

Residence of fish in the vicinity of a decommissioned oil platform in the North Sea

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The suggested use of decommissioned oil platforms as artificial reefs initiated a study of the abundance and residence of fish in the vicinity of the Albuskjell 2/4 Fox platform in the Norwegian sector of the North Sea. A study of fish residence was carried out by means of cylindrical coded ultrasonic VEMCO transmitters surgically implanted into the abdominal cavity of fish caught by handline and pots near the platform. After the operation, the fish were kept in a tank of running seawater to ensure that only fully recovered fish were released. Twenty-nine cod and two haddock were tagged. Eight ultrasonic receivers anchored around the platform recorded the presence of tagged fish. An additional receiver was placed at a neighbouring platform 8 km away. Data were collected from 25 May to 13 August 1998 and showed that approximately 50% of the tagged fish remained at or near the platform throughout this period. Four tagged cod were registered by the receiver at the neighbouring platform. Five tagged cod have been reported caught, one at the study platform, two at a nearby platform, and two at 9 and 150 km distance, respectively. When the platform was revisited in May 1999 four cod were detected.

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Introduction

In the Norwegian sector of the North Sea, several oil and gas platforms will be decommissioned over the next few years. It has been suggested that inert steel jackets of these platforms be used to create artificial reefs, as has successfully been done in the Gulf of Mexico (Gurney, 1992; Stanley and Wilson, 2000). Artificial reefs may benefit fisheries by aggregating fish otherwise too sparsely distributed for profitable fishing or by enhancing fish production. The potential of reefs to attract and aggregate fish has been documented from a number of studies, but the degree to which they contribute to increased production is still a topic for debate (see for a review: Pickering and Whitemarsh, 1997).

The few studies of fish around North Sea oil platforms have shown that they act as reefs by aggregating fish (Olsen and Valdemarsen, 1977; Valdemarsen, 1979). However, a report prepared for the oil industry

concluded that further research is required to found a better basis for decisions on future disposal plans for decommissioned platforms (Aabel *et al.*, 1997). In 1998, funding was provided for a case study at an inert platform. Our main objectives were to answer two questions: (1) do such reefs offer potential for sustainable exploitation by fishermen and (2) can they be used to enhance and protect fish stocks?

To answer the first question, information on residence time of fish and on the dynamics of their exchange rate between the reef and the surrounding area is important. Residence studies require the continuous monitoring of fish and the questions cannot be adequately answered by conventional external tags that only provide information on sites of release and recapture (Szedlmayer, 1997).

We implanted ultrasonic transducers mainly in cod (*Gadus morhua*) and the presence/absence of the tagged fish at a North Sea platform was monitored with automated receivers.

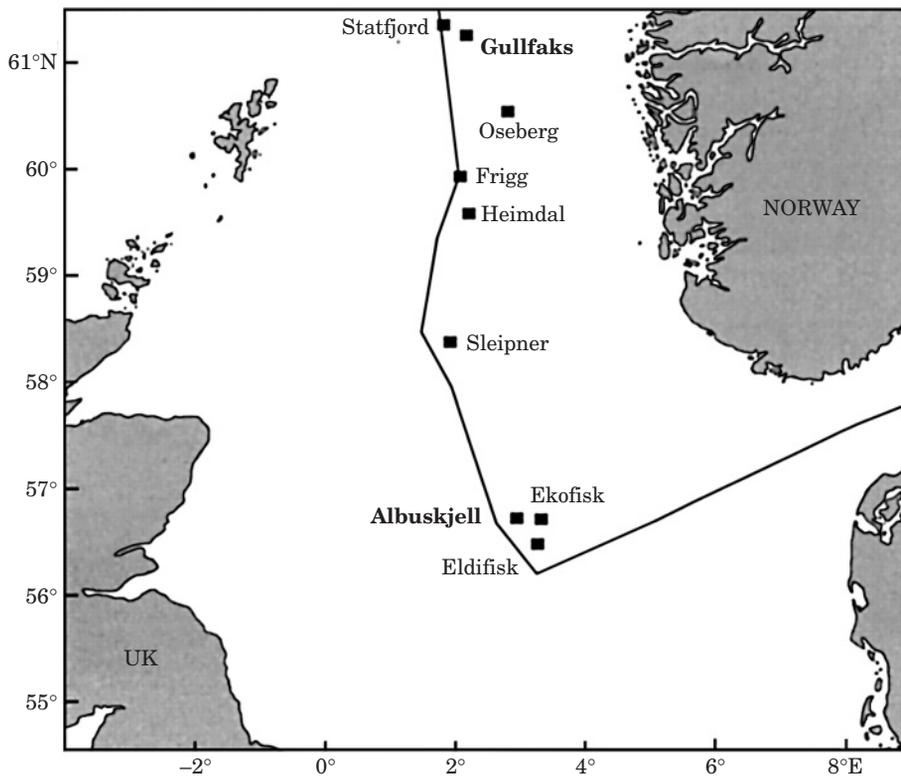


Figure 1. Position of the experimental site, the Albuskjell 2/4 platform.

Material and methods

The study was carried out around the Albuskjell 2/4 Fox platform at the Ekofisk field in the southern part of the Norwegian sector (Figure 1). This platform was taken out of production in 1996 but has been regularly maintained since. The platform is lit, but the noise level is much reduced compared to an active platform and there is no waste discharge. The platform has a steel jacket of approximately 50×65 m at base with a volume of $182\,360\text{ m}^3$. Water depth is 70 m and the bottom is mostly sand with some mud and gravel.

Fish were caught by handline and pots near the platform on 22 and 23 May 1998. Healthy fish were anaesthetized and an acoustic transmitter was surgically implanted into the abdominal cavity. The tagged fish were then kept in containers of running seawater for up to 12 h to ensure that they had fully recovered before they were released. A total of 31 acoustically tagged fish were released (29 cod in the range of 32–70 cm and 2 haddock (*Melanogrammus aeglefinus*) of 35 and 37 cm).

The transmitters used were cylindrical 16-mm VEMCO coded acoustic pingers with 15-month batteries. The transmission frequencies were 51, 57, 63, and 69 kHz, with 8, 8, 9, and 6 transmitters, respectively, on the same frequency. To record the presence and

movements of the tagged fish, 8 data-logging VEMCO 20VR coded receivers were moored at a distance of 2 m above the bottom around the platform. Two were positioned close to the platform (~125 m) and the other 6 were evenly distributed all round at a distance of 500 m (Figure 2). Another VR20 receiver was placed at the neighbouring Albuskjell 1/6 Alfa platform, located approximately 8 km away.

The receivers scanned a set of pre-set frequencies in sequence, for 30 s each. The data logged were pinger code, frequency, time, signal (dB), noise (dB), and gain (dB). Signal strength was recorded to estimate the approximate location of the pinger, based on the signal strength recorded by the different receivers. The receivers had a storage capacity and battery life of approximately 1 month. They were first lifted for replacement of batteries and downloading of data on 9 July and finally retrieved on 9 September. Owing to limited storage capacity, the effective periods of operation were 25 May to 3 July and 9 July to 13 August 1998. The eight receivers were set out again around the Albuskjell 2/4 Fox platform from 8 to 10 May 1999.

A calibration study was carried out to check the accuracy of position calculations based on variation in recorded signal strength. A pinger was placed at 5 locations along a transect line (2 m above the bottom)

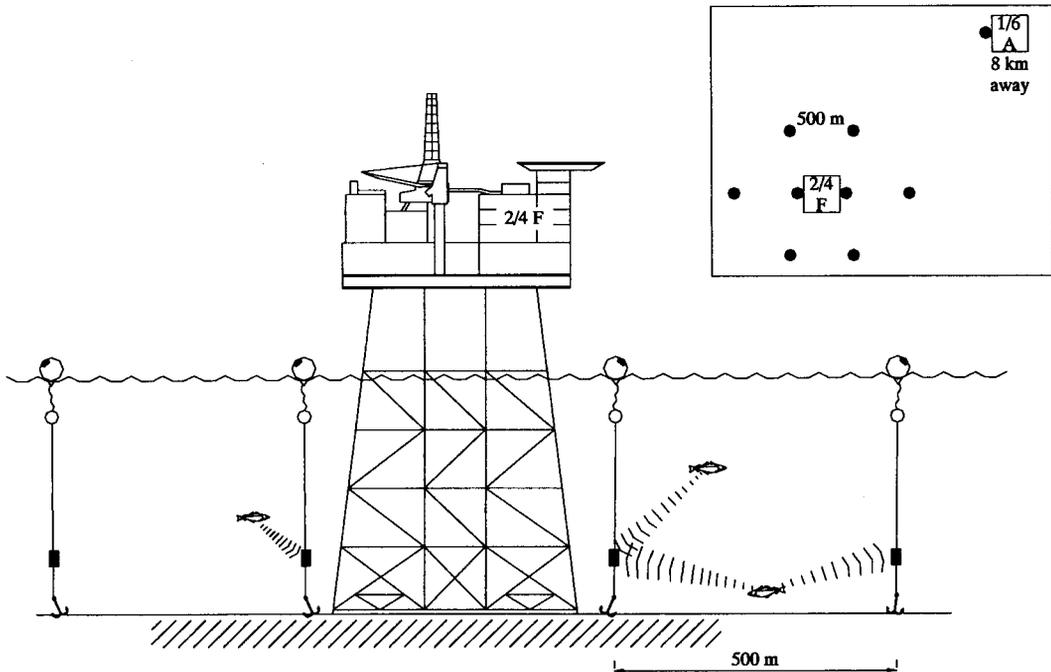


Figure 2. Schematic location and anchoring of the receivers around the Albuskjell 2/4 Fox and 1/6 Alfa platforms.

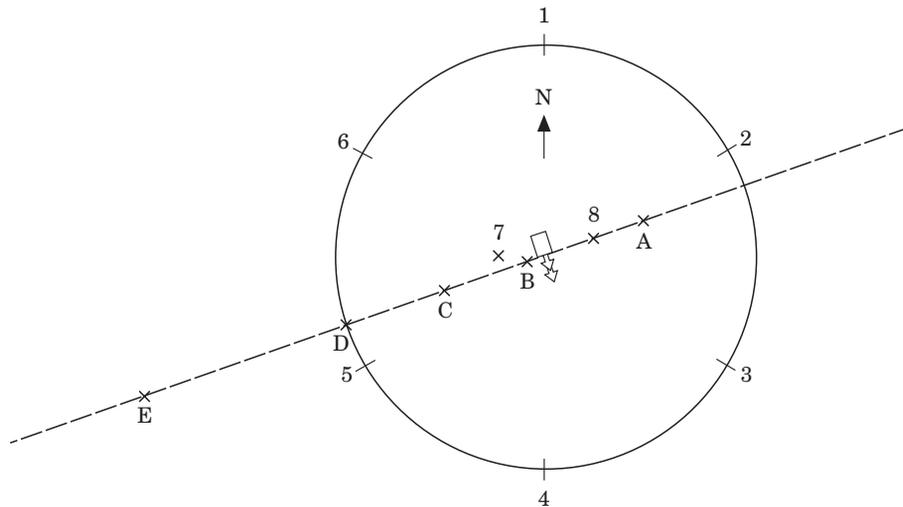


Figure 3. Schematic drawing showing location of the receivers (1 to 8) and positions where the pinger was placed (A–E).

and kept there for 11–16 min (Figure 3). The distance from the pinger to the receiver is given by the equation:

$$20\log R + \alpha R = SL_S + G + 99$$

where R is the distance (m), α is the absorption coefficient (dB/m), SL is the source level of the transmitter (dB re 1 μ Pa @ 1 m), S is signal strength reported by VR20 (dB), and G is the variable gain reported by

the VR20 (dB). The results from the calibration test showed that estimated distance from a receiver to a stationary pinger was highly variable between detections. Moreover, accuracy was poor. Detection range was up to 1.4 km (Table 1).

The Norwegian Meteorological Institute provided data on windspeed and direction and on wave height at the neighbouring Ekofisk Centre. Measurements were taken every 3 h.

Table 1. Actual and estimated distances (m) from the receivers (4 and 7 not activated) to the pinger positions during the calibration experiment.

Pinger	Receiver	Actual	Estimated	
A	1	490	198, 215, 235, 573	
	2	260	139, 319	
	3	390	94, 198	
	5	750	368, 394, 450	
	6	700	166, 234, 368, 479	
	8	130	70, 70	
	B	1	520	368
		2	550	510
3		530	126, 181	
6		480	104	
8		300	215	
C	1	630	394, 422	
	2	750	479	
	3	660	422, 541	
	5	260	29, 94	
	6	380	166	
	8	380	450, 607	
D	3	920	641	
	5	100	51, 94	
	6	410	198	
	8	380	541	
E	1	1260	541	
	3	1400	676	
	5	450	139, 152	
	6	770	181	
	8	1130	943	

Results

Figure 4 shows the residence of each fish near the platform as visualized by the maximum number of detections per hour among the eight receivers. Three patterns can be discerned: Fish that stay at the platform throughout the observation period; fish that leave the platform for shorter or longer periods but eventually return; and fish that left the platform shortly after tagging and never returned. Eighteen fish (including the two haddock; 24 and 25) were detected at the platform at the end of the experiment on 12 August. Four cod (2, 5, 17, and 20) were detected by the single receiver at the 1/6 Albuskjell Alfa platform. Fish 2 was registered from 1 to 9 September, fish 5 appeared on 10 July and stayed until the end of August, fish 17 was detected on 15 August (2 days after it left Albuskjell 2/4 Fox) and stayed for 2 days, and fish 20 was only observed on 9 August (10 detections during a 1-h interval). Four tagged cod were detected at the Albuskjell 2/4 Fox platform when the receivers were set out again in May 1999 (fish 6, 11, 12, and 14).

Five cod have been recaptured (Table 2). One was caught at the study platform in September during an experimental gillnet fishing, two were caught by anglers

fishing from platforms at the Ekofisk Centre, and two have been caught by commercial fishing vessels.

Although the maximum number of detections per hour was significantly negatively correlated with wave height, this factor explained only a minor part of the variation in detection rate ($r < 0.4$).

Discussion

Our study focused on cod, the main large predator at the platform. Other locally abundant species were saithe (*Pollachius virens*) and mackerel (*Scomber scombrus*) (Soldal *et al.*, 2002). Cod was chosen because it is a target species for the fleet of gillnetters fishing at the many wrecks in the North Sea. It was also the main species caught by line and pots around the platform. Moreover, it is known to survive the handling involved in tagging. A survival experiment of cod tagged with identical transmitters and similar surgical procedures showed no mortality beyond the first few hours of tagging (S. Espeland, Flødevigen Research Station; pers. comm.). Similar results have been obtained for salmonids (Eveson and Welch, 2000). Post-release mortality of the tagged fish is therefore not considered a likely source of bias.

The results indicate that cod reside to a moderate degree around platforms. About half of the tagged fish stayed in the direct vicinity throughout the 3-month period, while only 4 were still present after approximately 1 year. It is unknown whether these 4 fish had stayed permanently at the platform throughout the 1-year period, because no monitoring was conducted from mid-August 1998 to May 1999. A moderate site fidelity in cod is further supported by the seasonal variation in catch rates at the platform (Løkkeborg *et al.*, 2002). A study in the Gulf of Mexico showed that about 50% of the red snapper (*Lutjanus campechanus*) released stayed at the release site, while the other half only moved to nearby reefs (Szedlmayer, 1997). However, one should be apprehensive of generalizations across species and areas, even within the North Sea (Løkkeborg *et al.*, 2002).

The recaptures of two tagged cod at the Ekofisk Centre (13 km away) and the recordings of 4 cod at the nearby 1/6 Alfa platform (8 km away) further provide clear evidence that cod actually move around among platforms. One fish covered the distance between the 2 Albuskjell platforms in 2 days. It is unknown why and how fish are attracted by these structures. Possible stimuli may be light or sound/vibration stimuli from the drilling and deck machinery or breaking waves.

Fish may seek reef structures for a variety of reasons, e.g. reduced risk of predation, shelter from currents, or good feeding conditions (Bohnsack *et al.*, 1991; Spanier, 1996). Todd *et al.* (1992) showed that the presence of

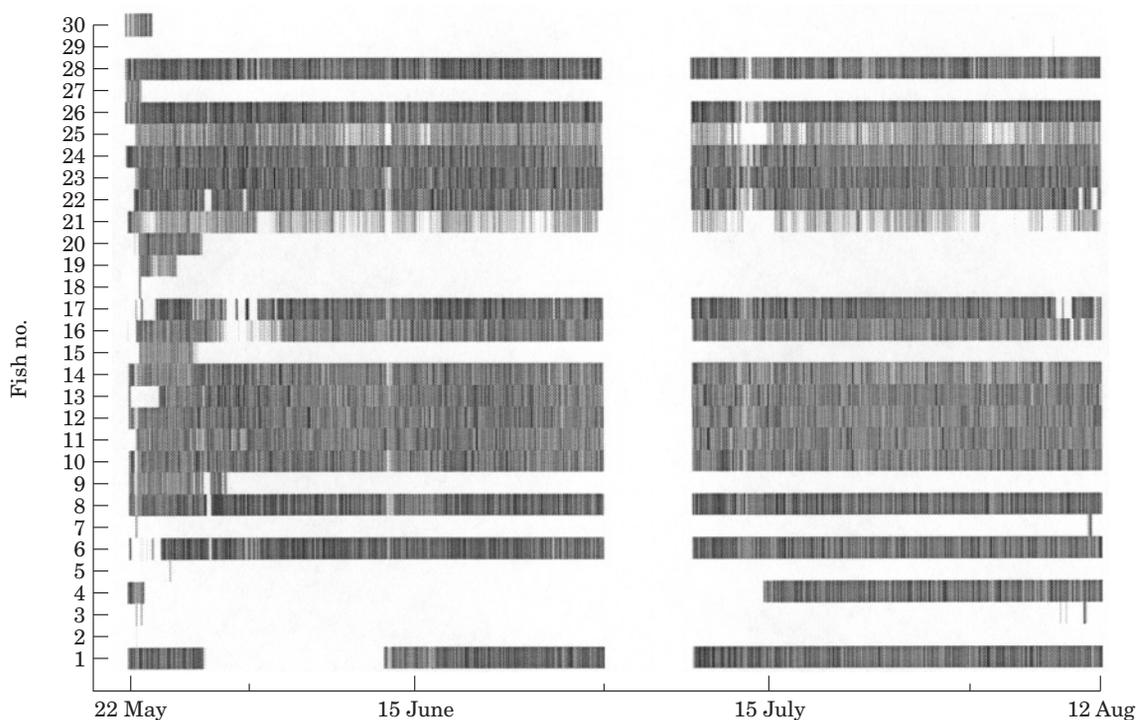


Figure 4. Maximum number of recordings per hour of cod and haddock (fish 24 and 25) tagged with ultrasonic transmitters at Albuskjell 2/4 Fox (black represents the highest number of recordings observed – 16; white absence). The pinger on fish 31 failed (tested upon return of tag) and this fish is therefore excluded.

Table 2. Summary of data on recaptured fish (*transmitter failed).

Fish No.	Last observed at Albuskjell 2/4 Fox	Recaptured date	Location	Gear
8	End of observation period	4 Sep 1998	Fox	Gillnet
9	30 May	10 June 1998	10 km E Fox	Trawl
19	25 May	25 Feb 1999	150 km SE Fox	Gillnet
20	28 May	4 Sep 1998	Ekofisk Centre	Hook
31	*	25 June 1998	Ekofisk Centre	Hook

cod at a reef site varied in accordance with the abundance of sandeel (*Ammodytes* spp.) in the reef area. Based on a preliminary analysis of stomach contents from fish caught at the Albuskjell platform, we have no indication that food varies with distance from the platform.

The acoustic tagging system used did not allow for detailed monitoring of fish movements in the vicinity of the platform. The calibration study clearly demonstrated that signal strength as a measure of distance to a transmitter has neither the precision nor the accuracy required for following movements of individual fish. The problem is aggravated by the limited home range of the cod around the platform. Hydroacoustic surveys (Soldal *et al.*, 2002) and fishing experiments (Løkkeborg *et al.*,

2002) showed that fish density fell sharply outside 100–300 m distance from the platform. The acoustic recordings and video observations further showed that the cod stayed close to the bottom near the steel structures (Soldal *et al.*, 2002).

Detection frequency was only marginally affected by the weather conditions. This may largely be explained by the habit of the cod to remain close to the bottom at 70-m depth, where the receivers were positioned. Detection would thereby only moderately be affected by wave-generated noise. Also, fishermen observe that fish tend to move somewhat away from the platform during periods of bad weather (Løkkeborg *et al.*, 2002), and therefore are possibly more readily detected by the receivers than when they are close to the structure.

Although the system of coded pingers and automated receivers was not suited for monitoring small-scale fish movements, it proved a valuable tool for studying movements on the larger scale by measuring presence or absence of an animal at a given site and movements among platforms.

Acknowledgements

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