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The survival of skates (Rajidae) caught by demersal trawlers fishing in UK waters

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ABSTRACT

Skates and rays are a common component of mixed demersal fisheries, and large quantities may be discarded. Given their biological vulnerability, understanding the fate of these elasmobranchs is of management concern. Estimates of discard survival are needed for modelling the possible benefits of management measures. In this study, the focus is on the Bristol Channel skate fishery, where on-board holding tanks were used to assess the short-term rates of survival of trawl-caught skates (Rajidae). From monitoring the survival rates of 162 fish kept in specially designed on-board holding tanks for periods of up to 72 h, the short-term rate of survival was 55%. Visual inspection of "health" at time zero was a good indicator of survival, because 79% of skates with a poor health score did not survive. Mortality rates for fish of moderate health and good "health" were 16% and 5%, respectively. This information allows one to predict the consequences of fishing practice on discard survival using a larger dataset on fish scored for health before tagging and release. The proportion in poor condition on capture is positively correlated with estimated codend weight, so technical modifications to fishing gear aimed at reducing unwanted by-catch would increase the survival of discarded skates. Combined with information on discarding rates in the study area, the results indicate that discard mortality removes almost as many fish from the skate stock as are landed commercially.

1. Introduction

Global catches of skates and rays (batoids) have more than doubled since 1970, with >200,000 t being caught in 2006 (FAO, 2008). This trend of increasing fishing pressure on the fish is of growing international concern (Stevens et al., 2000; Dulvy et al., 2000), and some of the larger batoids have disappeared from parts of their former range (Brander, 1981; Rogers and Ellis, 2000). The principal rationale behind many of these concerns is that the life history of elasmobranchs (late age-at-maturity, low reproductive output, slow growth) makes them vulnerable to overfishing, and that the large size of batoids in particular makes them susceptible to capture in fishing nets even from a young age (Ellis et al., 2008). Bonfil (1994) reported that global catches of sharks and skates (750,000 t) may represent half of what is actually being caught, and that large quantities subsequently discarded. Understanding the fate of discarded fish post-capture is therefore of management concern. Moreover, estimates of discard survival are required if fisheries managers are to gauge the efficacy of potential management measures.

Although many skates (Rajidae) are landed in mixed demersal fisheries, targeted fisheries also operate in certain areas and at certain times of the year. The Bristol Channel fishery (Fig. 1) is one of the UK's most notable target fisheries for skates, with annual landings (by weight) accounting for 20% of the total skate landings of England and Wales. Skates caught in the Bristol Channel (ICES Division VIIf) are currently valued at approximately €1.5 million annually. The main skate species in the Bristol Channel are *Raja clavata*, *Raja microocellata*, *Raja brachyuran* and *Raja montagui*. *Leucoraja naevus* is found in the outer parts of the Channel and other skates are found occasionally (Ellis et al., 2005). These species are the main ones of the local commercial fisheries (Cefas, unpublished data). It has been estimated that of the estimated 3.8 million skates (3237 t) caught annually in this region, 2.2 million (823 t; 60% by number, 20% by weight) are subsequently discarded (Enever et al., 2007).

Broadhurst et al. (2006) reviewed the results of 80 published studies that quantified the survival rates of >120 different species of fish. Of these, just two field-based studies (Stobutzki et al., 2002; Laptikhovsky, 2004) assessed the survival rates of batoids following their capture in trawl fisheries. Trawl fisheries are thought to be responsible for fifty percent of the estimated 81 million tonnes of fish annually landed worldwide (Kelleher, 2005). Furthering our understanding to the factors that affect survival rates of batoids

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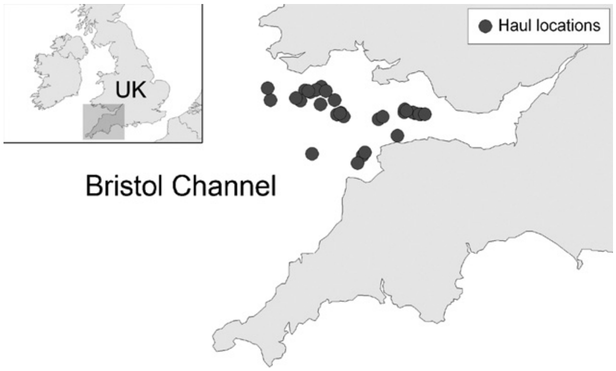

Fig. 1. The Bristol Channel showing haul locations by vessel.

in trawl fisheries is important for their effective management. In addition, understanding discard mortality alongside other sources of mortality will contribute to a better understanding of their population dynamics (Bonfil, 1994; Stevens et al., 2000; Revill et al., 2005). In this work we assess the survival rates of skates captured by commercial fisheries in one area of northern Europe, and describe some biological and physical factors that affect the survival of skate discards.

2. Materials and methods

2.1. The survey

The study was conducted on board two commercial trawlers operating typical twin-rig otter trawls, both with a track record of catching skates in the Bristol Channel (Fig. 1). Seven trips ranging from 3 to 5 days long were made during May and August 2007 (Table 1). In all, 32 tows were conducted in areas where the vessel would normally fish for skates, all made at towing speeds of 3–5 knots in water 30–60 m deep.

2.2. Skate survival

Short-term survival of discarded skates was assessed for two haul durations, 16 tows of a duration "normal" in commercial practice (2.7–4.3 h; referred to subsequently as commercial tows), and 16 shorter tows (0.75–2.0 h; referred to as short tows) (Table 2). Skates caught in seven of the commercial tows, the first from each trip, were held in tanks for approximately 3 days (Fig. 2), a limit imposed by trip duration. The experiments therefore provided short-term survival estimates only, although most fish mortality (93%) was within the first 24 h. When sorting commercial catches, there is inevitably a period of time before the unwanted fish are discarded, primarily because of the deployment of the gear for the next tow and the initial processing of the catch. To account for this, skates taken in the commercial tows were selected randomly from the fish pound and placed in holding tanks between 10 and 20 min after the catch had been brought on board. In all, 124 skates from seven commercial tows were kept in the holding tanks for up to 64 h. For trips conducted on Vessel 1, half the tanks were filled with skates from commercial tows and the other half with fish caught in the short tows. It was not possible to conduct short tows on Vessel 2, so all tanks were filled with skates from commercial tows only (Table 2). After the short tows, skates were taken immediately from the sorting pounds and placed in one of 12 holding tanks. In all 38 skates from nine short tows were kept in the holding tanks for up to 64 h.

Table 1
Summary of trips and hauls sampled, and the mean tow durations and codend weights for short tows and commercial tows.

Vessel	Trip	Departure–arrival date	Short tows			Commercial tows		
			No. of hauls	Mean tow duration (S.E.)	Mean haul weight (S.E.)	No. of hauls	Mean tow duration (S.E.)	Mean haul weight (S.E.)
1	1	07–10/07/07	5	0.9 (0.1)	80 (13)	5	4.0 (0.1)	253 (30)
1	2	23–26/07/07	6	1.1 (0.2)	98 (18)	3	4.1 (0.1)	204 (28)
1	3	27–30/07/07	5	1.2 (0.2)	67 (22)	4	3.8 (0.5)	161 (18)
2	4	01–03/04/07	(–)	(–)	(–)	1	4.5 (n.a.)	(–)
2	5	30/04–02/05/07	(–)	(–)	(–)	1	4.3 (n.a.)	(–)
2	6	21–25/08/07	(–)	(–)	(–)	1	2.7 (n.a.)	(–)
2	7	27–29/08/07	(–)	(–)	(–)	1	3.0 (n.a.)	(–)
Total			16	1.0 (0.1)	82 (10)	16	3.9 (0.2)	210 (19)

Values in parentheses refer to the standard error (S.E.) of the estimate. n.a.: insufficient data for estimation of S.E. (–): no data. *Vessel 1*: length overall, 14.95 m; gross tonnage, 50; main engine, 358 kW; net spread, 21.3 m; bridle length, 55 m; rockhoppers, 36 cm; codend, 85 mm mesh diameter constructed from 4 mm single braided twine. *Vessel 2*: length overall, 14.98 m; gross tonnage, 34; main engine, 298 kW; net spread, 20.1 m; bridle length, 46 m; rockhoppers, 36 cm; codend, 80 mm mesh diameter constructed from 4 mm single braided twine.

Table 2
Survival rates, holding duration, and mean lengths of skates held in vivier tanks from commercial tows and short tows.

Trial	Tow duration (h)	Species	Length (cm)	Mean time in tank (h)	*n*	Survival rate (%)
Commercial tow	3.2 (0.2)	*Leucoraja naevus*	35.0 (1.4)	48.0 (0.0)	6	33
	3.1 (0.1)	*Raja microocellata*	43.6 (0.9)	58.5 (1.9)	39	51
	3.9 (0.2)	*Raja brachyura*	41.3 (2.9)	48.0 (0.0)	11	55
	3.9 (0.1)	*Raja clavata*	55.4 (2.1)	60.6 (0.8)	68	59
Mean	3.6 (0.1)		49.4 (1.3)	58.2 (0.8)	124	55
Short tow	0.8 (n.a.)	*Raja brachyura*	90.0 (n.a.)	64.0 (n.a.)	1	0
	0.8 (0.0)	*Raja brachyura*	58.3 (2.0)	64.0 (0.0)	3	67
	0.8 (0.0)	*Raja clavata*	69.1 (1.4)	64.1 (0.8)	34	91
Mean	0.8 (0.0)		68.8 (1.5)	64.1 (0.7)	38	87
Land-based trial	n.a.	*Raja clavata*	66.2 (1.4)	72.0 (0.0)	5	100

Values in parentheses refer to the standard error of the estimate. n.a.: insufficient data for estimation of S.E.