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THE PROBABILITYOF COD (*Gadus morhua*) AND LING (*Molva molva*) TO ENCOUNTER GILLNETS BASED ON *IN SITU* FISH MOVEMENTS

by

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ABSTRACT

The probability of cod (*Gadus morhua*) and ling (*Molva molva*) to encounter a fleet of four gillnets (110 m) set within a fixed survey area of 600x600 m^2 and soaked for a period of 12 h (1800-0600 hrs) is calculated on the basis of in situ observations of fish movement and random simulated start positions and setting directions of a fleet of gillnets. The movements of cod and ling, which were tagged by allowing them to voluntarily swallow bait-wrapped transmitters close to the sea bed, were studied by means of a stationary positioning system. The expected number of encounters per fish for the fleet of gillnets varied between 0.127 and 0.626 for cod and 0.077 and 0.614 for ling with a fish density of three fish per 0.1 $(n.mile)^2$.

INTRODUCTION

Estimates of the abundance of groundfish from fishery-independent data are mostly based on acoustic and trawl surveys. However, for several reasons such as bottom topography, lack of swimbladder etc., bottom trawl and acoustic surveys may not be suitable for abundance estimation. In such situations, stock assessment may only be made by using catch data from passive fishing gear such as traps, gillnets and longlines (Powles and Barans, 1980; Zenger and Sigler, 1992; Degerman et al., 1988).

The basic assumption in estimation of abundance of fish using data from scientic surveys is that catch (n) in a fishing gear and the density/abundance (N) are related by the equation

$$q = n / N$$

where q is the catchability coefficient. For gillnets, the catchability coeffiecient is assumed to be the product of two probabilities: the probability that a fish encounters the net (Pe) and the probability that a fish that encounter the net will get caught (Pc) (Rudstam et al., 1984). Both Pe and Pc may vary with the fish length. For a gill net of a given mesh size, catches usually comprise fish of a relatively narrow size range (Hamley 1975). Encounter probability is considered to be directly proportional to distance travelled by a fish during the sampling period, and swimming distance is related to the size of the fish (Rudstam et al., 1984).

In this paper, the probability of cod and ling to encounter a fleet of four gillnets (110 m) set within a fixed survey area of 600x600 m^2 and soaked for a period of 12 h (1800-0600 hrs) is calculated on the basis of in situ observations of fish movement and random simulated start positions and setting directions of a fleet of gillnets.

MATERIAL AND METHODS

The data for the present study were collected during four cruises: two aimed at cod in the Ramfjord (northern Norway) and two for ling in the Osterfjord (western Norway). An overview of the experiments is given in Table 1.

Table 1. Overview of the experiments. Figures in brackets are number of fish tagged.

Year	Month	Area	Species	Depth
1994	May	Ramfjord	Cod (5)	40-80 m
1996	April/May	Osterfjord	Ling (7)	80-100 m
1996	September	Ramfjord	Cod (6)	40-80 m
1997	February	Osterfjord	Ling (4)	80-100 m

A stationary positioning system (VR-20, Vemco Ltd) was used to track cod and ling with acoustic transmitters. The positioning system had a fixed array of three hydrophone buoys with radio transmitters to a base station onboard F/F "Fjordfangst" (Fig. 1). The hydrophone bouys were anchored to the sea bed in a triangular configuration with a distance between the bouys varying from 400 to 1000 m. To determine the position of a tagged fish, the hydrophones received a number of pulses from the transmitters, and the time at which each pulse was received was recorded by an internal clock in each buoy. The data were transmitted to the base station, which calculated an average positional fix from the time delay of pulse arrivals at the hydrophones. A fix was made every 28 s, and when several fish were being tracked simultaneously, the time interval between positional fixes on each fish would be multiples of 28 s, i.e. when tracking four fish the system determined the position of each fish every 1 min 52 s.

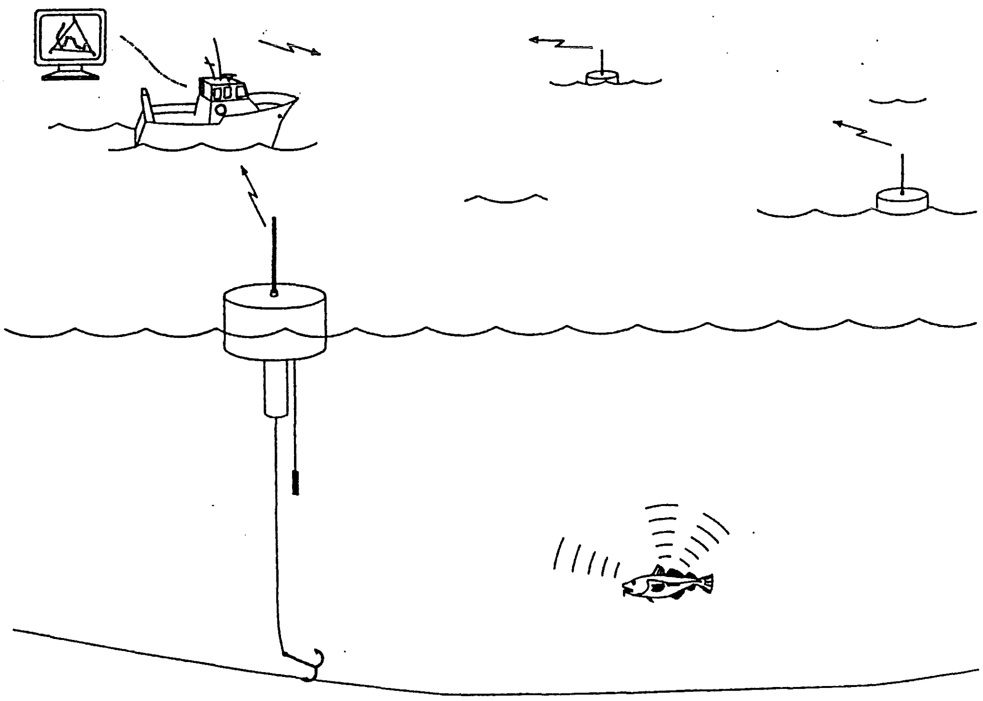

Figure 1. The positioning system showing the hydrophonebuoys and the research vessel with the base station.

Cod and ling were tagged in situ by allowing them to voluntarily swallow bait-wrapped acoustic transmitters attached by fine thread to a frame placed on the sea bed. The transmitters used (48 mm long, 16 mm in diameter and weighing 9 g in water) give horisontal (two-dimensional) positional fixes (x,y coordinates). An underwater camera was used to identify and to estimate the lenght of the fish tagged by comparing the fish length with part of the frame which had marks 10 cm apart. In the 1994 experiment, Ramfjord, two of the cod with transmitters were caught by longline during a following experiment and these cod were measured (see Table 2).

The fish tracked generally stayed within the range of the positioning systemt throughout the observation period. Fish which moved out of range during the sampling period (1800-0600 hours) were excluded from the analysis. During the 22 selected sampling periods , the following fish were used (Table 3).

Table 2. Lenght, data tagged and other details of individual fish used in the analysis.

Year	Area	Fish no	Length (cm)*	Date tagged	Comments
1994	Ramfjord	1	~40	11 May	
		2	~50	12 May	
		3	~45	14 May	
		4	46.6	14 May	Caught (17 May)
		5	54.0	14 May	Caught (19 May)
1996	Osterfjord	1	~60	23 Apr	
		2	~60	23 Apr	
		3	~60	24 Apr	
		4	~60	24 Apr	
		5	~70	24 Apr	
		6	~60	25 Apr	
		7	~60	27 Apr	
1996	Ramfjord	1	~40	18 Sep	
		2	~50	19 Sep	
		3	~50	19 Sep	
		4	~40	20 Sep	
		5	~40	20 Sep	
		6	~50	20 Sep	
1997	Osterfjord	1	~75	3 Feb	
		2	~60	4 Feb	
		3	~60	4 Feb	
		4	~70	5 Feb	

*Visually estimated, except for caught fish on longline whose lenghts were measured

RESULTS - DISCUSSION

Examples of cod and ling movements within two 12 h (1800-0600 hrs) sampling periods are given in Figure 2. The simulated settings with encounter recorded are shown for one of the sampling periods (Figure 3).

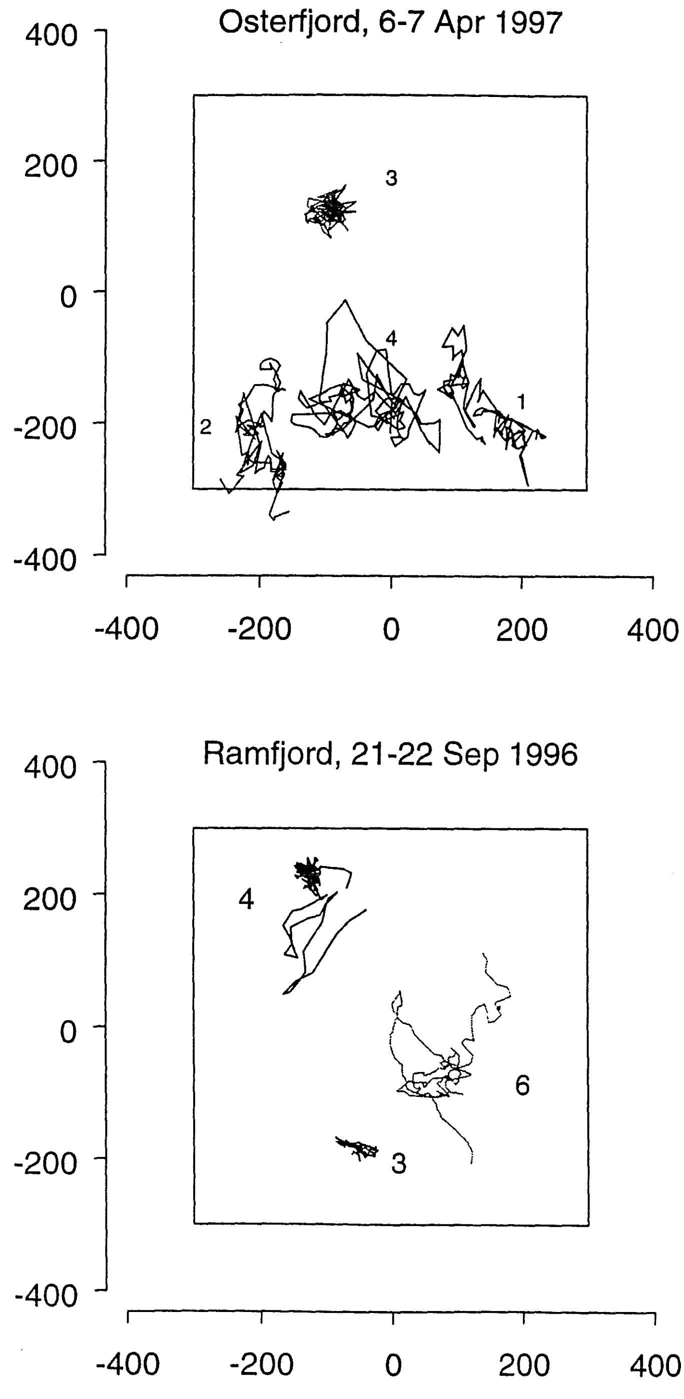

Figure 2. Fish movements for two of the sampling periods (ling upper, cod lower) used in the simulations of encounter rates. Numbers refer to fish number (see Table 2).

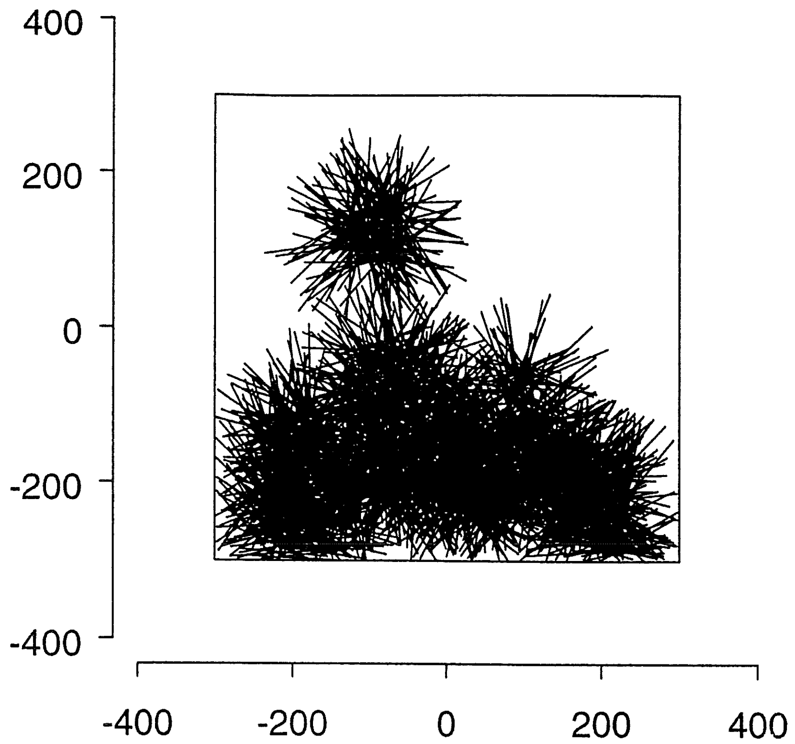

Figure 3. The simulated settings (1950 out of 5000) in the Osterfjord for which encounter was recorded during the period 6-7 April 1997.

Expected encounter rates for the fleet of gillnets with densities of 3 fish per 0.10 (n. mile)^2 varied between 0.127 and 0.626 for cod and 0.077 and 0.614 for ling (Table 3). Thus, for this density of fish, from two to thirteen random settings of the fleet are required to have at least one expected encounter for ~~cod~~ ling. As a curiosity, if we transfer the encounter probabilities for ling to "Storegga" (a well known fishing ground for ling off mid-Norway), where catch rates of 120 fish per 110 m of net is quite common during the peak season, a minimum density of 600-~~1800~~ fish per 0.10 (n. mile)^2 has occurred in the area.

Table3. Sampling periods, fish numbers and simulated encounter rates.

Year	Area	Date	Fish no.	Encounter rate per fleet	Range (per fish)
1994	Ramfjord	12-13 May	2	0.086	0.086
		13-14 May	1	0.036	0.036
		14-15 May	1,3,4,5	0.496	0.102-0.142
		15-16 May	1,3,4	0.626	0.014-0.319
		17-18 May	1,2,3,5	0.518	0.027-0.230
		18-19 May	1,3,4	0.305	0.037-0.193
		19-20 May	1,3,4	0.353	0.009-0.217
		25-26 May	1,2,4	0.460	0.088-0.234
1996	Osterfjord	24-25April	2,3,4	0.614	0.140-0.272
		25-26 Apr	2,3,4,5,6	0.655	0.084-0.244
		28-29 Apr	2,4,6,7	0.578	0.048-0.258
		29-30 Apr	2,4,6,7	0.186	0.023-0.069
		30-01 Apr/May	2,6	0.210	0.071-0.138
		01-02 May	2,6	0.301	0.149-0.152
		02-03 May	6	0.117	0.117
1996	Ramfjord	19-20 Sep	1,2,3	0.451	0.060-0.262
		20-21 Sep	2,3,4,6	0.569	0.093-0.204
		21-22 Sep	3,5,6	0.244	0.019-0.128
1997	Osterfjord	04-05 Feb	1,3,4	0.200	0.059-0.077
		06-07 Feb	1,2,3,4	0.362	0.036-0.147
		09-10 Feb	1,2,3	0.225	0.023-0.159
		10-11 Feb	1,2,3	0.077	0.012-0.048

Large day-to-day variations in catch rates are frequently observed for passive fishing gears. A marked between-fish variation in search range was observed even for fish of roughly the same length within the same area and at the same time (Table 3). The present study demonstrates that this large variation can be explained solely by variation in the search range of the fish. Our results suggest that it is an oversimplification to model encounter rate solely based on fish length (Rudstam et al., 1984).

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