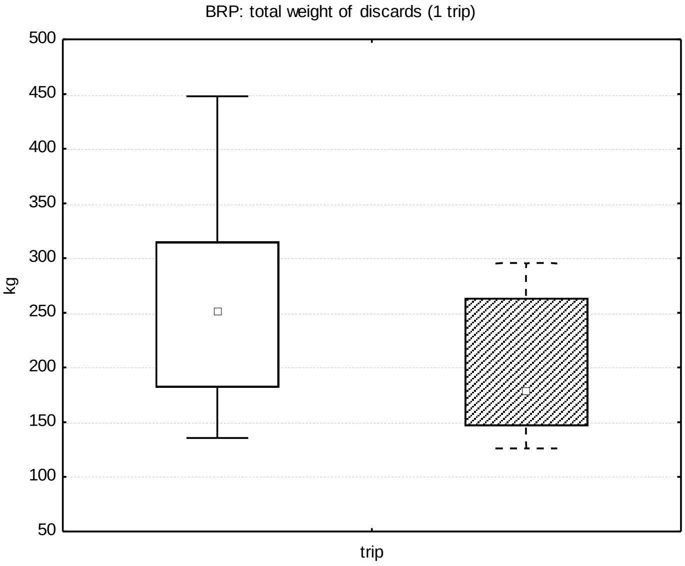
The analysis of discard weights from different beam trawl configurations indicate that a T90 cod has little effect on the discard weight: a reduction was observed during only 1 trip and the combined data indicate a significant, yet small (8.4%), increase of the amount of discards (average of 222kg in the standard beam trawl and 245kg in the T90 beam trawl).

The BRP, on the other hand, significantly reduces the discard weights, when used separately or in combination with a T90 cod end. The impact of the reduction varies from trip to trip, but is consistent and highly significant. When used separately, the discards are reduced with 21% (average of 258kg in the standard beam trawl and 199kg in the BRP beam trawl). In the combined experiment, the mean reduction still amounts up to 18% (average of 275kg in the standard beam trawl and 215kg in the T90+BRP beam trawl).

Table 18-2: Effects of T90, BRP and a combination of both on the weight of discards (kg)

Treatment	Trip	Nr of tows	Wilc p-value	% difference discard weight	remarks
T90	B	18	0.35	-4.7	
	C	12	0.03	13.3	
	D	27	0.01	15.4	
	all	57	0.02	8.4	
BRP	C	12	0.002	-20.6	Limited data
T90+BRP	AB	16	0.001	-13.7	
	E	29	<0.001	-23.3	
	C1	10	0.005	-16.7	
	C2	10	0.009	-8.4	
	D	9	0.09	7.8	Weights are rough estimates
	F	14	0.001	-36.8	
	all	88	<0.001	-18.1	


T90: total weight of discards (3 trips)
kg
0
100
200
300
400
500
600
700
800
B
C
D
trip


BRP: total weight of discards (1 trip)
kg
50
100
150
200
250
300
350
400
450
500
trip

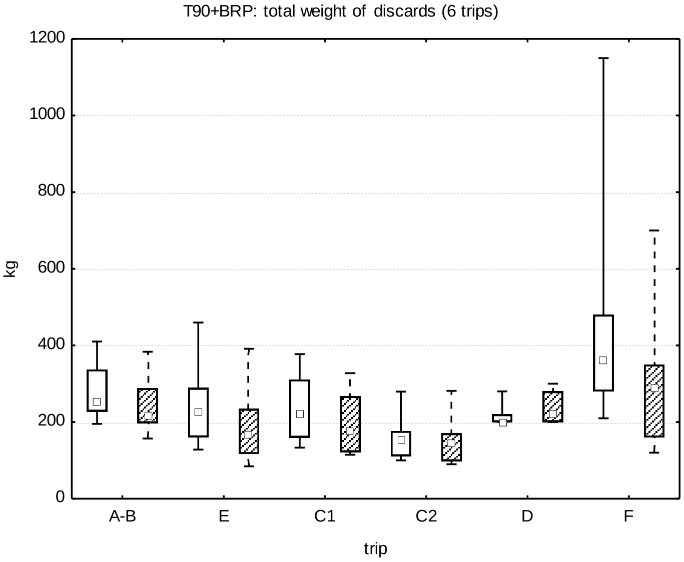

T90+BRP: total weight of discards (6 trips)
kg
0
200
400
600
800
1000
1200
A-B
E
C1
C2
D
F
trip

Fig. 18-1 - Effects of T90, BRP and T90+BRP on the total weight of discards per trip (standard beam trawl = white box and full line whiskers; experimental beam trawl = striped box and interrupted line whiskers)

18.3.2 Effect T90, BRP and T90+BRP on the weight of commercial fish species

Table 18-3 and Fig. 18-2 illustrate the effects of beam trawl modifications on the catch weight of the main target species (> MLS – Minimum Landing Size). Sole and plaice are the main target species of the large segment of the fleet, so losses due to modifications are problematic for the industry. Losses of other species at marketable size, such as cod, whiting, haddock, hake and various flatfish species should be minimized as well.

The results show that the use of a T90 cod end does not result in significant losses of marketable fish (p>0.05 for pooled data of all species). On the contrary, the catches of sole increased by 8.6% (significant increase by 11% on 1 trip), and the catches of plaice by 8.1%. For hake, lemon sole, long rough dab and dab, the amount of data are limited and the variability in weight differences is rather high, so conclusions are hard to make.

The BRP without a T90 cod end has only been tested on 1 trip, so results should be interpreted with care. Small but insignificant losses were observed in sole (-3.6%), hake (-16.3%) and lemon sole (-0.7%). Small increases in weight were seen in plaice (6.4%), anglerfish (1.2%) and dab (8.2%).

The combined effects of the T90 cod end and the BRP resulted in a significantly larger catch of plaice (p=0.0037) with a mean increase of 11.8% in weight over all trips. Increases were also observed in sole (3.3%), cod (75%) and dab (12%), but these were not significant. The data are insufficient to draw any sound conclusions about cod (only 1 trip and very low numbers per tow). Weight losses were observed in haddock (-9%, significant), hake (-32.5%, not significant) and lemon sole (not significant).

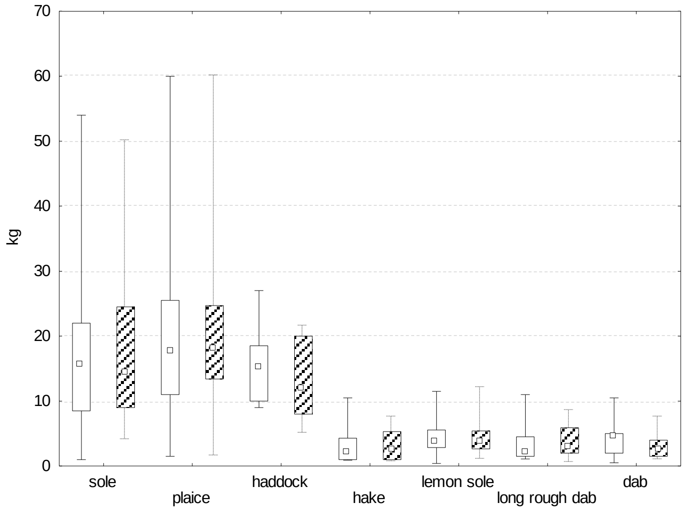
Table 18-3: Effects of T90, BRP and T90+BRP on the weight of commercial fish species (kg). / = insufficient data

Treatment	Fish species	Trip	Nr of tows	Wilc p-value	% difference weight
T90	sole	B	32	0.71	10.6
		C	27	0.63	3.7
		D	27	0.02	10.9
		all	89	0.18	8.6
	plaice	B	35	0.5	5.9
		C	27	0.15	11.1
		D	/	/	/
		all	62	0.17	8.1
	hake	B	18	0.6	16.9
		C	/	/	/
		D	/	/	/
		all	18	0.6	16.9
	lemon sole	B	30	0.10	25.8
		C	3	/	-17.4
		D	/	/	/
		all	33	0.25	21.8
	long rough dab	B	17	0.23	20.5
		C	/	/	/
		D	/	/	/
		all	17	0.23	20.5
	dab	B	5	0.71	15
		C	7	0.063	-35.4
		D	/	/	/

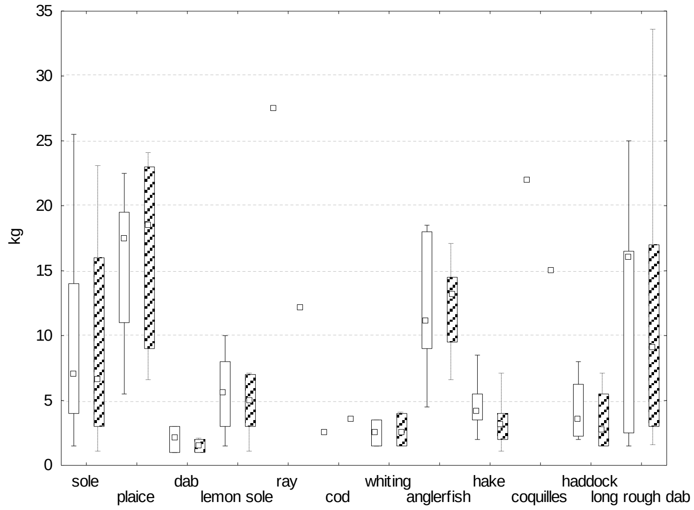
		all	13	0.08	-14.3
BRP	sole	C	15	0.61	-3.6
	plaice	C	11	0.53	6.4
	hake	C	9	0.11	-16.3
	lemon sole	C	11	0.29	-0.7
	long rough dab	C	7	0.67	1.17
	anglerfish	C	5	0.89	8.2
	dab	C	/	/	/
	ray	C	/	/	/
	cod	C	/	/	/
	whiting	C	/	/	/
	coquilles	C	/	/	/
	haddock	C	/	/	/
T90+BRP	sole	AB	33	0.94	8.8
		C2	22	0.48	4.6
		C1	19	0.57	-2.5
		E	63	0.075	-1
		D	16	0.41	4.7
		F	14	0.73	14.7
		all	167	0.61	3.3
	plaice	AB	34	0.02	21
		C2	23	1.0	2.9
		C1	20	0.014	20.9
		E	63	0.41	7.2
		D	/	/	/
		F	/	/	/
		all	140	0.0037	11.8
	cod	AB	/	/	/
		C2	/	/	/
		C1	/	/	/
		E	28	0.15	74
		D	/	/	/
		F	/	/	/
		all	28	0.15	74
	haddock	AB	7	0.39	-4.1
		C2	/	/	/
		C1	/	/	/
		E	18	0.18	-5.8
		D	/	/	/
		F	/	/	/
		all	29	0.02	-9
	hake	AB	/	/	/
		C2	7	0.08	-32.5
		C1	/	/	/
		E	/	/	/
		D	/	/	/
		F	/	/	/
		all	7	0.08	-32.5
	lemon sole	AB	/	/	/
		C2	23	0.18	-4
		C1	/	/	/
		E	/	/	/
		D	/	/	/
		F	/	/	/
		all	23	0.18	-4
	dab	AB	/	/	/
		C2	10	0.14	11
		C1	/	/	/
		E	/	/	/
		D	/	/	/
		F	/	/	/

	all	13	0.15	12
whiting	all	/	/	/
long rough dab	all	/	/	/

T90: weight of commercial fish species



BRP: weight of commercial fish species



T90+BRP: weight of commercial fish species

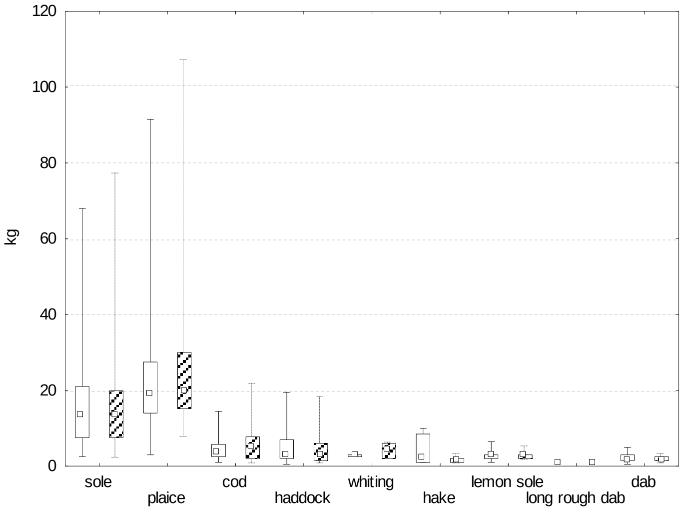


Fig. 18-2 - Effects of T90, BRP and T90+BRP on the weight of commercial fish species (data pooled over all trips per species)

18.3.3 Effect T90, BRP and T90+BRP on the length-frequency distributions of various commercial and non-commercial species

18.3.3.1 SOLE

The effects of trawl modifications on the length distribution of sole can be deduced from Table 18-4 and Fig. 18-3.

Calculation of the percentage of individual soles in the experimental beam trawl compared to the standard beam trawl shows that a T90 cod end does not only increase the total catch of sole in weight (see 7.3.2), but also in numbers. When all trips are pooled, significantly larger numbers of soles were caught with the experimental beam trawl (112% of the catch of the standard trawl). However, the increase in numbers is mainly due to a higher number of undersized individuals (220%), but marketable fish are also more abundant (110%). The size –frequency distribution curve of the T90 trawl is shifted to the right compared to the standard trawl, but both curves peak at the MLS (24cm). The percentages (red dots) are very variable at the smallest sizes but consistently rise above 100% at lengths above MLS.

The BRP has no significant effects on the size distribution of caught sole, with only a small loss of especially undersized sole (80% compared to standard trawl). The length-frequency curves of the experimental and standard beam trawl are almost identical.

The combination of T90 and BRP shows variable results when examining the trips separately. Some trips had a larger sole catch, while others suffered a small loss of marketable soles (max 9%). The loss of undersized soles with the BRP seems to compensate for the increased numbers of small soles with the T90 cod end. In all cases, the differences between treatments are not significant indicating that the variation between treatments is not larger than it would be if two standard trawls would be used. Consequently, length-frequency curves are again almost identical, with the percentages in the experimental trawl approaching 100% for the most common length classes.

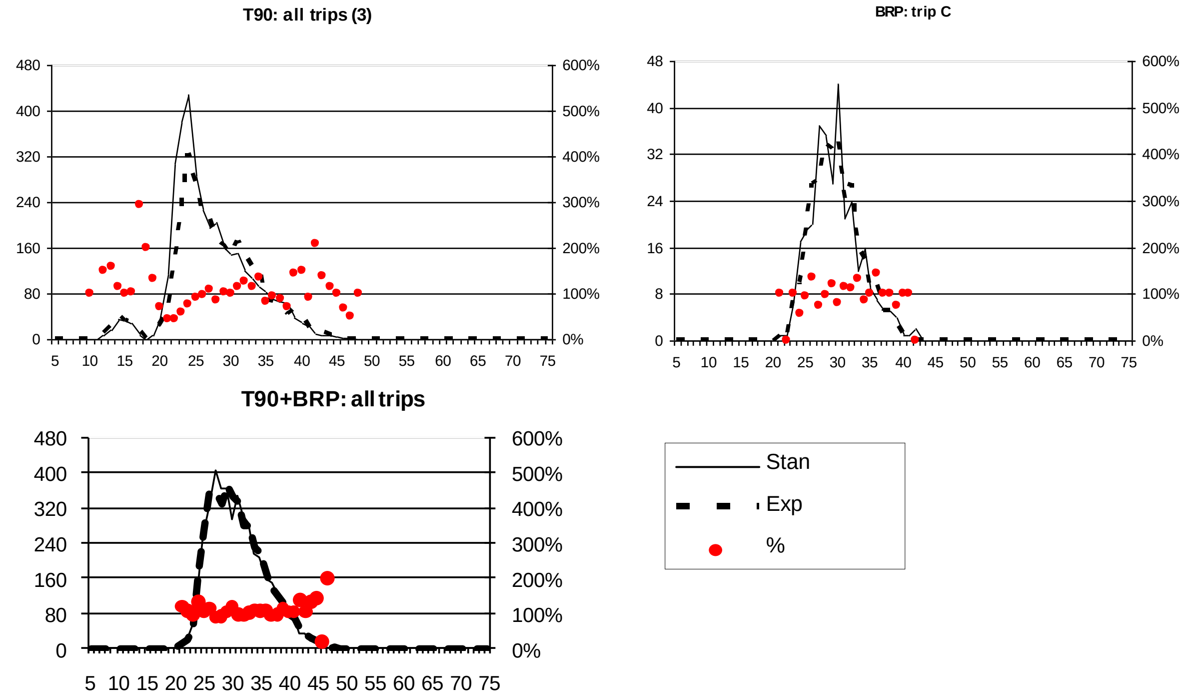


Fig. 18-3- Length frequency-distributions of sole, data of trips pooled per treatment. X-axis: length (cm)

Table 18-4: Effects of T90, BRP and T90+BRP on the length distribution of sole.

/ = insufficient data; exp= experimental beam trawl, stand= standard beam trawl

Treatment	Trip	Nr of tows	Size	% in exp. compared to stand.	Wilc p-value
T90	B	18	<MLS	211	0.59
			>MLS	102	0.60
			all	105	0.48
	C	12	<MLS	158	0.23
			>MLS	95	1.0
			all	96	0.93
	D	15	<MLS	231	0.037
			>MLS	118	0.002
			all	121	0.02
	All	45	<MLS	226	0.018
			>MLS	110	0.008
			all	112	0.004
BRP	C	12	<MLS	89	0.71
			>MLS	98	0.75
			all	98	0.69
T90+BRP	AB	16	<MLS	136	0.28
			>MLS	99	0.85
			all	100	0.90
	C1	19	<MLS	79	0.34
			>MLS	100	0.79
			all	99	0.76
	C2	18	<MLS	89	1.0
			>MLS	91	0.98
			all	91	0.91
	E	31	<MLS	77	0.41
			>MLS	96	0.35
			all	96	0.45

	D	7	<MLS	200	0.59
			>MLS	114	0.13
			all	114	0.13
	F	3	<MLS	480	/
			>MLS	121	/
			all	128	/
	All	94	<MLS	118	0.62
			>MLS	103	0.61
			all	104	0.58

18.3.3.2 PLAICE

When using a T90, a BRP or both, the overall effect is an increase in catch weight of plaice (see 7.3.2). However, when examining abundance data, it seems that less fish are caught. Reductions are highly significant in 2 trips during which both the T90 cod end and the BRP were tested. During trip AB, more fish were caught, so the effect of the adaptations is variable between trips. In the case of T90 or BRP alone, reductions are limited and mostly concern undersized fish (87% compared to standard trawl in T90; 90% in BRP).

The increase of weight should logically be the result of an increased proportion of larger fish. In figure 4, there is an upward trend of the percentage in the experimental trawl for fish larger than the MLS (red dots), especially for the BRP. The shift in length-frequency curve towards larger fish is most pronounced for the BRP, but is not dramatic.

Table 18-5Effects of T90, BRP and T90+BRP on the length distribution of plaice.

/ = insufficient data; exp= experimental beam trawl, stand= standard beam trawl

Treatment	Trip	Nr of tows	size	% in exp compared to stand	Wilc p-value
T90	B	18	<MLS	83	0.35
			>MLS	96	0.74
			all	87	0.66
	C	12	<MLS	90	0.21
			>MLS	99	0.81
			all	92	0.21
	D	/	/	/	/
	all	30	<MLS	87	0.07
			>MLS	98	0.71
			all	90	0.12
BRP	C	12	<MLS	90	0.11
			>MLS	106	0.50
			all	96	0.53
T90+BRP	AB	16	<MLS	145	0.30
			>MLS	112	0.07
			all	116	0.07
	C1	10	<MLS	84	0.04
			>MLS	89	0.37
			all	85	0.05
	C2	18	<MLS	79	0.003
			>MLS	12	0.003
			all	72	0.003
	E	29	<MLS	70	0.14
			>MLS	94	0.83
			all	80	0.99
	all	66	<MLS	78	0.001
			>MLS	83	0.16
			all	80	0.002

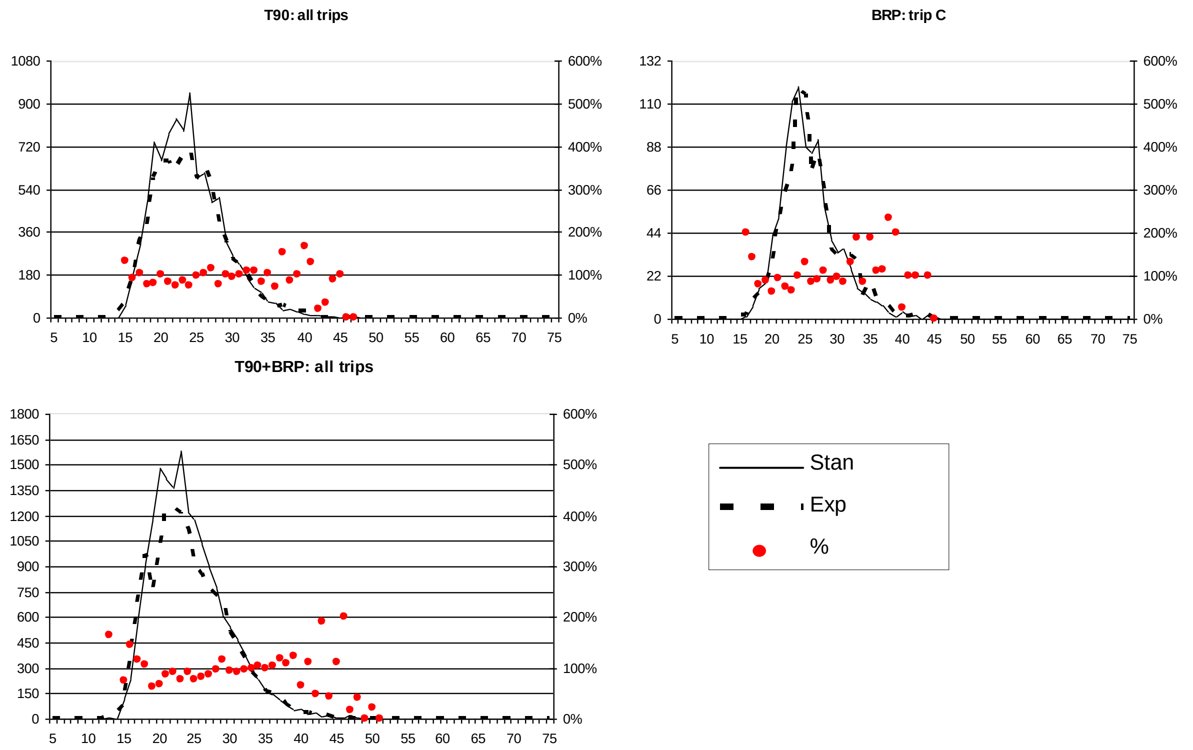


Fig. 18-4 - Length frequency-distributions of plaice, data of trips pooled per treatment. X-axis: length (cm) ; Y-axis: numbers

18.3.3.3 GADOIDS

For cod, the abundances per tow were very low (<10 individuals), which resulted in discontinuous data across the length range (figures not shown). Data were pooled over all trips per treatment, but no significant effects were observed (table 6). There is a trend towards loss of marketable cod with the BRP and an increase of all lengths of cod with the T90 cod end but further research is needed to confirm these observations.

The results for whiting reveal some significant effects: there is a substantial reduction of especially undersized individuals when using a BRP (35% compared to standard trawl). However, the combined use of T90 and BRP results in a significant reduction of marketable whiting. The loss of undersized whiting is compensated by the small increase resulting from the T90 cod end (shift towards the lefts in length-frequency curve; see Fig. 18-5).

The most spectacular impact of the use of a T90 cod end can be observed for hake (MLS=27cm). Catches of both undersized and marketable fish are reduced with almost 90% (table 6 and figure 6), while the BRP has no significant effects. The effect of the T90 cod end is dampened in the combined experiment, but still considerable.

The data for bib are limited (no MLS, data pooled), but still show an interesting trend (table 6): the abundance of bib is strongly reduced when a T90 cod end is used (42% compared to the standard beam trawl with T90, 64% with T90+BRP). The length-frequency distribution (not shown) is discontinuous due to the scarcity of data, so gathering additional data is advisable.

As for haddock, losses of undersized individuals are quite substantial and highly significant (59% compared to standard trawl with T90, 70% with BRP, 66% with T90+BRP). There are no significant changes for marketable fish (>30cm; see Fig. 18-7). Above the MLS, however, the percentages in the experimental beam trawl show an upward trend in all treatments.

Table 18-6: Effects of T90, BRP and T90+BRP on the length distribution of gadoids.

/ = insufficient data; exp= experimental beam trawl, stand= standard beam trawl

Species	Treatment	Nr of tows	size	% in exp compared to stand	Wilc p-value
cod	T90	26	<MLS	132	0.23
			>MLS	129	0.57
			all	131	0.14
	BRP	11	<MLS	100	0.79
			>MLS	71	0.12
			all	92	0.61
	T90+BRP	55	<MLS	105	0.46
			>MLS	126	0.10
			all	112	0.81
whiting	T90	25	<MLS	117	0.54
			>MLS	63	0.09
			all	102	1.0
	BRP	11	<MLS	35	0.02
			>MLS	66	0.18
			all	42	0.006
	T90+BRP	53	<MLS	96	0.88
			>MLS	47	0.008
			all	81	0.25
hake	T90	17	<MLS	14	0.22
			>MLS	10	0.0003

			all	10	0.0003
	BRP	11	<MLS	107	0.88
			>MLS	59	0.48
			all	73	0.33
	T90+BRP	9	<MLS	14	0.27
			>MLS	21	0.04
			all	17	0.05
bib	T90	8	all	42	0.33
	BRP	8	all	101	0.89
	T90+BRP	23	all	64	0.01
haddock	T90	31	<MLS	59	0.002
			>MLS	86	0.099
			all	61	0.001
	BRP	12	<MLS	70	0.03
			>MLS	105	0.84
			all	72	0.04
	T90+BRP	60	<MLS	66	<0.001
			>MLS	94	0.61
			all	71	<0.001

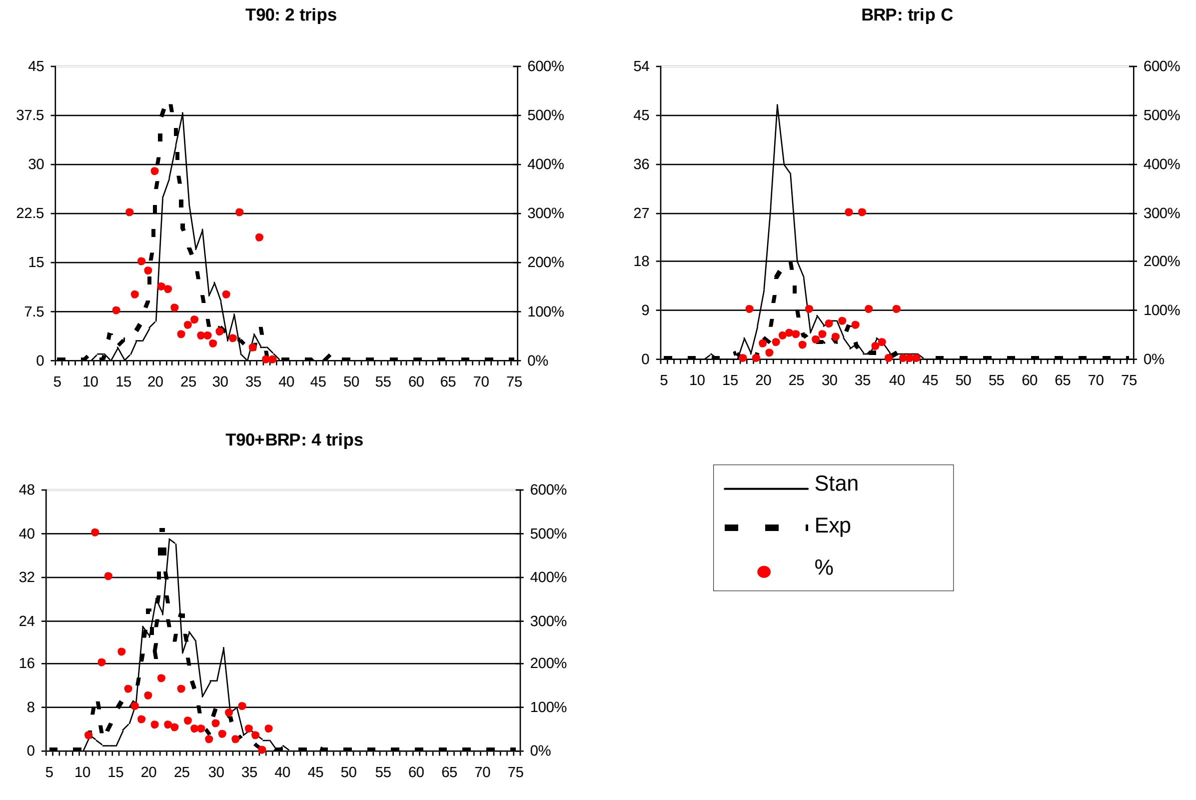


Fig. 18-5 - Length frequency-distributions of whiting, data of trips pooled per treatment. X-axis: length (cm) ; Y-axis: numbers

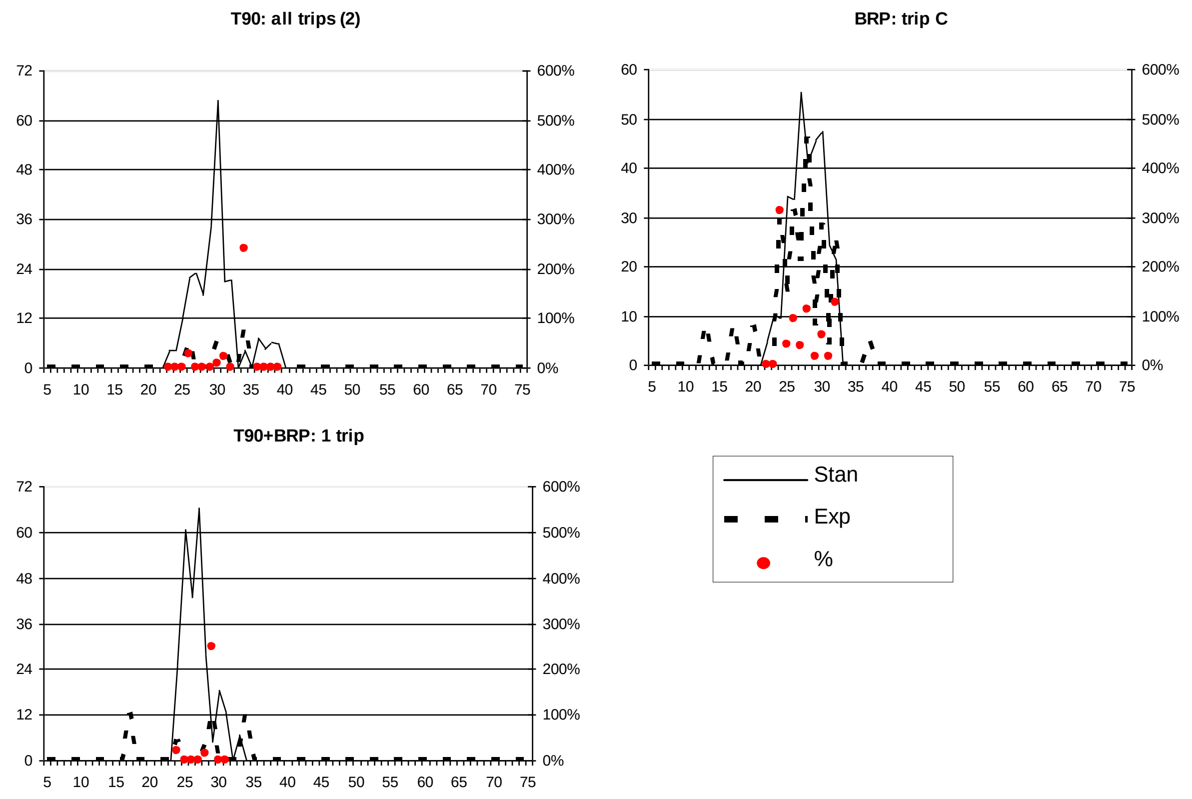


Fig. 18-6 - Length frequency-distributions of hake, data of trips pooled per treatment. X-axis: length (cm) ; Y-axis: numbers

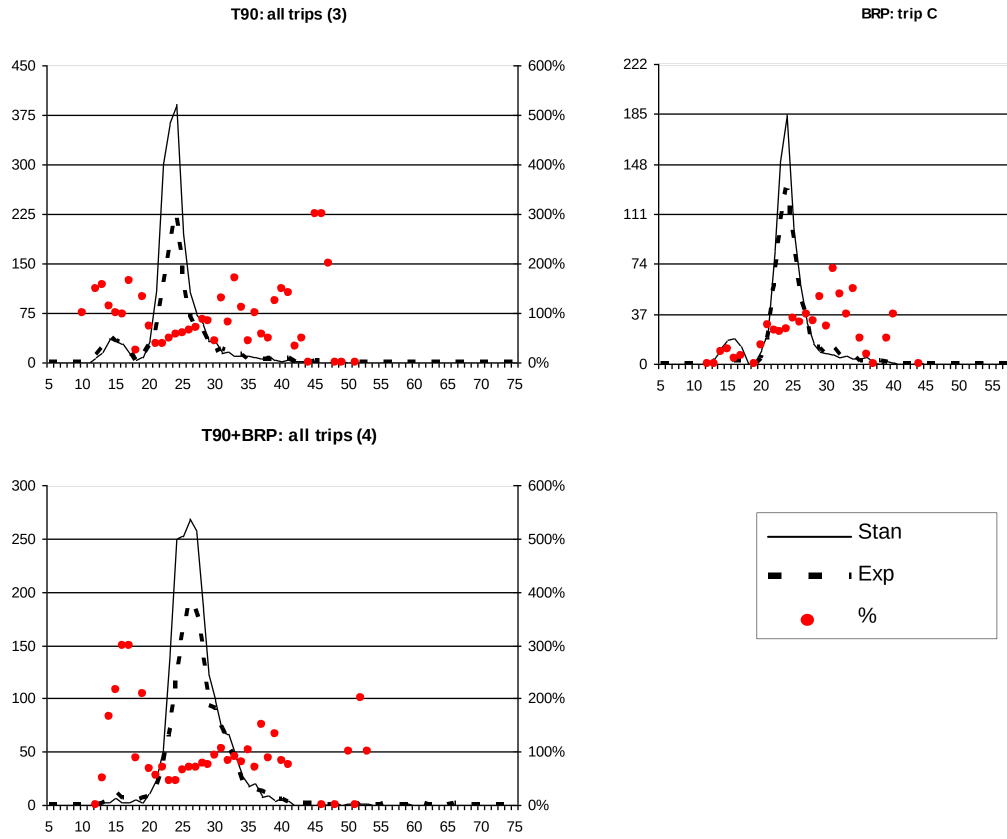


Fig. 18-7 - Length frequency-distributions of haddock, data of trips pooled per treatment. X-axis: length (cm) ; Y-axis: numbers

18.3.3.4 RAYS, SKATES AND DOGFISH

Data on rays and skates were gathered sporadically, and few data are available about the marketable fraction (Table 18-7). Furthermore, no distinction was made between species. Still, an analysis of the length-frequency data shows that the BRP (alone or combined with a T90) may cause a reduction in abundance, but confirmation by other studies is necessary.

The same trend is observed in dogfish, but in this case the reduction is significant and averages 27%. The length-frequency curve (not shown) is too fragmentary to make any conclusions about shifts in size.

Table 18-7: Effects of T90, BRP and T90+BRP on the length distribution of dogfish and skates and rays.

/ = insufficient data; exp= experimental beam trawl, stand= standard beam trawl

Species	Treatment	Nr of tows	Size	% in exp compared to stand	Wilc p-value
rays and skates	T90	33	all	110	0.92
	BRP	10	all	59	0.85
	T90+BRP	65	all	88	0.08
dogfish	T90	30	all	78	0.33
	BRP	12	all	73	0.03
	T90+BRP	65	all	88	0.12

18.3.3.5 FLATFISH OTHER THAN SOLE AND PLAICE

Data for flatfish other than sole and plaice are definitely insufficient to draw any conclusions, but for lemon sole and dab, there are some interesting significant results: for lemon sole there is a reduction in abundance when using a T90 code end in combination with a BRP; and there is a loss of dab when using a BRP, alone and combined with a T90 cod end.

Table 18-8: Effects of T90, BRP and T90+BRP on the length distribution of long rough dab, lemon sole and dab.

/ = insufficient data; exp= experimental beam trawl, stand= standard beam trawl

Species	Treatment	Nr of tows	Size	% in exp compared to stand	Wilc p-value
long rough dab	T90	7	all	84	0.73
	BRP	9	all	93	0.86
	T90+BRP	6	all	73	0.75
lemon sole	T90	26	all	92	0.47
	BRP	12	all	94	0.69
	T90+BRP	24	all	59	0.02
dab	T90	34	all	103	0.60
	BRP	10	all	61	0.01

T90+BRP	47	all	85	0.04

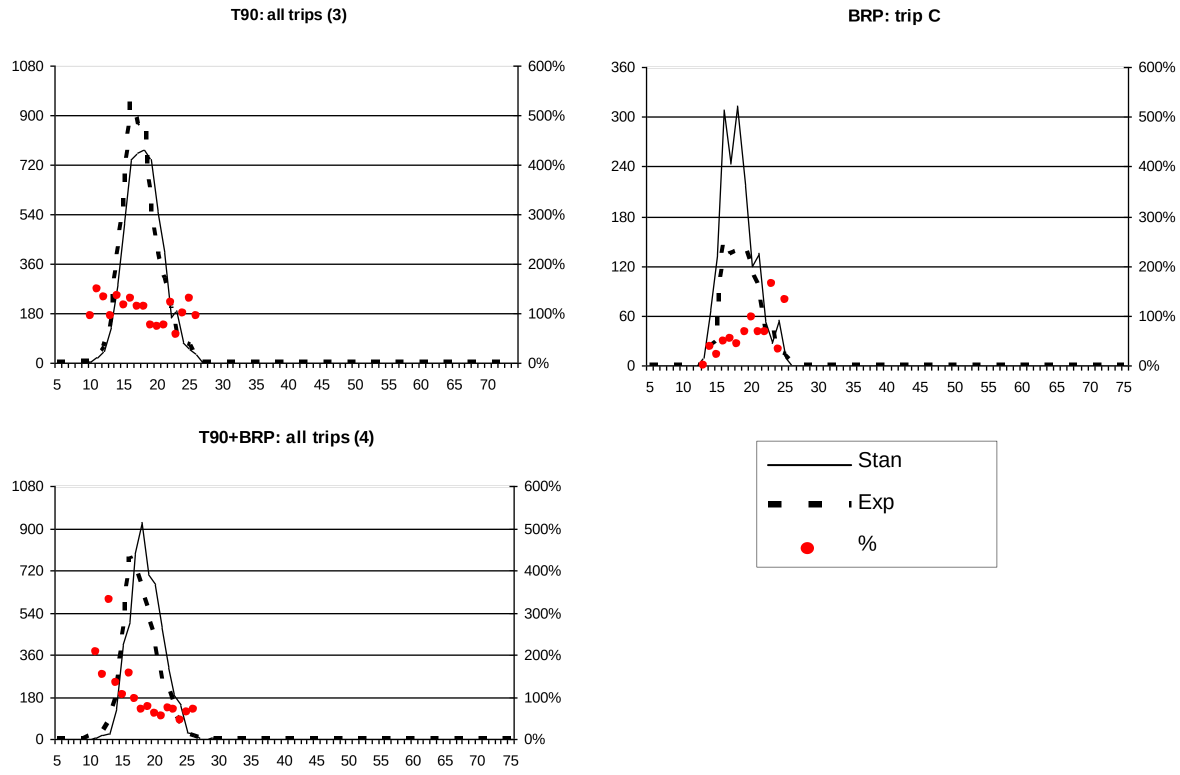


Fig. 18-8 - Length frequency-distributions of dab, data of trips pooled per treatment. X-axis: length (cm) ; Y-axis: numbers

18.3.3.6 ANGLERFISH, NORTH SEA CRAB, GURNARD AND DRAGONET

For anglerfish, there are no significant differences between standard and experimental treatments (Table 18-9). For North Sea crab, however, the data showed a significant increase of abundance when using a T90 cod end. The cause of that increase is unclear.

For gurnards, there is a near-significant increase when using a T90 cod end and a significant decrease when using a beam trawl (70% compared to standard trawl). The effects of both treatments seem to neutralize each other in the combined experiments.

The effects of the BRP on the non-commercial dragonet are readily clear: there is a significant loss of about 59% when the BRP only is applied and a loss of 62% in the combined experiment (Table 18-9, Fig. 18-9).

Table 18-9: Effects of T90, BRP and T90+BRP on the length distribution of long anglerfish, north sea crab, gurnard and dragonet.

/ = insufficient data; exp= experimental beam trawl, stand= standard beam trawl

Species	Treatment	Nr of tows	Size	% in exp compared to stand	Wilc p-value
anglerfish	T90	29	all	90	0.18
	BRP	12	all	105	0.94
	T90+BRP	30	all	81	054
north sea crab	T90	26	all	148	0.04
	BRP	12	all	71	0.14
	T90+BRP	55	all	114	0.32
gurnard	T90	32	all	151	0.06
	BRP	12	all	70	0.004
	T90+BRP	55	all	98	0.77
dragonet	T90	17	all	126	0.28
	BRP	11	all	41	0.008
	T90+BRP	9	all	38	0.01

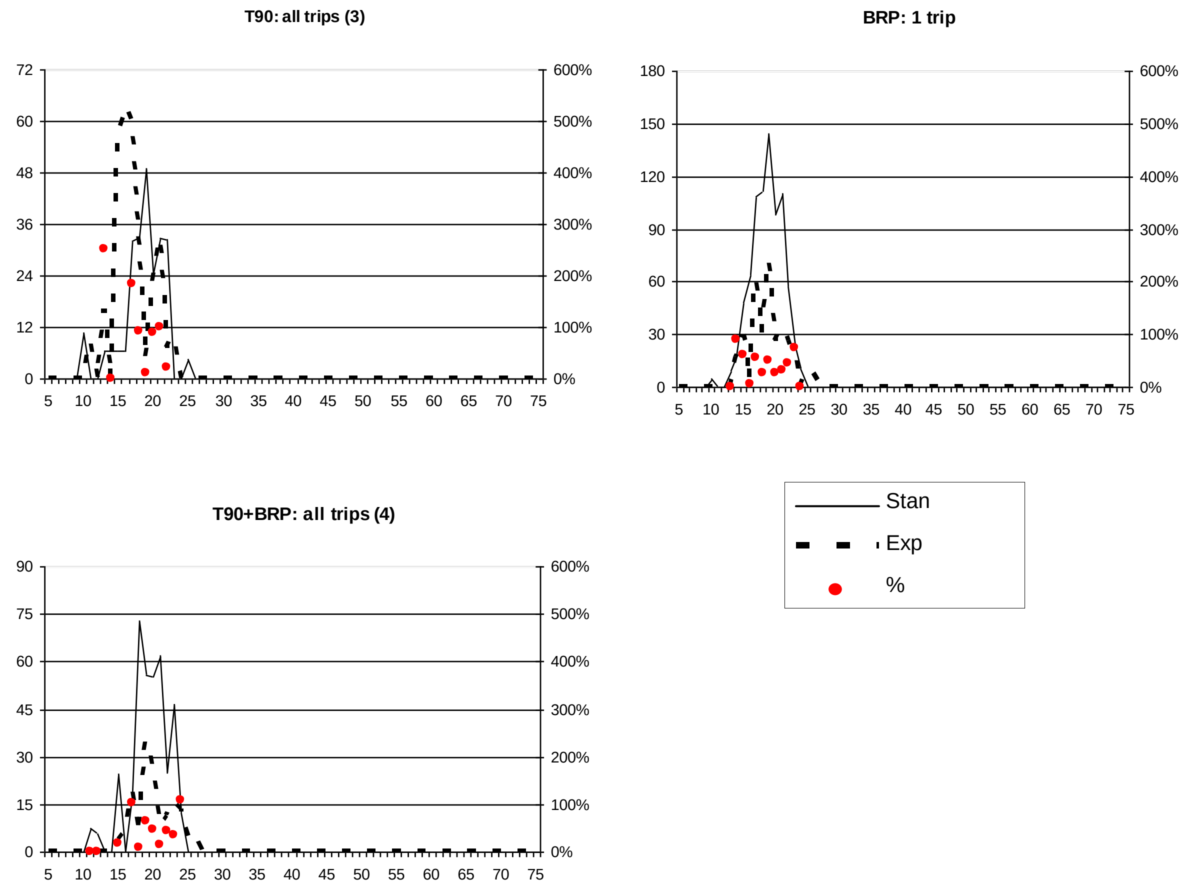


Fig. 18-9 - Length frequency-distributions of dragonet, data of trips pooled per treatment. X-axis: length (cm) ; Y-axis: numbers

18.4 Conclusions

18.4.1 Effect T90, BRP and T90+BRP on the total weight of discards

The experiments confirm the results of RV and 'eurocutter' trials that a BRP significantly and consistently reduces the weight of the discards: in the current large segment trials with 21% and 18% for BRP and T90+BRP, respectively. The reduction percentages of the commercial trials, however, are less spectacular than the ones obtained in the other trials (up to 80% reduction). In this regard, it should be noted that discard weights from large segment trials include inert material (rocks, empty shells etc.), while this fraction was sorted out and disregarded in the other trials, so their results only concern the benthic fraction of the discards. Consequently, these reduction percentages should not be compared between RV, eurocutter and large segment trials. Nevertheless, the impact of a BRP is clear: there is a substantial reduction of discards.

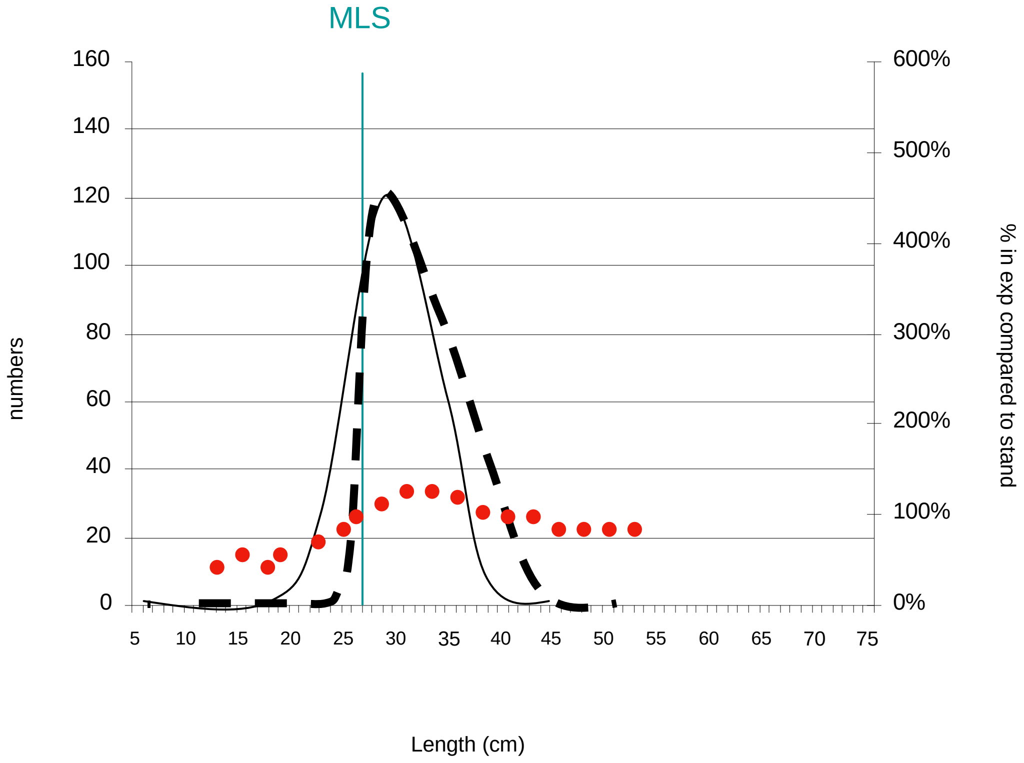
18.4.2 Effect T90, BRP and T90+BRP on the weight of commercial fish species

Analysis of the weights of target species of marketable size showed no significant losses in the case of a T90 end. For the most important commercial species, i.e. sole and plaice, mean catch weights even increased with 8.6% and 8.1%. On the other hand, a small amount of sole (-3.6%) was lost when using a BRP, but its use had a positive effect on catches of plaice (+6.4%). In the combined experiment, increases of plaice were significant (11.8%), and there was no more loss of sole (+3.3%). Consequently, it can be concluded that the use of beam trawl modifications has no negative effects on the catch weights of the target species. This confirms earlier RV and eurocutter trials.

As for less commercially important species, significant effects on catch weights were only seen in the combined experiment for haddock, with a catch weight reduction of 9%. Some species showed small to moderate increases or losses, but these were not significant. In general, the variability of the weights of these species within trips was rather high and the amount of data (tows) was low, resulting in inconclusive statistical results. Furthermore, the accuracy of weight measurements on a large commercial vessel is inherently lower than on RV trials, so effects have to be outspoken and consistent to be signalled in catch comparisons. Therefore, results of weight comparisons should always be interpreted together with abundance and length data.

18.4.3 Effect T90, BRP and T90+BRP on the length-frequency distributions of various commercial and non-commercial species

Experiments on RV's and eurocutters showed that especially the T90 cod end enhances the length selectivity of sole (less undersized soles). In that case, the length-frequency distribution ideally should have the following shape (full line = standard; interrupted line = T90):



The results of T90 on large segment trials do show a similar shape for sole (fig 7.3) but less outspoken, with a large variability of percentages in the experimental trawl at the small and large size classes and a small shift of the interrupted line to the right. However, this positive effect is blurred when T90 and BRP are used together.

An unfavourable length-selectivity for plaice was observed with T90 during eurocutter trials, but this was not exactly confirmed by the current experiments: a catch reduction in numbers was observed for all trips, especially for undersized fishes, but there was no significant shift in length-frequency curve. Especially for the BRP, there was a trend towards an increased proportion of larger fish, without a loss of marketable sizes.

The effects of net modifications were considerable for gadoids:

- For whiting, effects of T90 and BRP were opposite with a 35% reduction of undersized individuals with the BRP and similar increase with the T90. During RV trials, however, a substantial increase of whiting was observed with a BRP. The increase of small whiting in the current T90 trials is probably due to an enhanced water flow through the net, which inhibits small whiting to escape the net in the front section of the trawl.
- For hake the BRP had no significant effects but the T90 caused a reduction of 90% for all sizes.
- For bib, results showed a trend towards a reduction due to the T90 cod end
- For haddock, losses of undersized fish are significant and substantial (59-70%)

For skates, rays and dogfish, only limited data were available but the results clearly show that the BRP enables the escape of large numbers of dogfish, which is logical given the epibenthic lifestyle of this species group. This reduction was, however, not observed during RV trials.

Results for less commercial and non-commercial species show some results that merit a more detailed investigation in the future:

- Significant loss of lemon sole with T90+BRP
- Significant loss of dab with BRP
- Significant loss of gurnard and dragonet with BRP

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