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# A study of fish behaviour in the extension of a demersal trawl using a multi-compartment separator frame and SIT camera system

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ABSTRACT

A rigid separator frame with three vertically stacked codends was used to study fish behaviour in the extension piece of a demersal trawl. A video camera recorded fish as they encountered the separator frame. Ten hauls were conducted in a mixed species fishery in the northern North Sea. Fish behaviour was analysed using the camera observations from several of these hauls by assigning seven descriptive attributes and also using catch data. Gadoids, in particular haddock (*Melanogrammus aeglefinus*), whiting (*Merlangius merlangus*), and saithe (*Pollachius virens*), were caught in the upper codend, whereas *Nephrops* (*Nephrops norvegicus*) were caught in the lower codends. Catches of flatfish were more uniformly distributed among the three codends. Unlike the flatfish, gadoids reacted to the presence of the separator frame. The camera method and the separator frame yielded different information about fish behaviour within the trawl, and together the two methods provided a more complete picture of the catching process. Behavioural observations, vertical distribution, and the methodology are discussed, as is the potential for improving species separation in demersal trawls.



## 1. Introduction

For decades, gear technologists have studied fish behaviour in order to use species-specific behaviour during the capturing process to enhance both size and species selectivity (Wardle, 1993). *In situ* observations have shown a pattern of general behavioural responses of some fish species as they enter the trawl. One such finding is that the vertical preference in the trawl cavity differs among species such as haddock, whiting, and cod (e.g., Main and Sangster, 1981; Wardle, 1993). Behavioural observations conducted at sea have been supplemented by experimental studies to further explore the interaction between fish and fishing gears (e.g., Glass et al., 1993; Glass and Wardle, 1995, 1996). Many studies have separated species in the forward part of the trawl (e.g., Main and Sangster, 1982, 1985a; Engås et al., 1998; Ferro et al., 2007). However, Thomsen's (1993) observations indicated that the vertical preferences of some fish species change as the fish progress towards the codend. This implies that behaviour-based selection potentially changes along the horizontal axis of the trawl.

The goals of fish behaviour studies vary from simple observations about spatial preferences of a single species at a specific point in the trawl to complex multi-species interactions between fish and fishing gear throughout the catching process. The technologies used to study fish behaviour vary accordingly and range from simple camera systems to advanced acoustic systems or a combination of both (Graham et al., 2004). Although the quality of underwater cameras has improved greatly during the last decade, recording fish behaviour can fail due to the turbidity of the water, gear effects, and the rapid reduction in natural light at depth. High-resolution scanning sonar systems provide direct observations at greater depth (Engås and Ona, 1990), but the recorded fish echoes still must be identified to species. This can be accomplished by using flash photography, but this method requires relatively high densities of fish to produce a sufficient number of images containing the target species and may it influence fish behaviour.

The main objective of this study was to conduct a detailed survey of fish behaviour in the extension of a demersal trawl to determine the potential for separating species in this section of the trawl. We focused on the trawl aft-end because the most commercially important species caught in Danish fisheries (e.g., *Nephrops*, cod, and flatfish) all enter the trawl close to the seabed and therefore are difficult to separate in the forward part of the gear. In this study, a simple, rigid, multi-compartment separator frame was inserted into the trawl and a light-sensitive silicon intensified target (SIT) video camera mounted in front of the frame was used to observe how fish reacted as they encountered the separator frame.

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## 2. Materials and methods

### 2.1. Gear outline and catch data

A cruise was conducted onboard the 64 m long, 3300 HP Norwegian research vessel Johan Hjort in November 2004 in the northern North Sea. A 540 meshes (120 mm) combined fish and *Nephrops* trawl design commonly used in the Danish mixed species fishery was used during the cruise. The trawl was fished with 84 m single sweeps and a rockhopper ground gear equipped with 31 cm rubber discs. The aft end of the trawl was modified into a four-panel extension and codend to fit the rectangular shape of the separator frame. The separator frame was placed in the extension at an angle of about 50° relative to the lower panel. It was installed two meshes behind the joining round between the last tapered belly section and the extension piece, which meant that it was effectively 12 m in front of the codline. Non-selective collection bags made of 42 mm (PE) were attached to each compartment to retain fish passing through the separate sections of the frame. The trawl was rigged with Scanmar sensors to monitor gear geometry.

The separator frame consisted of three vertically stacked compartments (Fig. 1). The upper compartment covered the upper 50% of the frame and the middle and lower compartments covered 25% each. The unequal sizes of the three compartments were designed to obtain more detailed information from the lower part of the trawl, especially for low-swimming species such as *Nephrops* and flatfish species. All commercially important species caught in each compartment were identified and measured. A total of 10 hauls were conducted, and camera observations were made for 3 of these hauls.

### 2.2. Camera observations

A low-light silicon-intensified target (SIT) video camera was placed in the top panel in front of the separator frame overlooking the three compartment openings leading into the three separate codends. The camera was attached on the outside of the extension to prevent it from disturbing fish swimming their way through the extension section. Video recordings were made without the use of artificial light. The top panel in front of the separator frame was cut open to make a 1.5 m long hole to obtain a clear view of the separator frame and the entry to the three compartments (Fig. 1). Cod, haddock, whiting, and flatfish were recorded and identified. Very few saithe and *Nephrops* were observed, thus these species were not included in the subsequent analysis. Flatfish species were identified from the onboard measurement of the catch because it was not possible to distinguish between the different flatfish species from the video recordings. Consequently, no species-specific behaviour was determined for flatfish using the underwater observations. A simple descriptive model was made and used to describe fish behaviour in front of the frame. Behaviour recorded by the camera was assigned seven descriptive attributes:

1. Orientation: (a) head pointing forward towards the trawl mouth or b) backwards towards the codend.
2. Reaction: (a) the fish shows no reaction when passing through the field of view; (b) horizontal reaction: the fish reacts to the presence of the frame with horizontal movements only; or (c) vertical reaction: the fish reacts to the presence of the frame with vertical movements related to the level at which it entered the field of view.
3. Holding: (a) the fish holds its position in front of the frame by maintaining a swimming speed that is equal to or greater than the towing speed for less than 1 min; (b) holding for longer than 1 min; or (c) no holding.
4. Re-entry: (a) the fish enters one compartment, leaves it, and then re-enters the same compartment; (b) it re-enters a compartment upwards; or (c) it re-enters a compartment downwards or d) exhibits no re-entry.
5. Final entry: (a) entry into the upper compartment; (b) entry into the middle compartment; or (c) entry into the lower compartment.
6. Escape attempts in front of the separator frame: (a) unsuccessful mesh penetration; (b) successful mesh penetration; or (c) successful escape through the observation hole.
7. Panic and escape attempts after passing the separator frame: (a) sudden, fast, and uncontrolled swimming in what seems like a random direction; (b) escape attempts: the fish tries to escape through the meshes but does not succeed; (c) escapes: the fish escapes from the gear through the meshes; or (d) the fish shows no signs of panic or escape attempts.

## 3. Results

### 3.1. Catch data from the separator frame

Catch data were collected for all 10 hauls (see Table 1 for the operational conditions). The separator frame exhibited stable performance with regard to angle of attack and opening in all three

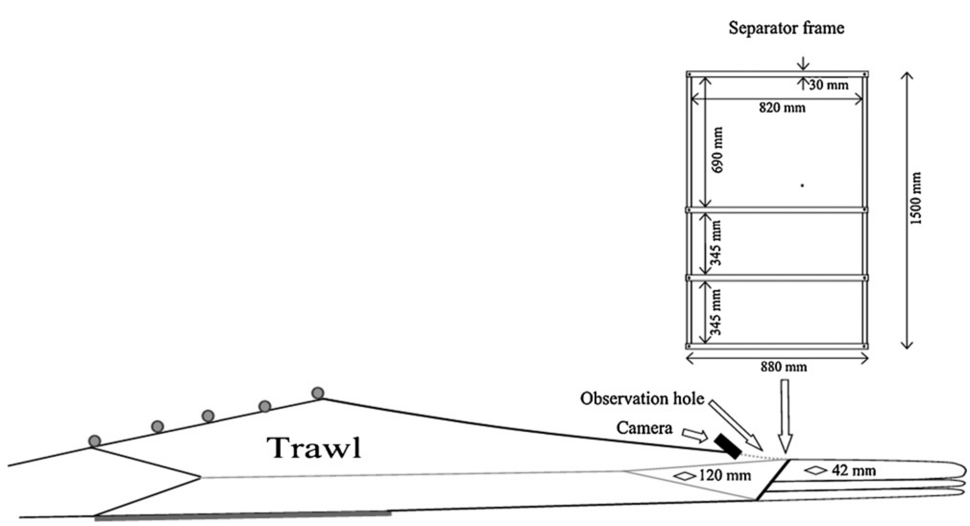


**Fig. 1.** Schematic drawing showing the position of the separator frame and camera. All measures of the separator frame are given in mm.