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Species composition of skates (Rajidae) in commercial fisheries around the British Isles and their discarding patterns

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Recent regulations have required European nations to report commercial landings of Rajidae (skates) to species level since 2008. Morphological similarities between some species, variability in colouration and regional differences in common names may compromise the accuracy of some of these data. An increased proportion of rajid landings reported by the U.K. (England, Wales and Northern Ireland) are now reported to species level (42% in 2008, rising to 92% in 2010). Recent landings (2007–2010) of Rajidae by the U.K. indicated that the majority of reported landings were made by otter trawl (55·9%), tangle and gillnet (18·7%) and beam trawl (15·5%). Approximately 70% of recent landings originated from four ICES Divisions: the Irish Sea (VIIa), western English Channel (VIIe), Bristol Channel (VIIf) and southern North Sea (IVc). Recent species-specific landings of Rajidae are appraised in terms of the species reported and the overall composition, and potential problems identified. Data from observer trips have been used to estimate the species composition of Rajidae taken in some of the main commercial fisheries operating around the British Isles, and these data are compared to landings. Although there was typically broad agreement between these data sets in terms of the main species landed, misidentification issues were apparent and Rajidae with highly patchy distributions may be under-represented in observer data. Data from observer trips were also used to examine the discard and retention pattern. Most rajid species were first retained from total lengths, L_T, of 27–34 cm, with 50% retention occurring at between 49 and 51 cm and near-full retention at L_T of 60–67 cm. Beam trawls captured a higher proportion of smaller individuals, whilst gillnets (>150 mm mesh size) caught proportionally more larger rajids.

Key words: Celtic Seas; *Dipturus*; landings; *Leucoraja*; North Sea; *Raja.*

INTRODUCTION

Rajidae (skates) are an important component of the demersal fish assemblage in many areas, with *c*. 14 species occurring on the continental shelf of the British Isles (Wheeler, 1992; Table I). Their biological characteristics (*e.g.* longevity, slow growth rate, late age at maturity, protracted development period and low fecundity) make them highly vulnerable to over-exploitation (Holden, 1973; Ellis *et al.,* 2008). Their large size, flattened shape and aggregating nature also make them susceptible to capture in various fisheries (Ellis *et al.,* 2010).

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TABLE I. Taxonomic list of skates (Rajidae) occurring around the British Isles, including adjacent deep-water habitats in the north-east Atlantic Ocean. Those species that may be encountered on the continental shelf are highlighted (*)

Genus and species	Common name	Source
Amblyraja hyperborea	Arctic skate	(2)
Amblyraja jenseni	Short-tail skate	(2)
**Amblyraja radiata*	Starry ray	(1)
Bathyraja pallida	Pale ray	(2)
Bathyraja richardsoni	Richardson's ray	(2)
Bathyraja spinicauda	Spinetail ray	(2)
[*Dipturus batis*]	[Common skate]	(1,2,3,4)
**Dipturus* cf. *flossada*	Blue skate	
**Dipturus* cf. *intermedia*	Flapper skate	
Dipturus linteus	Sailray	(5)
Dipturus nidarosiensis	Norwegian skate	(2)
**Dipturus oxyrinchus*	Long-nosed skate	(1)
**Leucoraja circularis*	Sandy ray	(1)
**Leucoraja fullonica*	Shagreen ray	(1)
**Leucoraja naevus*	Cuckoo ray	(1)
Malacoraja kreffti	Krefft's ray	(2)
Malacoraja spinacidermis	Soft skate	(5)
Neoraja caerulea	Blue ray	(2)
**Raja brachyura*	Blonde ray	(1)
**Raja clavata*	Thornback ray	(1)
**Raja microocellata*	Small-eyed ray	(1)
**Raja montagui*	Spotted ray	(1)
**Raja undulata*	Undulate ray	(1)
Rajella bathyphila	Deepwater ray	(2)
Rajella bigelowi	Bigelow's ray	(2)
**Rajella fyllae*	Round skate	(1)
Rajella kukujevi	Mid-Atlantic skate	(2)
**Rostroraja alba*	White skate	(1)

Sources: (1) Wheeler (1992); (2) Wheeler *et al.* (2004); (3) Griffiths *et al.* (2010); (4) Iglésias *et al.* (2010); (5) Froese & Pauly (2011). Note: *Dipturus batis* is now considered to refer to two species.

Traditionally, skates were of a low market value until the late 1880s and early 1900s, when they became increasingly important (Ellis *et al.*, 2010). Since the late 1950s, however, U.K. landings have declined considerably and, in recent years, management measures may have restricted some fishing opportunities (ICES, 2010). Although there are some localized U.K. fisheries that target skates (*e.g.* in the southern North Sea and Bristol Channel), skates are often landed as an economically important part of the by-catch in mixed demersal trawl fisheries (Enever *et al.*, 2009; ICES, 2010).

Skate landings for most nations (including the U.K.) were, until 2008–2009, typically reported under a generic category of 'skates and rays' (ICES, 2010). The lack of species-specific data meant that some formerly abundant skate species, including the *Dipturus batis*-complex and *Rostroraja alba* (Lacèpède 1803), have disappeared from parts of their former range almost unnoticed (Brander, 1981; Rogers

& Ellis, 2000). The generic 'skates and rays' data have hampered individual stock assessments, with recent ICES advice for skate stocks based on the interpretation of their spatial distribution and relative abundance in fishery-independent groundfish surveys (ICES, 2008*a*, *b*).

In recent years, there has been an increased focus on using observers to collect data on commercial fishing vessels (Borges *et al*., 2005; Enever *et al*., 2007; Gonçalves *et al*., 2007), so that total catches of commercial species can be better estimated. Data from observer trips may also provide valuable information on the spatial distribution and length-frequency of discarded and retained fishes, and can be used to estimate the species composition of those taxa not reported routinely to species level in landing statistics, and of other groups of fishes for which species-specific data are limited (*e.g.* skates). Such information can augment those data collected during fishery-independent surveys (Ellis *et al*., 2005*a*, *b*). To date there have been few studies examining the by-catch and discard patterns of elasmobranchs in European fisheries (Carbonell *et al*., 2003; Coelho *et al*., 2003, 2005; Damalas & Vassilopoulou, 2011) and elsewhere in the world (Tamini *et al*., 2006).

The aims of this study were to (1) examine the proportion of Rajidae now being reported to species level, (2) compare the species composition of Rajidae landed by the main fisheries (based on fishing gear and area) with the species composition of Rajidae recorded during observer trips on commercial fishing vessels and (3) examine the length-based discard and retention patterns of Rajidae (with retained fishes those that fishers kept on board for marketing) by gear and species, including for those Rajidae currently listed as 'prohibited species' in European fisheries (CEC, 2011).

MATERIALS AND METHODS

LANDINGS DATA

Landings data for U.K.-registered vessels were extracted from the U.K. Fishing Activity Database (FAD) for the period 2007–2010 inclusive, with data allocated to gear and ICES Division (Table II). These data included reported landings for England, Wales, Northern Ireland and the Channel Islands, as well as Scottish landings outside Scotland (Fig. 1). The various gears were allocated to the following broad categories of gear type: (1) beam trawl, (2) otter trawl, including pair trawls and twin rig trawl, (3) *Nephrops* trawl, (4) gillnets, including drift and trammel nets, (5) lines (including hand lines and longlines) and (6) other gears (*e.g.* seines, mid-water trawl and dredges). These data were examined to identify which combinations of gear and ICES Division accounted for most of the reported rajid landings. It is recognized that these data may not be accurate for inshore fleets, where several gears can be used by a single vessel, and that each of these broad gear types can represent multiple métiers.

OBSERVER DATA

The Centre for Environment, Fisheries and Aquaculture Science (CEFAS) observer programme collects catch and discard information on English-registered commercial fishing vessels, and has been undertaken since 2002, as required by EC Data Collection Framework 199/2008. Data used for the purpose of this study were for the period 2002–2010. Vessel selection and sampling protocols were described by Enever *et al*. (2007) and Catchpole *et al*. (2011). Large catches were sub-sampled, although those data from hauls with raising factors >50 were excluded in the present analysis. All length measurements of Rajidae refer to total length (L_T), as measured to the centimetre below.

TABLE II. Reported U.K. landings of Rajidae for the years 2007 to 2010, giving total landings (t), and the quantity reported to species level by area and gear type for the main U.K. fisheries

		Total landings of Rajidae (t)				Skate landings reported to species level (t)			Skate landings reported to species level (%)		
Area	Gear	2007	2008	2009	2010	2008	2009	2010	2008	2009	2010
Irish Sea	NT	114·3	153·9	124·3	121·8	60·0	72·6	94·1	39·0	58·4	77·3
	OT	110·5	84·8	56·9	37·9	50·4	52·6	37·0	59·5	92·4	97·7
	GN	14·9	3·3	16·8	15·9	3·2	16·7	9·6	97·6	99·0	60·0
Bristol Channel	OT	503·6	520·0	406·4	520·0	222·6	324·1	485·3	42·8	79·8	93·3
	GN	72·6	86·0	103·4	131·0	13·7	73·1	106·2	15·9	70·7	81·1
	BT	60·4	32·9	32·0	24·8	11·1	22·3	24·8	33·7	69·7	99·9
Celtic Sea	OT	180·7	239·0	165·9	253·9	164·9	163·6	253·8	69·0	98·6	100·0
	BT	167·1	154·8	137·2	130·6	124·3	132·0	130·6	80·3	96·2	100·0
	GN	24·7	11·2	12·3	40·2	7·0	10·3	39·7	62·6	83·8	98·7
Western English Channel	OT	316·6	271·3	200·7	298·3	27·1	153·0	294·1	10·0	76·2	98·6
	GN	80·9	87·0	121·9	129·8	26·6	106·9	122·7	30·6	87·7	94·5
	BT	93·6	105·6	75·2	87·6	19·9	55·3	87·5	18·8	73·5	99·9
Southern North Sea and eastern English Channel	GN	168·4	219·6	168·1	184·1	50·4	94·9	151·8	22·9	56·4	82·4
	OT	157·9	171·8	148·5	135·0	95·4	128·2	128·5	55·5	86·4	95·2
	BT	58·1	51·5	65·0	58·3	15·1	57·5	58·2	29·3	88·5	99·8
	LL	84·5	92·6	22·4	49·3	56·9	22·3	49·2	61·5	99·6	100·0
Central and northern North Sea	OT	41·7	59·0	68·0	33·8	20·5	62·1	33·4	34·8	91·3	98·7
	BT	16·0	9·3	22·8	23·9	3·4	22·8	23·7	36·1	100·0	99·3
West of Ireland	OT	53·4	72·1	14·6	16·4	59·8	14·6	16·4	82·8	99·7	100·0
Other	–	73·2	44·2	45·0	89·0	12·0	29·1	42·7	27·3	64·7	48·0
Total		2393·3	2469·9	2007·3	2381·6	1044·4	1613·9	2189·4	42·3	80·4	91·9

Gear types: BT, beam trawl; OT, otter trawl; GN, gill and tanglenets; NT, *Nephrops* trawl; LL, longline.

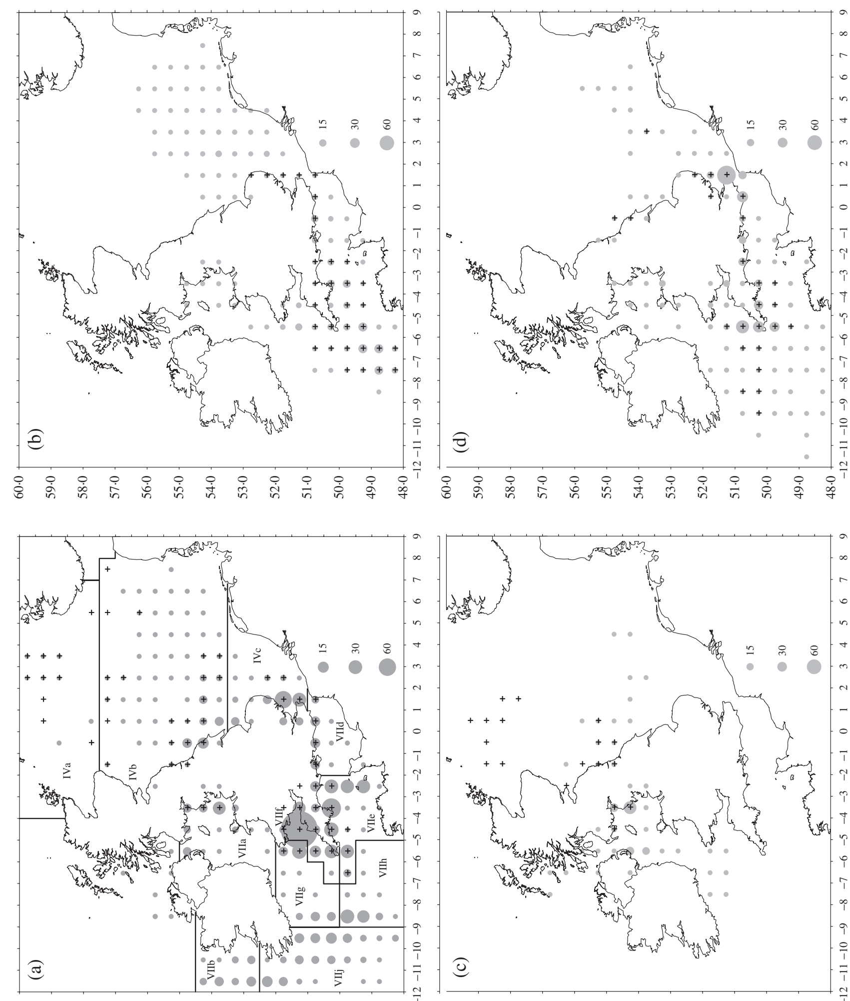

FIG. 1. Spatial distribution of U.K. commercial landings of Rajidae indicating the mean annual landings (t) for the period 2008–2010 by ICES statistical rectangle (●) and those rectangles for which there were observer data indicated (+). Data given for (a) otter trawl, (b) beam trawl, (c) *Nephrops* trawl and (d) gillnet.

SPECIES IDENTIFICATION

Species identification of Rajidae, both in fisheries-independent and fishery-dependent data, remains problematic (ICES, 2007, 2010). These problems can result from either poor species identification or, more simply, from the use of common names that can be attributable to multiple species.

To minimize potential misidentification issues, the spatial distribution of all species and their size distributions were compared with published studies (Ellis *et al.*, 2005*a*, *b*), so that records of fishes outside their known biogeographical and bathymetric range, less than the size at birth or greater than the maximum L_T of the species could be checked. Where possible, these data were corrected. If no appropriate corrections could be made, then the records were analysed at the family level. At the start of the discard observer scheme, 120 cm was used as a maximum L_T, and a few early records of the *D. batis*-complex ($n = 7$) and *Dipturus nidarosiensis* (Storm 1881) ($n = 1$) reported L_T of '120 cm+'. These data were converted to the mean L_T of specimens >120 cm recorded in subsequent years (126 cm for the *D. batis*-complex and 159 cm for *D. nidarosiensis*).

CONVERSION OF TOTAL LENGTH TO MASS

The L_T-based data collected by observers on commercial vessels was converted to biomass, using L_T and mass relationships for the various species as collected during scientific trawl surveys (CEFAS, unpubl. data). Data for *Dipturus oxyrinchus* (L. 1758), *D. nidarosiensis* and *Leucoraja circularis* (Couch 1838) were too limited to determine a species-specific L_T and mass relationship, and so the L_T and mass relationships for congeneric species [*D. batis*-complex and *Leucoraja fullonica* (L. 1758)] were applied. The L_T for *Rajella fyllae* (Lütken 1887), *R. alba* and skates of uncertain identification (treated as Rajidae), were converted to mass using the L_T and mass relationship for *Raja clavata* L. 1758.

DATA ANALYSIS

The species composition of retained rajids during observer trips on commercial fishing vessels was calculated from the total estimated biomass aggregated across different trips, for the years 2008–2010. This was undertaken for the main U.K. fisheries (as identified from national landings data, Table II) for which there was observer coverage. The observer data available for these fisheries over the period, in terms of the number of trips and hauls (for those trips in which rajids were encountered) are shown in Table III. The spatial coverage of reported landings and observer data are shown in Fig. 1.

For the analyses of L_T-based discard and retention patterns, data covered the North Sea ecoregion (ICES Sub-area IV and Division VIId) and Celtic Seas ecoregion (VIa, VIIa,b,e-j), and data from other regions were excluded. For the six main commercial Rajidae species by mass [*Leucoraja naevus* (Müller & Henle 1841), *L. fullonica, Raja brachyura* Lafont 1873, *Raja microocellata* Montagu 1818, *Raja montagui* Fowler 1910 and *R. clavata*], the L_T -frequency distributions for discarded or retained Rajidae were examined by gear (Figs 2 and 3) and species (Fig. 4) for the period 2002–2010. Analyses for gillnet catches were also undertaken separately by mesh size (≤150 and >150 mm). Catch and landings data for *Raja undulata* Lacépède 1802 and *D. batis*-complex were analysed separately for the periods before and after their inclusion on the 'prohibited species list' of the EC's technical regulations.

RESULTS

REPORTED LANDINGS FROM U.K.-REGISTERED VESSELS

From 2007 to 2010, U.K.-registered vessels reported between 2007 and 2393 t of rajids each year (Table II). These landings were made primarily by otter trawl

TABLE III. Observed fisheries with discarded or retained skates by gear (BT, beam trawl; OT, otter trawl; GN, gill and tanglenets; NT, *Nephrops* trawl; LL, longline) and area for the main U.K. fisheries for the years 2008–2010

		2008		2009		2010	
Area	Gear group	Trips	Hauls	Trips	Hauls	Trips	Hauls
Irish Sea	NT	17	29	6	8	2	7
	OT	7	27	2	4	6	13
	GN	—	—	—	—	—	—
Bristol Channel	OT	15	51	14	46	10	45
	GN	3	21	3	14	1	2
	BT	1	18	3	65	3	67
Celtic Sea	OT	5	12	2	4	2	14
	BT	7	175	5	98	4	51
	GN	3	23	2	5	5	48
Western English Channel	OT	69	131	31	60	22	52
	GN	3	6	11	21	9	26
	BT	9	70	28	273	19	127
Southern North Sea and eastern English Channel	GN	15	38	20	64	7	15
	OT	6	32	6	13	9	42
	BT	1	35	2	28	4	103
	LL	1	2	—	—	—	—
Central and northern North Sea	OT	19	85	19	82	26	139
	BT	—	—	—	—	—	—
Total		181	755	154	785	129	751

Source: CEFAS observer programme.

(55·9%), gillnet (18·7%) and beam trawl (15·5%), with smaller quantities taken by *Nephrops* trawl (5·9%), lines (3%) and 'other gears' (1%). The overall proportion of total skate landings reported to species level increased from *c*. 42% (2008) to 92% (2010) (Table II).

In terms of the spatial distribution, the majority of these landings (>85%) were reported from six ICES Divisions, covering the south-western approaches (VIIf: 27·1%; VIIe: 20·5% and VIIh: 8%), Irish Sea (VIIa: 10·0%), eastern English Channel (VIId: 7·4%) and southern North Sea (IVc: 12·6%). More than 95% of the reported skate landings originated from 19 combinations of gear and ICES Division (Table II).

IRISH SEA

Otter trawlers in the Irish Sea (ICES Division VIIa) caught and retained mostly *R. clavata* (81·4–98·8% of reported landings; 99·4–100% of retained skates in observer trips). *Raja brachyura* was of secondary importance in the reported landings (1·2–12·6%), although this species was not recorded during observer trips (Table IV).

The south-west of the Isle of Man and the grounds off Cumbria are important fishing grounds for *Nephrops norvegicus* (L. 1758) and *R. clavata* was the main skate species reported in both the commercial landings (96·7–98·6%) and observer data

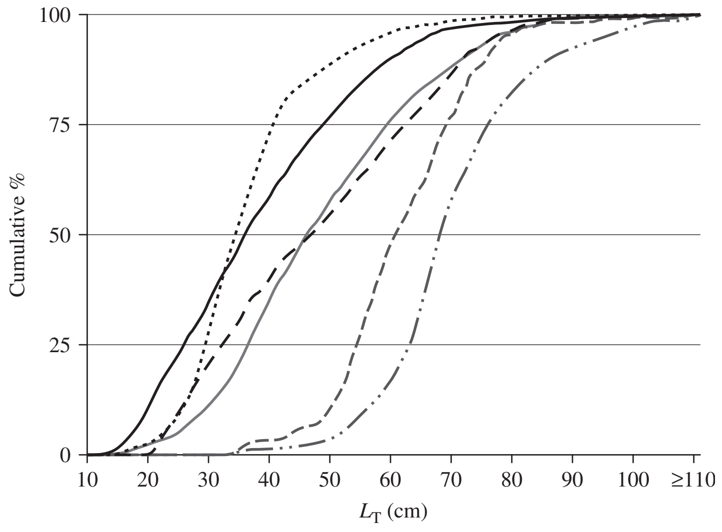

FIG. 2. Cumulative total length (L_T) frequency of all Rajidae caught by broad category of fishing gear [beam trawl (—), *Nephrops* trawl (...), otter trawl (—), gillnets ≤150 mm (– – –), gillnet >150 mm (–..–) and longline (– – –)] as observed in the CEFAS observer programme (2002–2010).

(88·4–100%; Table IV). The average proportions of *R. brachyura* and *R. montagui* in reported landings were 1·1 and <0·2%, respectively. The former species was not observed during observer trips, whilst the latter was estimated to account for *c*. 3% of the retained skates.

Reported landings from gillnetters in the Irish Sea comprised two skate species (*R. clavata* and, to a lesser extent, *R. brachyura*), although there were no observer data for this fishery during the study period.

Overall, seven skate species were reported in landings data, including *D. batis*-complex, and observer coverage only recorded four of these species.

BRISTOL CHANNEL

Gillnet and otter trawl catches in the Bristol Channel (ICES Division VIIf) were both dominated by three skate species: *R. brachyura, R. clavata* and *R. microocellata* (Table V). There was broad agreement in the main species taken by otter trawl, and the mean proportions from reported landings and observer coverage were 28·1 and 30%, respectively (*R. brachyura*), 31·9 and 25% (*R. clavata*) and 31·4 and 41·4% (*R. microocellata*). Small quantities of *R. montagui* were also present in both data sets. The species composition of gillnet catches also indicated a high proportion of *R. brachyura, R. clavata* and *R. microocellata*, although the catch proportions were more variable.

There was also an overall agreement between commercial and observer data for the main species taken by beam trawlers (*L. naevus, R. brachyura, R. microocellata* and *R. montagui*). The beam trawl fleet, which usually operates further offshore, consistently reported more *L. naevus* than the otter trawl fleet. Although *R. clavata* was reported in commercial beam trawl landings, this species was not recorded in the observer programme.

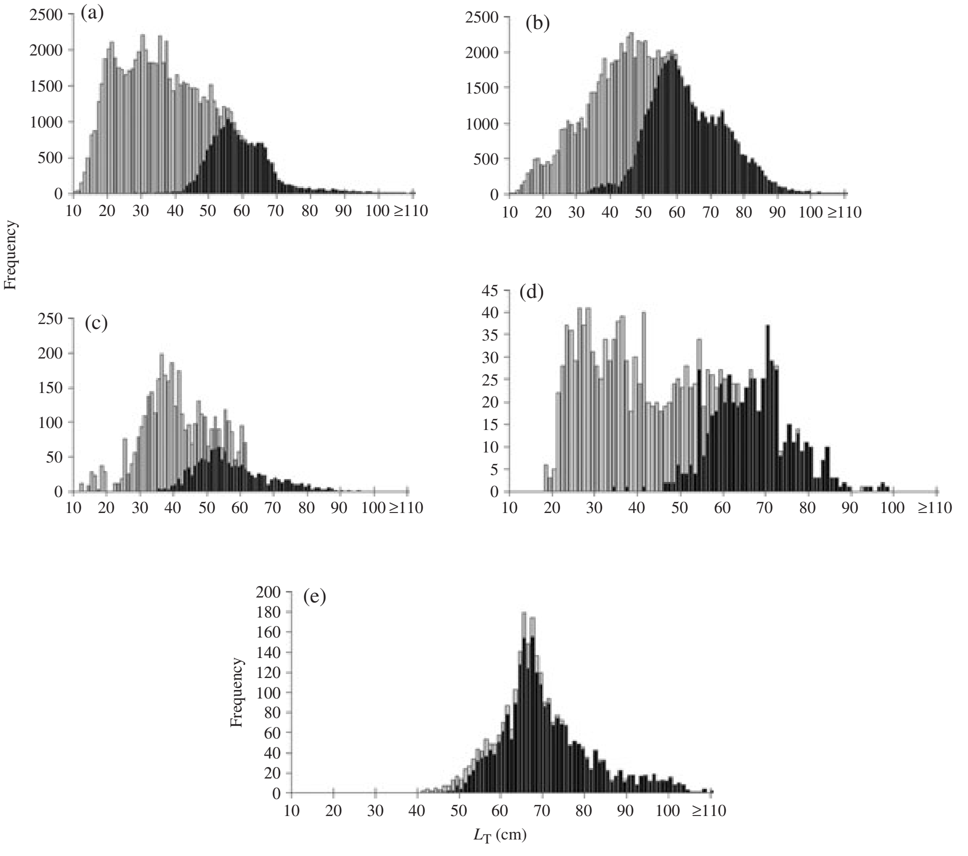

FIG. 3. Total length (L_T) frequency of discarded (□) and retained (■) commercial skates (excluding *Dipturus batis*-complex and *Raja undulata*) by (a) beam trawl, (b) otter trawl, (c) *Nephrops* trawl, (d) gillnets (≤150 mm mesh size) and (e) gillnets (>150 mm mesh size), as recorded in the CEFAS observer programme.

Overall, commercial landings data included six skate species that were not reported in the observer programme: *Amblyraja radiata* (Donovan 1808) *D. batis*-complex, *D. nidarosiensis, D. oxyrinchus, L. circularis* and *L. fullonica* (Table V).

CELTIC SEA AND WESTERN ENGLISH CHANNEL

Leucoraja naevus was the main skate species reported in the Celtic Sea (ICES Divisions VIIg-h), and consistently made up 73–79% of beam trawl landings, and *c*. 41·5 and 33·8% of reported otter trawl and gillnet landings, respectively (Table VI). A comparable proportion of *L. naevus* was evident in the observer data for beam trawl and gillnet.

Relatively high proportions of *L. fullonica* and *D. batis*-complex were also reported in this area. *Leucoraja fullonica* comprised *c*. 1·3 (beam trawl) to 16·9% (otter trawl) of reported landings, and observer data suggested *L. fullonica* could account for 8·6% of beam trawl landings.

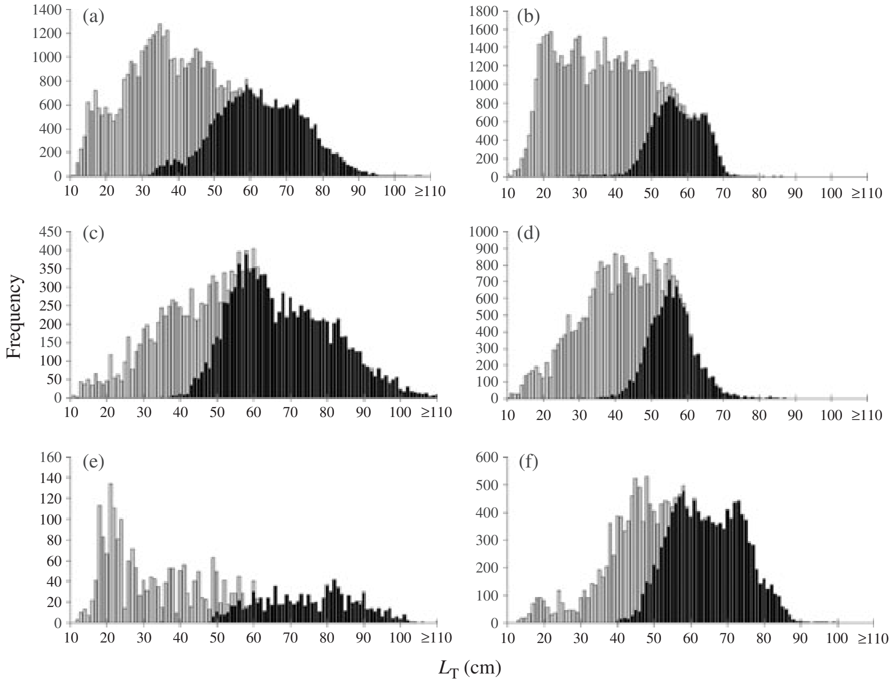

FIG. 4. Total length (L_T) frequency of discarded (□) and retained (■) (a) *Raja clavata*, (b) *Leucoraja naevus,* (c) *Raja brachyura*, (d) *Raja montagui*, (e) *Leucoraja fullonica* and (f) *Raja microocellata* (all gear types, 2002–2010), as recorded in the CEFAS observer programme.

The main species retained and landed by all commercial fleets in the western English Channel (ICES Division VIIe) were *R. brachyura* and *L. naevus* (Table VII). The major species landed by beam trawlers in this ICES Division were *R. brachyura* (41·7%) and *L. naevus* (33%), and observer data also indicated that these were the main species landed. *Raja montagui, R. clavata* and *R. microocellata* were of secondary importance. Landings from gillnetters and otter trawlers included a similar range of skate species, although a greater proportion of *R. clavata* was reported.

Reported landings of *R. undulata* and *D. batis*-complex decreased over the study period, in line with the introduction of management measures in 2009. Commercial landings data from both the Celtic Sea and western English Channel included five skate species that were not recorded on observed trips: *A. radiata, D. nidarosiensis, D. oxyrinchus, L. circularis* and *R. alba* (Tables VI and VII).

SOUTHERN NORTH SEA AND EASTERN ENGLISH CHANNEL

Commercial fisheries by beam trawl, otter trawls and gillnets in the southern North Sea (ICES Division IVc) and eastern English Channel (VIId) reported primarily *R. clavata* and *R. brachyura*, with smaller quantities of *R. microocellata* and *R. montagui* (Table VIII). *Raja clavata* was the main species landed in the overall area, accounting for *c*. 51·7, 87·2 and 95·8% of reported beam trawl, gillnet and otter trawl landings. *Raja brachyura* was also an important constituent of beam trawl (28·9%) and gillnet (9·2%) catches. Landings of *R. brachyura* from gillnetters were

Table IV. Species composition of Rajidae in U.K. fisheries operating in the Irish Sea based on reported landings and CEFAS observer programme (retained species only)

	Nephrops trawl						Gill and tangle nets			Otter trawl					
	Reported landings			Observer data			Reported landings			Reported landings			Observer data		
Name	2008	2009	2010	2008	2009	2010	2008	2009	2010	2008	2009	2010	2008	2009	2010
Amblyraja radiata	—	—	<0·1	—	—	—	—	—	—	—	—	—	—	—	—
Dipturus batis	—	0·8	—	—	—	—	—	—	—	—	0·1	—	—	—	—
Leucoraja naevus	1·2	0·3	0·9	4·0	—	8·6	—	—	—	0·0	0·1	0·9	—	—	—
Raja brachyura	1·1	0·2	2·0	—	—	—	14·0	0·1	0·1	1·2	3·3	12·6	0·1	—	—
Raja clavata	97·7	98·6	96·7	90·2	100	88·4	86·0	99·9	99·9	98·8	94·6	81·4	99·8	100	99·4
Raja microocellata	—	—	—	—	—	—	—	—	—	—	—	0·1	—	—	—
Raja montagui	—	<0·1	0·4	5·9	—	3·0	—	—	—	—	2·0	5·0	0·1	—	0·6
Total	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100

TABLE V. Species composition of Rajidae in U.K. fisheries operating in the Bristol Channel based on reported landings and CEFAS observer programme (retained species only)

	Beam trawl						Gill and tangle nets						Otter trawl					
	Reported landings			Observer data			Reported landings			Observer data			Reported landings			Observer data		
Name	2008	2009	2010	2008	2009	2010	2008	2009	2010	2008	2009	2010	2008	2009	2010	2008	2009	2010
Amblyraja radiata	0·2	—	—	—	—	—	—	—	—	—	—	—	<0·1	—	—	—	—	—
Dipturus batis	1·5	—	—	—	—	—	4·4	<0·1	<0·1	—	—	—	1·3	—	—	—	—	—
Dipturus nidarosiensis	—	—	—	—	—	—	—	—	—	—	—	—	<0·1	—	—	—	—	—
Dipturus oxyrinchus	—	—	—	—	—	—	—	—	<0·1	—	—	—	—	—	—	—	—	—
Leucoraja circularis	1·5	0·5	0·1	—	—	—	1·3	2·6	—	—	—	—	4·1	2·0	2·8	—	—	—
Leucoraja fullonica	0·6	—	<0·1	—	—	—	—	2·9	3·8	—	—	—	0·7	1·0	0·1	—	—	—
Leucoraja naevus	24·1	28·5	22·8	19·1	14·4	13·5	27·7	11·8	9·5	17·2	0·4	—	1·5	0·4	0·3	0·2	0·4	0·1
Raja brachyura	50·8	45·8	35·3	74·0	35·6	78·6	62·0	43·7	28·4	0·6	89·7	—	28·2	23·7	32·4	24·3	16·3	49·3
Raja clavata	6·3	5·2	15·0	—	—	—	0·6	23·0	27·3	42·5	—	45·8	30·4	31·8	33·5	18·5	20·4	36·0
Raja microocellata	7·6	9·4	12·2	3·4	25·6	2·4	3·9	15·2	30·3	34·1	9·1	54·2	30·5	35·9	27·8	51·5	59·2	13·4
Raja montagui	7·4	10·6	14·5	3·5	24·4	5·5	—	0·8	0·7	5·6	0·8	—	3·3	5·2	3·2	5·5	3·8	1·1
Total	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100

TABLE VI. Species composition of Rajidae in U.K. fisheries operating in the Celtic Sea, based on reported landings and CEFAS observer programme (retained species only)

	Beam Trawl						Gill and tangle nets						Otter trawl					
	Reported landings			Observer data			Reported landings			Observer data			Reported landings			Observer data		
Name	2008	2009	2010	2008	2009	2010	2008	2009	2010	2008	2009	2010	2008	2009	2010	2008	2009	2010
Amblyraja radiata	0·5	0·6	0·3	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Dipturus batis	7·7	0·5	—	18·3	—	—	25·1	<0·1	—	—	—	—	4·0	—	—	—	—	—
Dipturus nidarosiensis	—	—	—	—	—	—	—	—	—	—	—	—	20·6	2·8	<0·1	—	—	—
Dipturus oxyrinchus	0·4	—	<0·1	—	—	—	—	1·2	0·5	—	—	—	11·0	5·3	—	—	—	—
Leucoraja circularis	2·9	1·0	0·1	—	—	—	3·0	—	—	—	—	—	0·1	1·8	0·1	—	—	—
Leucoraja fullonica	1·4	1·7	0·7	6·2	4·6	15·0	—	0·2	6·0	—	—	23·0	5·6	15·0	30·1	—	—	—
Leucoraja naevus	72·9	78·8	77·0	73·7	93·2	82·6	37·7	41·6	22·2	4·5	90·9	59·7	30·3	47·7	46·6	0·1	—	0·2
Raja brachyura	4·7	5·6	5·3	<0·1	—	—	20·3	22·1	4·4	3·0	—	0·5	8·8	4·7	4·4	60·4	8·8	37·3
Raja clavata	4·5	5·7	6·4	1·3	0·6	—	3·0	9·0	28·8	46·9	—	0·4	14·1	16·6	12·0	12·1	43·1	19·1
Raja microocellata	5·1	5·8	8·6	0·3	—	—	10·9	21·9	29·2	44·6	—	—	4·8	5·5	5·7	25·5	41·8	40·3
Raja montagui	<0·1	0·4	1·6	0·1	1·7	2·4	—	4·0	9·0	1·0	9·1	16·4	0·1	0·7	1·2	1·9	6·3	3·0
Rostroraja alba	—	—	—	—	—	—	—	—	—	—	—	—	0·6	—	—	—	—	—
TOTAL	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100

TABLE VII. Species composition of Rajidae in U.K. fisheries operating in the western English Channel, based on reported landings and CEFAS observer programme (retained species only)

	Beam trawl						Gill and tangle nets						Otter trawl					
	Reported landings			Observer data			Reported landings			Observer data			Reported landings			Observer data		
Name	2008	2009	2010	2008	2009	2010	2008	2009	2010	2008	2009	2010	2008	2009	2010	2008	2009	2010
Amblyraja radiata	1·7	—	—	—	—	—	0·2	<0·1	<0·1	—	—	—	0·4	<0·1	<0·1	—	—	—
Dipturus batis	5·0	<0·1	—	2·6	—	—	4·3	0·1	—	—	—	—	0·3	0·1	—	—	—	—
Dipturus nidarosiensis	—	—	—	—	—	—	—	—	—	—	—	—	—	—	<0·1	—	—	—
Dipturus oxyrinchus	—	—	<0·1	—	—	—	<0·1	—	0·1	—	—	—	—	—	<0·1	—	—	—
Dipturus circularis	0·3	<0·1	0·2	—	—	—	—	0·1	0·2	—	—	—	0·1	0·2	<0·1	—	—	—
Leucoraja fullonica	0·3	0·2	0·1	—	—	0·3	—	0·1	0·3	—	—	—	—	0·3	0·2	0·9	—	—
Leucoraja naevus	32·8	28·4	37·9	6·0	14·4	15·6	49·3	24·0	21·4	57·8	71·2	66·3	32·4	7·2	9·2	23·4	29·9	50·7
Raja brachyura	29·7	48·7	46·7	60·3	75·9	66·1	38·2	47·5	35·1	—	15·7	20·9	60·0	50·9	43·9	28·3	22·7	13·0
Raja clavata	4·3	8·7	3·0	6·6	2·4	7·5	4·1	24·5	28·8	20·0	9·6	6·3	0·9	29·2	19·1	5·3	6·9	5·9
Raja microocellata	3·0	4·3	2·9	5·6	0·5	4·9	3·8	2·3	9·7	6·0	1·9	1·6	6·0	6·2	7·5	10·9	10·1	8·9
Raja montagui	18·8	7·6	9·1	5·2	6·8	5·6	<0·1	1·4	4·4	16·2	1·5	4·9	0·1	5·8	20·0	27·7	23·0	21·4
Raja undulata	4·2	2·1	—	13·7	—	—	—	—	—	—	—	—	—	0·1	—	3·6	7·4	—
Rostroraja alba	—	—	—	—	—	—	—	—	<0·1	—	—	—	—	<0·1	—	—	—	—
Total	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100

TABLE VIII. Species composition of Rajidae in U.K. fisheries operating in the southern North Sea and eastern English Channel, based on reported landings and CEFAS observer programme (retained species only)

	Beam trawl						Gill and tangle net						Otter trawl					
	Reported landings			Observer data			Reported landings			Observer data			Reported landings			Observer data		
Name	2008	2009	2010	2008	2009	2010	2008	2009	2010	2008	2009	2010	2008	2009	2010	2008	2009	2010
Amblyraja hyperborea	—	1·0	3·0	—	—	—	—	—	<0·1	—	—	—	—	—	—	—	—	—
Dipturus batis	—	<0·1	—	—	—	—	0·3	—	0·3	—	—	—	—	—	—	—	—	—
Dipturus oxyrinchus	—	—	—	—	—	—	0·8	<0·1	1·0	—	—	—	<0·1	—	<0·1	—	—	—
Leucoraja circularis	—	—	—	—	—	—	—	—	<0·1	—	—	—	—	—	—	—	—	—
Leucoraja fullonica	—	—	—	—	—	—	<0·1	<0·1	0·1	—	—	—	—	—	<0·1	—	—	—
Leucoraja naevus	—	0·3	0·3	—	—	—	—	<0·1	<0·1	—	—	—	—	—	—	—	—	—
Raja brachyura	30·8	29·6	26·2	66·8	24·5	30·1	6·4	12·5	8·6	1·2	0·4	—	4·6	3·4	1·8	—	5·1	18·9
Raja clavata	46·2	53·0	55·9	33·2	73·4	60·1	90·5	84·2	86·8	97·1	99·4	100·0	94·5	95·4	97·6	100·0	39·9	72·0
Raja microocellata	4·2	2·0	0·4	—	—	3·7	—	1·4	1·0	1·7	—	—	0·1	0·3	0·2	—	16·7	1·2
Raja montagui	15·7	13·7	14·1	—	2·1	6·1	0·1	1·6	2·3	—	0·3	—	0·6	0·7	0·2	23·1	7·9	—
Raja undulata	3·1	0·4	—	—	—	—	1·9	0·1	—	—	—	—	0·1	0·1	—	—	15·3	—
Rostroraja alba	—	—	—	—	—	—	—	0·1	—	—	—	—	—	—	<0·1	—	—	—
Total	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100

proportionately higher in the reported landings than from the observer data. Although *R. montagui* accounted for *c*. 14·5% of reported beam trawl landings, observer data indicated a much lower proportion (2·7%).

Skate landings from longliners were composed primarily of *R. clavata* (79·3–93·8%), and *R. brachyura* (5·6–17·4%), with smaller quantities of *R. montagui* and *R. microocellata* also taken (Table IX).

Seven species of skate [*Amblyraja hyperborea* (Collett 1879), *D. batis*-complex, *D. oxyrinchus*, *L. circularis, L. fullonica, L. naevus* and *R. alba*] were recorded in low quantities in landings data and were not reported during observer trips (Table VIII). Once again, the proportion of *R. undulata* in reported landings decreased over the study period.

NORTHERN AND CENTRAL NORTH SEA

Commercial otter trawlers in the central and northern North Sea (ICES Divisions IVa,b) landed primarily *R. clavata* (*c*. 89·5%) and, to a lesser extent, *R. montagui* (6·8%). Small quantities of *R. brachyura* and *L. naevus* were also reported (Table IX). Data from the observer programme suggested a higher proportion of *R. montagui* in the catch than indicated from reported landings.

Reported beam trawl landings from this area comprised primarily *R. montagui* (49·6%), *R. clavata* (32·4%) and *R. brachyura* (16·8%), although no comparable data from observer programmes were available.

Although a 'prohibited' species, there were reported landings of the *D. batis*-complex, indicated in both landings and observer data (Table IX). Small quantities of *A. radiata* were reported in the landings, although this species is generally discarded.

DISCARD AND RETENTION PATTERNS

Beam trawlers caught proportionally more small skates than the other gears, followed by small-mesh gillnets (90–150 mm mesh size), otter and *Nephrops* trawls. While larger gillnets (200–256 mm mesh size) caught proportionally more large skates (Fig. 2).

The high proportion of small skates caught in beam trawlers (<120 mm mesh size) were generally discarded [Fig. 3(a)]. First retention was at *c*. 27 cm L_T, with nearly all skates retained at ≥61 cm L_T. The L_T at 50% retention was *c*. 50–51 cm.

Otter trawlers (80–130 mm mesh size) captured proportionally more large skates, which were retained from *c*. 27–30 cm L_T [Fig. 3(b)], with 50% retention at *c*. 50 cm and near-full retention at 62 cm L_T. A high proportion of the skates caught by *Nephrops* trawlers (80–110 mm mesh size) were small, with skates generally retained from 35 cm, 50% retention at 49–50 cm and near-full retention ≥62 cm L_T [Fig. 3(c)].

Gillnet fisheries landed skates ≥46 cm, and full retention occurred at >60 cm L_T [Fig. 3(d)]. Smaller-mesh gillnets [≤150 mm mesh size, Fig. 3(e)] invariably captured a greater proportion of small skates in comparison with larger gillnets [>150 mm mesh size, Fig. 3(f)].

In general, the main commercial skate species were retained from L_T of 27–34 cm, and 50% retention occurred at 49–51 cm. Nearly all skates were retained at >60 cm L_T (Fig. 4). Although data were more limited for *L. fullonica* than for

Table IX. Species composition of Rajidae in U.K. fisheries operating in the southern North Sea and eastern English Channel (longline), and central and northern North Sea (beam and otter trawl), based on reported landings and CEFAS observer programme (retained species only)

	Longline				Beam trawl			Otter trawl					
	Reported landings			Observer data	Reported landings			Reported landings			Observer data		
Name	2008	2009	2010	2008	2008	2009	2010	2008	2009	2010	2008	2009	2010
Amblyraja hyperborea	—	—	<0·1	—	—	—	2·3	—	<0·1	—	—	—	—
Amblyraja radiata	—	—	—	—	—	—	—	—	<0·1	<0·1	1·1	—	4·3
Dipturus batis	—	—	3·3	—	—	—	—	<0·1	—	0·3	—	—	2·1
Dipturus oxyrinchus	—	—	—	—	—	—	—	—	—	—	—	3·2	—
Leucoraja naevus	—	—	—	—	0·1	—	1·0	0·3	2·3	4·1	6·9	3·3	9·4
Raja brachyura	17·4	5·6	15·2	—	10·8	16·3	23·2	0·5	0·3	2·7	2·5	0·2	2·7
Raja clavata	79·3	93·8	80·9	99·4	36·1	24·4	36·8	86·8	92·2	89·5	65·7	80·9	30·6
Raja microocellata	—	0·3	0·4	—	<0·1	0·1	—	—	0·4	—	—	—	—
Raja montagui	3·2	0·3	0·1	0·6	52·9	59·3	36·6	12·4	4·7	3·4	23·8	12·3	50·9
Raja undulata	<0·1	—	—	—									
Total	100	100	100	100	100	100	100	100	100	100	100	100	100

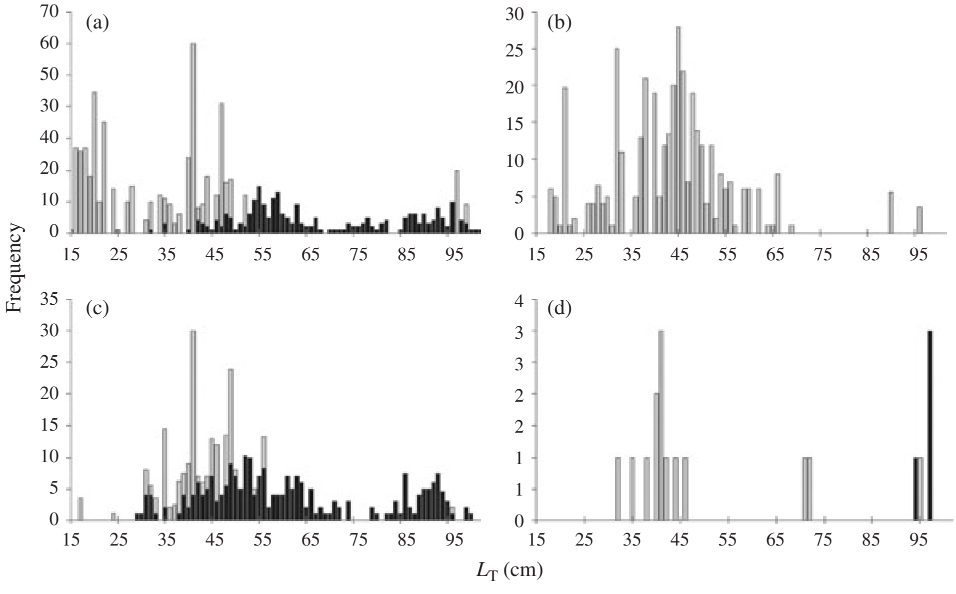

FIG. 5. Total length (L_T) frequency of discarded (▒) and retained (■) *Raja undulata* captured by (a), (b) beam trawl for the periods (a) 2002–2008 and (b) 2009–2010, and (c), (d) otter trawl for the periods (c) 2002–2008 and (d) 2009–2010, as recorded in the CEFAS observer programme.

other species, there was a tendency for the L_T at first and 50% retention (48 and 53 cm, respectively) to be slightly higher than for other species.

Other rajid species, including *D. oxyrinchus*, *D. nidarosiensis*, *A. radiata*, *L. circularis* and *R. fyllae* were also recorded during the discard observer programme. *Amblyraja radiata* was the most abundant of these and was generally discarded across the entire L_T range (12–69 cm).

PROHIBITED SPECIES

Of the three skate species that are currently listed as prohibited species, some data were available for two species (*R. undulata* and *D. batis*-complex) and only limited data were available for *R. alba.* Marketable sized fish of the first two species were typically retained before their prohibited status in 2009 [Figs. 5(a), (c) and 6(a), (c)], and observer data since then indicated that both species are usually discarded, with only occasional specimens retained [Figs. 5(b), (d), and 6(b), (d)].

DISCUSSION

SPECIES-LEVEL REPORTING OF SKATE LANDINGS IN U.K. FISHERIES

There has been increased concern over the status of elasmobranchs, and particularly larger-bodied skates, since Holden (1973) highlighted the biological susceptibility of elasmobranchs, and Brander (1981) documented the loss of the

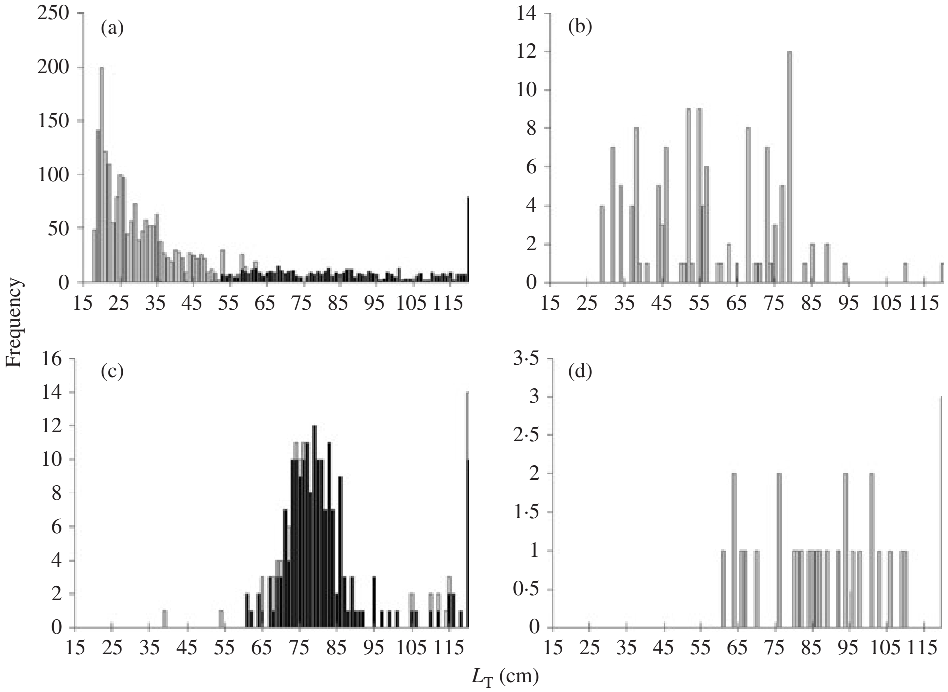

FIG. 6. Total length (L_T) frequency of discarded (□) and retained (■) *Dipturus batis*-complex captured (a), (b) by beam trawl for the periods (a) 2002–2008 and (b) 2009–2010, and (c), (d) gillnet for the periods (c) 2002–2008 and (d) 2009–2010, as recorded in the CEFAS observer programme.

D. batis-complex from the Irish Sea. Nevertheless, the introduction of management measures has not only occurred slowly, but for much of the time has been implemented at the family-level, despite there being important species-specific differences in the life history and susceptibility of the various stocks in the skate complex. For example, some large-bodied skates (*D. batis*-complex and *R. alba*) have disappeared from parts of their former range, whilst there may be healthier populations of some of the smaller-bodied and more productive stocks, such as *A. radiata* and *R. montagui* (Walker & Hislop, 1998; Rogers & Ellis, 2000).

The first EC measures were only established in 1999, when a total allowable catch (TAC) for 'skates and rays' was fixed for the North Sea. This TAC has since been reduced (typically in the region of 8–25% per year), and the TAC was reduced to a record low of 1397 t for 2010. Although the TAC has been higher than reported landings for much of this period, the quota may have been restrictive for some fisheries, depending on its allocation. TAC for skates and rays elsewhere in European seas in the ICES area (*e.g.* Divisions IIIa and sub-areas VI–IX) were only established in 2009.

The EC has also implemented other measures, for example a by-catch quota was introduced in 2007, whereby skates should not comprise >25% (by live mass) of the catch retained on board. This measure, which was unpopular with inshore fishermen in the southern North Sea, may have led to increased discarding and not reduced fishing mortality, and was later applied only to vessels >15 m overall length. Given the increased conservation interest in large-bodied skates, the EC recently included three skates (D. *batis*-complex, *R. undulata* and *R. alba*) on the list of 'prohibited species' (CEC, 2011).

One of the major problems for the assessment and management of the different skate species has been that much of the reported landings data were aggregated across all species (Ellis *et al*., 2008; ICES, 2010). Although certain skate species may be landed separately in some fisheries, they were traditionally landed according to ease of processing (skinning) and size, and species with similar characteristics were often combined (Fahy, 1989; M. J. Holden, unpubl. data). There have been some recent national market sampling programmes to better understand the species composition of skates (Machado *et al*., 2004; Figueiredo *et al*., 2007), but no recent published information is available for U.K. fleets.

Since 2008, TAC and quota regulations have required skates (*A. radiata, D. batis*-complex, *L. naevus, R. brachyura, R. clavata* and *R. montagui*) caught in EC waters of ICES Division IIa and sub-area IV to be reported separately (CEC. 2008). This was extended to other ICES divisions, including the Celtic Seas ecoregion, in 2009, and other species (*L. circularis, L. fullonica* and *R. microocellata*) were also to be recorded separately in this region.

Although the proportion of skate landings reported to species level has increased, both in the U.K. and elsewhere in northern Europe (ICES, 2010), there are still several issues regarding the accuracy of these data, and potential misidentifications and confusion between species.

COMPARISON OF LANDINGS DATA AND OBSERVER DATA

After the requirements for species-specific recording of landings were introduced, training in species identification (and circulation of species identification sheets) was undertaken by CEFAS scientists in several areas. This training focused typically on the most common species caught in the area, and so there is some doubt over the accuracy of reports of some less frequently landed species, such as *R. alba* and *Dipturus* spp. (ICES, 2010). Therefore, there is still a need for further training and quality control of the data (*e.g.* through market sampling programmes).

It is important to recognize that large data sets (including national landing statistics, observer data and even fishery-independent trawl surveys) need to be subject to appropriate quality control, as potential errors may occur, including input errors, misidentifications and confusion resulting from regional differences in common names. There may also be confusion between the generic term 'skate', which has traditionally been applied by commercial fishermen to all rajids, and the common names of the long-snouted species within the genus *Dipturus*. It should also be noted that commercial landings for a trip can be divided *pro-rata* between the rectangles fished during that trip. Hence, it is possible for fishes that were caught in one ICES Division to be partly allocated to another Division, if fishing activities were conducted in both areas.

The reported skate landings from the main U.K. fisheries taking skate were more diverse than estimated from the observer programme, in terms of the total number of species retained and landed. The reasons for this discrepancy include some probable misidentifications and incorrect reporting of some species in landings data, and also the small proportion of commercial trips that have observers on board may reduce the chance of observing less frequent species.

There can also be important spatial and temporal differences in the skate species composition within both ICES Sub-areas and Divisions, and some elasmobranchs are known to have patchy distributions, and observer data may be limited in some of these fisheries. For example, skates reported by gillnetters operating in the Bristol Channel and Celtic Sea appeared quite variable both between years and between the two data sets. This may be due to the localized nature of some of these fisheries and low observer coverage.

In some areas, there were contrasting spatial distributions in the reported landings and national observer coverage, as discard sampling on foreign-owned, English-registered vessels is undertaken by the other country. For example, there was an apparent contrast in the landings of *L. naevus, L. fullonica* and *R. microocellata* in the Celtic Sea (Table VI), where reported landings by otter trawl indicated that these species accounted for, on average, 41·5, 16·9 and 5·3%, respectively. In contrast, data from the English observer programme reported a small proportion of *L. naevus* ($<1\%$) and did not record *L. fullonica.* The distribution of CEFAS observer trips was eastwards of the main fishing grounds (Fig. 1) and analyses of observer data for the Anglo-Spanish fleet are still required.

Nevertheless, there was usually broad agreement in the main species taken in the fisheries, and observer coverage can usefully appraise the validity (and potential discrepancies) of national landings data. Observer data collected on commercial vessels are normally used to provide information on discard levels of the main commercial species, but as demonstrated here, such data can also provide valuable information on the size range, spatial and temporal distribution, and species composition of species-complexes. For example, although this study has focused on skates, comparable analyses could be used to better understand the species composition of other fish landed in mixed categories, such as gurnards (Triglidae).

Analyses of the species composition for the main skate fisheries by geographical region (Tables IV–IX) show some potentially erroneous records that were neither supported by the known distribution of the species (Stehmann & Bürkel, 1984; Ellis *et al*., 2005*a*) nor corroborated by observer data. For example, *A. hyperborea* was reported in both the central and southern North Sea (Tables VIII and IX), although this species is not known to occur in these Divisions (Stehmann & Bürkel, 1984; ICES, 2010). The related *A. radiata* was reported in the Irish Sea, Bristol Channel, western English Channel and Celtic Sea (Tables IV–VII), whereas this northerly species occurs mainly to the north of the British Isles and in the northern and central North Sea. These records may represent misidentification of the sympatric *R. clavata*. Nevertheless, the quantities involved were generally low.

There has long been some confusion between *R. brachyura* and *R. montagui*, as these species can occur on the same fishing grounds and have quite similar colourations. There were several instances where the proportions of these two species appeared to be subtly different in national landing statistics and observer data. For example, landings data from Irish Sea *Nephrops* trawlers indicated a low proportion of *R. brachyura* ($\leq 2\%$), although this species was not recorded in observer trips (Table IV). In contrast, observer trips indicated a comparable proportion of *R. montagui.* Similarly, landings and observer data from beam trawl catches in the eastern English Channel and southern North Sea suggested some discrepancy (Table VIII).

Observer data indicated that, on average, *R. brachyura* and *R. montagui* accounted for 40·5 and 2·7%, respectively, whereas the corresponding values from landings data were 28·9 and 14·5%.

Although there were instances of potential confusion between these species, it should be recognized that *R. brachyura* has a patchy distribution (Ellis *et al*., 2005*a*). Discrepancies between the two data sets could occur if the temporal and spatial coverage of the observer trips either over or under sampled those fishing grounds where species with patchy distributions and high local abundance occur. Hence, the coverage of the observer programme should be accounted for when evaluating the validity of landings data for some species.

ICES has not been able to provide advice for *R. brachyura,* which can be a locally important commercial species, as catch rates in trawl surveys are both low and variable (ICES, 2010). Given the similarity in the morphology and colouration of *R. montagui* and *R. brachyura* and that there is uncertainty in the accuracy of commercial data, further training or market sampling may be required to better estimate the landings of these species.

Other problematic species, for which misidentification with sympatric species may occur include *L. fullonica* and *R. microocellata*. Confusion between these skates would explain the contrast in reported landings and observer information from the Bristol Channel (Table V).

Some of the records may also be problematic due to regional variations in common names. For example, 'sandy ray' is the widely accepted common name for the offshore species *L. circularis* but is also used regionally (*e.g.* in the Bristol Channel) to refer to small-eyed ray *R. microocellata*. Therefore, reported landings of *L. circularis* from the Bristol Channel (Table IV) and, to a lesser extent, the western English Channel (Table VI) may in fact relate to *R. microocellata*, which is one of the more frequent skates in those areas. This may also have occurred in the Celtic Sea (Table V), where reports for *L. circularis* are significantly higher than indicated by observer data and are more consistent with being *R. microocellata*. Similarly, both *R. microocellata* and *R. undulata* are sometimes called 'painted ray', which may also lead to confusion.

DISCARD AND RETENTION PATTERNS

The discard and retention patterns of skates in terms of gear suggested that there were differences in the selection patterns between the various gears. Gillnets with larger (>150 mm) mesh sizes had the lowest discards of small skates, whilst beam trawlers caught proportionally more small skates, so resulting in high levels of discarding. Otter trawls captured proportionally more large skates in comparison to beam trawls.

For the main commercial skate species (*L. naevus, R. brachyura, R. clavata, R. microocellata and R. montagui*), individuals <35 cm L_T were usually discarded, and 50% retention occurred at *c*. 49–53 cm L_T. Nearly all individuals of these species were retained at sizes of >60 cm L_T. The discard and retention pattern for *R. undulata* (prior to their listing as a prohibited species) was similar to the species discussed above, whilst the L_T at retention was slightly greater for *D. batis*-complex (Fig. 6), which would be expected given its longer snout.

Many factors can influence discard rates and patterns. Smaller skates are not of marketable size or value (or may be subject to a minimum landing size in some inshore areas). Other skates may be discarded because of insufficient quota, prohibited status or state of the fish (*e.g.* trawl-caught skates can be damaged in the codend; some skates caught in gillnets with a high soak time can be damaged by scavenging isopods), and such factors may account for the occasional incidences of larger fishes being discarded. The presence of observers may also influence the discarding practices of fishers.

There is a need for an improved understanding of discarding patterns in some fisheries, and also to have a better understanding of potential survivorship. The lack of swimbladders in elasmobranchs, and the robustness of some of these species, may result in relatively high discard survival (Broadhurst *et al*., 2006), and the more sedentary nature of skates may enable them to survive better in some fisheries in comparison to some sharks and dogfish that are ram ventilators.

To date, there have been comparatively few studies examining the discard survival of batoids (Kaiser & Spencer, 1995; Stobutzky *et al*., 2002; Laptikhovsky, 2004; Enever *et al*., 2009). Discard survivorship of skates will depend on a variety of factors, including the species (*e.g. R. clavata* has a thicker skin than some other skate species, which may afford some protection from damage), the gear used and its duration and soak time, contents of the net and fisher behaviour (Catchpole *et al*., 2007; Enever *et al*., 2009, 2010). Further studies on the factors affecting discard survival and collaborative work with the fishing industry to identify practical methods of improving discard survival are required. Estimates of discard mortality are also needed if total removals of the various species are to be used in future stock assessments.

PROHIBITED SPECIES

In addition to the requirements for species-specific reporting of commercial landings, it is also currently '*prohibited for EU vessels to fish for, to retain on board, to tranship or to land*' three species of skate; *D. batis*-complex, *R. undulata* and *R. alba* (CEC, 2011). This measure has been unpopular with fishermen operating in areas where *D. batis*-complex or *R. undulata* are locally common. Reported landings of these species have decreased, in line with these conservation measures, and observer data also demonstrate that these species are now typically discarded. The real extent of recent landings of the *D. batis*-complex is difficult to quantify, as there can be confusion (and potential misreporting) with congenerics (*D. nidarosiensis* and *D. oxyrinchus*).

Raja undulata accounted for up to 4% of landings in the western English Channel, and up to 2–3% of skate landings in beam trawl and gillnet catches from the eastern English Channel and southern North Sea in 2008, prior to regulations preventing their retention. These proportions were for the regions as a whole, and *R. undulata* can be locally abundant and one of the dominant rajids in an area covering the eastern part of VIIe and western part of VIId.

Although there were reported landings for the little-known *R. alba* from the Celtic Sea and English Channel (Tables VI–VIII), no voucher specimens or evidence is available, and these data should be treated with caution, as they may result from misidentifications.

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