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UK fisheries for skates (Rajidae): History and development of the fishery, recent management actions and survivorship of discards

J.R. Ellis, J.F. Silva, S.R. McCully, M. Evans and T. Catchpole

Skates (Rajidae) are vulnerable to overfishing because they are long-lived, slow growing, late to mature, have protracted breeding cycles and produce few young. Their large size, morphology and aggregating nature also make them susceptible to capture in mixed demersal fisheries, and several species are also taken in targeted fisheries (using longline, gillnet or trawl). The abundance and diversity of the skate community around the British Isles has changed over the course of the last 100 years. Some of the larger-bodied species (e.g. white skate *Rostroraja alba*) have disappeared, whilst the smaller-bodied species (e.g. spotted ray *Raja montagui* and thornback rays *R. clavata*) seem to have healthier populations. Research has also shown that some skate species can have very patchy distributions, and such locally abundant species may be prone to depletion. Current management regulations for skates include quotas (though this is a mixed quota for rajids), a minimum landing size (in some inshore waters of England and Wales), and some species are currently designated as prohibited species that cannot be retained. The efficacy of these and other potential measures is highly dependent on discard survival. Here we review the evolution of skate fisheries around the British Isles, discard and retention patterns of skates in selected UK fisheries, the recent introduction of management actions and discuss the merits of these and other potential measures in light of our current knowledge of discard survival.

Keywords: Rajiformes, Rajidae, fisheries, bycatch, survivorship

Contact author: Jim Ellis, Cefas, Pakefield Road, Lowestoft, Suffolk, NR33 0HT, United Kingdom

E-mail: jim.ellis@cefas.co.uk

1. The skate fauna of the British Isles

Approximately 14 species of skate (Rajidae) are known to inhabit the continental shelf surrounding the British Isles (Table 1). A variety of deep-water species also occur on the continental slope and in deep-water to the west and north of the British Isles, and there may be as many as 27 skate species around the British Isles. Little is known about the distribution, biology and fisheries of the deep-water skates, and further studies on these species are clearly needed. For the purposes of the present paper we focus on those skate species occurring on the continental shelf around the British Isles.

Early ichthyologists had differentiated between the blue or common skate and the flapper skate, although a taxonomic revision of the European skates in the 1920s combined these species as common skate *Raja batis.* Subsequent taxonomic work differentiated the rajids into various genera, with common skate then re-named *Dipturus batis.* French scientists examining the molecular genetics of skates have recently reported genetic differences in specimens of "*Dipturus batis*", and subsequently listed distinguishing characteristics for the two species (Iglésias *et al.*, 2010). A subsequent study has confirmed these genetic differences (Griffiths *et al.*, 2010). The nomenclature of the 'common skate complex' is currently being updated, and so the scientific name *Dipturus batis'* will soon be an invalid synonym. Taxonomists working on the problem have proposed that former scientific names should be resurrected for these two species: *Dipturus flossada* and *D. intermedia*, but this proposed change needs to be validated by the International Commission on Zoological Nomenclature (Iglésias *et al.*, 2010).

Although the overall geographical distributions of the two species are unclear, Griffiths *et al.* (2010) observed that samples from ICES Division VIa were generally genetically distinct from samples collected in the Celtic Sea, with flapper skate *Dipturus intermedia* and occasional blue skate *D. flossada* and taken in VIa, and *D. flossada* taken on the Rockall Bank and in the Celtic Sea.

2. UK skate fisheries: historical perspective

Traditionally, skates were of limited market value, and those that were landed in the early 1800s were generally for use as either pot bait or for fishermen's families (Day, 1880–1884; Steven, 1932). Indeed, along with gurnards, scad and dogfishes, skates and rays were referred to as 'rabble fish' (Couch, 1862). This lack of perceived importance was also mirrored in some of the earlier books on the biology of British marine fishes, for example McIntosh and Masterman (1897) excluded all elasmobranch fish. Nevertheless, in certain areas, skates were of importance for some markets (e.g. white skate were sold to the French, see Section 3).

In the late 1880s and early 1900s, however, skates became increasingly marketable, and Day (1880–1884) stated that "*now they are consigned to the London markets*". The increasing fishing power at this time resulted in a steady increase in skate landings during the first part of the 20th century. Reported UK skate landings were in the region of 25–30 000 t per year between 1908 and the mid-1930s (with the exception of the First World War). Skate landings began to decline in the late 1930's and, after the Second World War, landings were in the region of 20 000 t per year. Since 1958, UK landings have declined steadily (Figure 1) and have been <5 000 t per year since 2005. This recent period of decline will also reflect recent management measures that have reduced fishing capacity, and also the introduction of a quota for skates and rays (see Section 4) which may have become restrictive for some fisheries in recent years.

Despite the overall importance of the skate complex to UK fisheries, scientific studies to better understand this group of fish in UK seas have only been periodic, with much of our knowledge derived from a relatively small number of workers, such as Robert Clark (Clark, 1922, 1926, 1927), George Alexander Steven (Steven 1931, 1932, 1933, 1934, 1936, 1947) and Mike Holden and his co-workers (Holden, 1963, 1972, 1975; Holden *et al.*, 1971; Holden and Vince, 1973; Holden and Tucker, 1974). The studies of Marie-Henriette du Buit, based in Concarneau, have also provided invaluable information on the skates and skate fisheries along the western coasts of the British Isles (Du Buit, 1968a,b, 1970, 1972a,b, 1973, 1975a,b, 1976a,b, 1978, 1989; Du Buit and Maheux, 1986).

3. Longer-term changes in skate populations

Given that skates have traditionally been reported under the generic landings category "skates and rays", it has not been possible to fully evaluate longer term patterns in landings of particular species (ICES, 2009, 2010). Furthermore, even though some species-specific landings data are collected and/or reported by some European nations (e.g. for France), such information can contain taxonomic errors, for example spotted and blonde rays may be mixed together (see ICES, 2009), and the larger, long-nosed skates can be incorrectly identified (Iglésias *et al.*, 2010). Such taxonomic problems will also affect the species-specific landings data that are currently being collected, although most Member States have initiated some degree of training for market sampling staff.

Fishery-independent trawl surveys can provide species-specific data, and such surveys have been the basis of ICES advice (ICES, 2008a,b). However, it should be recognised that the suitability of these data are compromised by (a) incorrect species identifications in some surveys (e.g. in the case of thornback ray *Raja clavata* and starry ray (or thorny skate) *Amblyraja radiata* in some North sea surveys); (b) that the surveys were not originally designed to provide abundance indices for skates, and so the type of gear used and/or the distribution of survey hauls may not be appropriate for some skate species; and (c) catch rates for some of the more uncommon and/or patchily distributed skates are often low and variable. Also, it must be recognised that most of these surveys cover periods of less than 20 years old, and whereas they may be appropriate for examining recent trends in relative abundance, there is less opportunity for examining longer-term changes in relative abundance.

Given that skates have been subject to exploitation for over 100 years, yet species-specific data prior to the 1970's is only sporadic, qualitative information from the historical, ichthyological literature can help inform our perspectives on the distribution and general status of fishes, including skates (Quero and Cendrero, 1996). In terms of the major works on the fish of the British Isles, skates have had an inconsistent taxonomy and nomenclature, and so this is summarised in Annex I.

Historical accounts of British fishes allow us to infer that some of our larger-bodied skates have declined dramatically. Although this has been well documented for species such as the 'common skate complex' (Brander, 1981), it has been less documented for white skate *Rostroraja alba*. This species was "*much esteemed by the French who, as long ago as the time of Ray, 1658, observed that French vessels used to arrive at St Ives, in Cornwall, to purchase this fish; and which commerce has been continued up to the present time*" (Day, 1880–1884). Prior to this, Yarrell (1839) stated that "*The French are great consumers of skate, and this species is the favourite fish: their boats come to Plymouth during Lent to purchase skate"*. The importance of white skate was also highlighted by Couch (1862) who considered that white skate was "*the species to which they give a preference*", as it was the largest of the British rays "*For whilst its measurement is often equal to that of the largest common skate, its greater thickness causes it to be of heavier bulk*". French ichthyologists also regarded white skate to be common in the English Channel, Moreau (1881) writing "*La Raie blanche est assez commune dans la Manche pendant le mois d'été; elle paraît moins commune dans l'Ocean*". Although Nobre (1935) did not consider white skate to be particularly common in Portuguese waters, Lozano Rey (1928) had previously noted that "*La* R. alba *Lacépède es una especie propia de las costas atlánticas y mediterráneas europeas, que se encuentra con relative frequencia en todo el litoral ibérico. Vivo en profundidades de alguna consideración, capturándose con el arte del bou. Es una raya de alas carnosas algo estimata en los mercados por esa circunstancia y por la gran talla que pueda alcanzar*"[1].

It is thought that earlier descriptions of *Raia marginata* refer to juvenile white skate, and correspondents to Couch (1862) stated that this species was "*rather plentiful in Portland Roads, on a sandy bottom*" and that it "*prefers sandy bays, partially landlocked, and not very deep water*". Ominously, this correspondent to

[1] "R. alba Lacépède is a typical species of European Atlantic and Mediterranean coasts that is found with relative frequency off all Iberian coasts. It lives in a variety of depths and is captured with "el arte del bou" (a type of trawl). It is a ray with much flesh on the wings, somewhat esteemed in the markets for this reason and for the large size it can attain."

Couch later added "*the bordered ray has of late become much more scarce near Weymouth, if not altogether disappeared*". That this species was thought to prefer partially landlocked sandy bays would be supported by the presence of white skate in the Baie de Dournanez (Brittany), another area where this species seems to have been extirpated from. Although it is unclear as to exactly when the white skate declined most, it was probably in the late 1800s and early 1900s, given that Steven (1932) only recorded them in small quantities. Herdman and Dawson (1902) considered that it occurred in the Irish Sea, which is another area from where there have been no recent records, although these authors noted that some earlier reports of large skates could confuse white skate with the *D. batis* complex.

The decline in the numbers of white skate in the English Channel and other parts of northern Europe went unnoticed, or at least largely unreported, at least until highlighted by Dulvy *et al.* (2000) and Rogers and Ellis (2000). Although the loss of common skate in the Irish Sea was established in the scientific literature earlier (Brander, 1981), this paper suggested that *D. batis* was not uncommon in the late 1940s, and Brander (1981) commented that "*The disappearance of* R. batis *is therefore not surprising, but that this took place virtually unnoticed or without comment in the fisheries literature, perhaps is surprising".* Fisheries scientists had highlighted the need for the conservative management of skates, and elasmobranchs in general, for some years prior to this (e.g. Holden, 1973, 1974, 1977). Indeed, Holden (1977) considered that "*it seems very probable that these stocks of skates have not been replacing themselves for 15–20 years now*".

However, it must also be recognised that concerns over skates had long been expressed prior to this. For example, Minchin (1911) noted that "*unhappily the trawls are gradually extirpating the rays, a slow-growing and not very prolific tribe*". Subsequently, Howell (1921) highlighted that there were "*very large gaps which exist in our knowledge of the life-histories of the many tribes of Raiidae*" and felt that "*It will lamentable indeed if, when the time comes, naturalists remain unequipped with knowledge of the lives and habits of this widespread and most interesting family. For in that case exploitation is likely to proceed in unsound and un-economic lines*". The 1920s and 1930s did see progress in terms of biological studies on skates, but Steven (1932) also noted that "*The statistics at present available show an alarming decline in the total British catches of Rays and Skates from the English Channel*".

4. The introduction of management

Despite concerns over the status of skate stocks, including over-fishing and the loss of formerly abundant species from some areas, the introduction of management has been slow. Although some English and Welsh Sea Fisheries Committees (SFCs) introduced minimum landing sizes for all 'skates and rays', national and international measures have only been brought in relatively recently.

A total allowable catch (TAC) for all skates and rays was first established in the North Sea (the EC waters of ICES Division IIa and sub-area IV) for 1999, with the TAC set at 6,060 t for both 1999 and 2000 (Table 2). The TAC was then reduced by 20% (to 4,848 t) for the period 2001–2002. There have since been annual reductions of 8–25% in the skate and ray TAC for most years, and this TAC was reduced to a record low of 1,397 t for 2010. It should also be noted that the TAC has been higher than the reported landings for much of this period (although it must be recognised that quota may have been restrictive for some fisheries, depending on allocation), and so restrictive management may have only been in place for a few years. In terms of other EC waters (ICES Divisions IIIa, VI-IX), quotas for skates and rays were only established for 2009.

There have also been other measures introduced, including bycatch quotas and technical measures. For example, the 2007 skates and rays quota for the North Sea was deemed a bycatch quota, whereby skated were not to comprise more than 25% by live weight of the catch retained on board. This measure was unpopular with inshore fishermen in the southern North Sea, where *Raja clavata* is locally abundant, and was later applied only to vessels greater than 15 m overall length (Table 2). Some of the problems that arose with the introduction of the bycatch quota were the increased retention of non-target fish (e.g. lesser-spotted dogfish *Scyliorhinus canicula* and starry smooth-hound *Mustelus asterias*) to increase the total catch on board, and some vessels would land (or report) more fish from the adjacent fishing grounds in ICES Division VIId. There are also mesh size regulations for those fisheries targeting skates and rays (CEC, 1998).

Although the introduction of TACs and other measures have been used in skate management for about a decade or so, early management measures have traditionally been for the skate complex as a whole, and species-specific measures have only evolved since 2007, when skate landings for the North Sea were to be reported to species level, at least for the main species. The TAC for skates in the North Sea is now currently at a comparable level to the reported landings, and further reductions in this TAC may result in discarding. Such discarding may not benefit those stocks of most concern to managers, and so there needs to be due consideration of management measures that are more targeted to benefiting those skate stocks of concern.

In 2008, several skate species were listed as species that were not to be fished for, retained or sold, and there were some regional differences in these listings. Whereas some of these listings were not questioned by the fishing industry (e.g. white skate), there were complaints from the fishing industry regarding undulate ray (which can be locally abundant in some areas), and to a lesser extent common skate (which can be frequently caught in some offshore fisheries, and may have a high discard mortality in some of these fisheries).

Indeed, now that management measures have started to become restrictive for skates (either through 'prohibited species' or restrictive quotas), issues of discard survivorship have become increasingly important.

5. Recent species-specific landings: An appraisal of quality

In 2009, UK (English, Welsh and Northern Irish) registered vessels reported approximately 2,007 t of skates, of which only 393 t (19.6%) were not identified to species (Figure 2). Reported landings were made primarily by otter trawl (53.2%), gillnet (21.2%) and beam trawl (16.6%) (Figure 3), with smaller quantities taken by *Nephrops* trawl (6.5%), longline (1.4%) and other gears (1.2%). In terms of the origin of the catches, the majority of landings (> 90%) were reported from eight ICES Divisions (Figure 4-5), covering the south-western approaches (VIIf: 27.2%, VIIe: 20.3% and VIIh: 8.1%), the southern North Sea (IVc, 12.6%), Irish Sea (VIIa, 10.7%) and the eastern English Channel (VIId, 7.6%), and northern/central North Sea (IVa-b, 4.8%). Approximately 90% of reported skate landings originated from 17 combinations of gear and ICES division (Table 3).

The extent of species-specific reporting for batoids (Tables 4a-l) has shown a general improvement from 2008, with the mixed 'skates and rays' category (as a proportion of total batoid landings) decreasing from about 58% in 2008 to ca. 20% in 2009. However, there are still some concerns over the quality of some of these data, as discussed in the examples below.

In general terms, the <u>dominant</u> skates currently being reported from each ICES Division is broadly what would be expected from the biogeography of the species and their distributions as observed in fishery-independent surveys (e.g. Ellis *et al.*¸ 2005a,b). For example, *Raja clavata* is the main species landed in the southern North Sea, Irish Sea and eastern English Channel (Tables 4b,d,f), with *R. montagui* and *R. brachyura* of secondary importance. The two latter species are often landed together and are superficially similar, and this could severely compromise the quality of these data (see ICES, 2010 for further discussion).

UK fisheries in the south-west take a much greater diversity of skate species (Tables 4g-k), with up to 12 batoids reported from the western English Channel (but see below for discussion on potential misidentifications).

Despite the rapid improvement in the proportion of skate landings that are now reported to species level, there has to be due consideration of the data quality. For example, Artic skate *Amblyraja hyperborea* was reported from beam trawlers fishing in the southern North Sea (ICES Division IVc; Table 4b), although this species has never been reported in this Division. The related starry ray (or thorny skate) *Amblyraja radiata* was reported in both the western English Channel (VIIe; Table 4g) and southern Celtic Sea (VIIh; Table 4j), when it is rare or absent from these areas and most common off northern Scotland and in the North Sea (ICES Divisions Iva,b). A misidentification with the not dissimilar thornback ray *Raja clavata* may explain the reported landings.

Some of the erroneous records may also originate from regional variations in common names. For example, sandy ray is the widely used common name for the offshore *Leucoraja circularis*, whereas the local name sandy ray is also used in ports neighbouring the Bristol Channel (VIIf) to refer to small-eyed ray *Raja microocellata*, which is one of the main skate stocks in VIIf. Therefore, it is likely that the nominal reports of '*Leucoraja circularis*' in inshore areas are probably attributable to *Raja microocellata* (see Table 4h). This problem may also occur in the northern Celtic Sea (VIIg; Table 4i), where reported landings for sandy ray are considerably higher than might be expected, and are more consistent with being *R. microocellata*. In addition to confusion between common names, there can be taxonomic confusion between some of the skates in this area. For example, adult *Raja microocellata* are more spinulose than juveniles, and so there may be some confusion with shagreen ray *Leucoraja fullonica* in some south-western areas.

The tribe of 'long-nosed skates' (including *Dipturus oxyrinchus, D. nidarosiensis, D. batis*-complex) are also problematic, especially in those ports where they may only be landed occasionally. The reported landings of this genus in the eastern English Channel (Table 4f), although low, may be considered unreliable, and the accuracy of the species identification for south-western areas (Tables 4i-k) is uncertain, especially as '*Dipturus batis'* is a prohibited species, and fishermen may have reported them as another *Dipturus* species.

There is also concern over the reliability of data for *R. brachyura* and *R. montagui*, which are superficially quite similar. The former is a large-bodied skate with a patchy distribution and existing trawl surveys have not proved to be particularly informative for this species. Hence, there is a rationale for having improved studies on *R. brachyura.*

Given the concerns over some of these data, procedures are required to better assess and improve data quality, including further training for fishers and market officials.

In 2009 undulate ray *Raja undulata*, white skate *Rostroraja alba* and common skate *Dipturus batis* were "not to be retained" under TAC regulations, although there were still some reported landings (the finalised regulations were not brought in at the start of the year, and enforcers may have had an initial period of tolerance). Reported landings of undulate ray were from beam and otter trawlers in the English Channel (VIId-e) and by gillnetters in the eastern English Channel (VIId), and were <2 t (see Tables 4f-g).

Concerning reported landings of common skate, although they still occurred in 2009, actual landings may have been higher if some of the landings were reported as similar-looking congeners (e.g Norwegian skate *Dipturus nidarosiensis* or long-nosed skate *D. oxyrinchus*) (see Tables 4i-k). Reported landings of white skate in the English Channel (Tables 4f-g) ought to be verified, as so little is known about this species, and these records could be due to incorrect identifications.

6. Discard-retention patterns in UK fisheries

In 2009, the Cefas observer programme collected information on skates during 159 of the trips undertaken, with much of the data available collected from otter trawlers operating in ICES Divisions IVb, VIIe-f, beam trawlers in VIIe, and gillnetters working in IVc (Table 5). It should be noted that not all gears were sampled (e.g. there were no samples from longliners fishing for skates). Over the course of this sampling, data were collected for 12 different species of batoid (Table 6).

The length-frequency distributions of the skates being discarded or retained showed broadly similar patterns across the main species (blonde, cuckoo, small-eyed, spotted, shagreen and thornback ray), with first retention occurring at lengths of 40–43 cm total length (L_T), and near full retention at lengths of just over 62 cm L_T (Figure 6). The size at 50% retention was broadly in the range of 53–55 cm L_T, although possibly smaller in the case of *R. brachyura.*

For those species listed as 'prohibited species' on the TACs and quotas regulations, all common skate observed were discarded (length range observed 29–134 cm L_T). Although undulate ray (28–74 cm L_T) were usually discarded, a very small number of larger specimens (94–97 cm L_T) were retained, but these instances tended to be early in the year.

All starry ray *Amblyraja radiata* (observed length range: 21–53 cm L_T) and a 28 cm specimen of long-nosed skate *Dipturus oxyrinchus* were all discarded. In terms of other batoids, marbled electric ray *Torpedo marmorata* (17–51 cm L_T) and stingray *Dasyatis pastinaca* (64–66 cm L_T) were also discarded.

The length-frequency distributions for discarded/retained rajids (except common skate and undulate ray, for which landings were prohibited) was also analysed by gear (Figure 7). Results, as expected, showed that beam trawls captured proportionally more juveniles than the other gears, although comparatively few fish >70 cm L_T were observed. Otter trawls tended to catch proportionally fewer of the smallest length classes (<30 cm L_T) in contrast to beam trawl, although otter trawlers took proportionally more large skates (>70 cm). Data from observers on *Nephrops* trawlers recorded relatively few skates, possibly because several skate species do not favour muddy grounds, and most skates captured were juveniles that were discarded. Gillnets of 90–150 mm mesh size, which are not used to target skates, generally retained skates >50 cm L_T, with juveniles discarded. In contrast, larger mesh gill and trammel nets (which are used when targeting skates) were more selective and the comparatively few small (40–50 cm L_T) fish captured were discarded.

The length-based data collected by observers on commercial vessels was converted to biomass (using length-weight relationships collected during groundfish surveys, Table 7), and the skate species composition (by biomass) was estimated for the retained portion of the catch, aggregated across trips (Table 8).

In general there was close agreement between the commercial landings and the observer data in terms of the main species captured and retained (e.g. the importance of small-eyed ray in otter trawl catches in VIIf, blonde ray in VIIe and thornback ray in IVc). It should be noted that national landings showed a greater diversity of species taken across gear and divisions when compared to the discards observer programme data. For example, reported landings of small-eyed ray in VIIh by beam trawlers and of shagreen by gillnetters in the Bristol Channel (VIIf) had no supporting evidence from observer trips. Although the higher diversity in reported landings is expected, given that the number of observer trips is only a proportion of total number of commercial trips. However, for certain combinations of division and gear, observer data may be useful in gauging data quality or possible misidentifications in commercial data.

7. Discard survival

Discard mortality will include a proportion of the fish that die within the gear (and so may be dependent on gear type, tow duration or soak time, water depth, cod-end weight, catch composition etc.), as well as that proportion of the fish that die during on-board processing prior to discarding (which may be dependent on the method and duration of catch processing, air temperature etc.), as well as longer-term mortality that may be related to injuries sustained in the capture/discarding process, including potential predation on the discards by scavengers.

Discarding is an important issue for skates as (i) juveniles are often discarded (which may be due to local bylaws that provide a minimum landing size for skates and/or due to the low market value for smaller skates prompting discarding); (ii) quota may now be restrictive in some fisheries; and (iii) the EC has included several species as 'prohibited species', which fishers are encouraged to release as soon as practical. However there have only been a few studies on the survivorship of discarded skates (and elasmobranchs in general, see Broadhurst *et al.* (2006)), and so the effectiveness of those management measures that result in discarding is unclear.

In terms of discard studies elsewhere in the world, Stobutzki *et al.* (2002) recorded the within net survival for 847 elasmobranchs captured in prawn trawls off northern Australia, in which approximately 44% were considered to be alive after being landed on deck. There were, however, important species-specific differences in mortality, which ranged from 10% (in the case of the demersal batoid *Rhynchobatus djiddensis*) to 82% (in the case of the carcharhiniform sharks *Carcharhinus dussumieri* and *Rhizoprionodon* *acutus*). This study also reported that survival appeared to increase for larger fish, and females also had a higher chance of survival. It is unclear as to whether the improved survival of females was due to them attaining a greater length than males or for other reasons (e.g. female elasmobranchs often have thicker skin).

Laptikhovsky (2004) examined the survival of 66 skates (across eight taxa) caught from 80–190 m depth in a bottom trawl from the Falkland Island squid fishing grounds. Although ca. 65% of these skates were initially regarded as 'dead', there was some recovery in survival tanks and the actual mortality was estimated at 41%. Once again, there were some inter-specific differences and, for those species with the highest sample sizes, survival ranged from 55% (*Bathyraja brachiurops*) to 75% (*Bathyraja* sp., indet.).

Kaiser and Spencer (1995) examined the survival of a variety of taxa captured using a 4 m beam trawl, although tow duration was only 30 minutes. A sample of *L. naevus* (n = 32) was included within this study, and of the individuals placed in survival tanks, 59% remained alive after 5 days (120 h). Survival tanks were also used to estimate the survival of skates caught in commercial otter trawl in the Bristol Channel (Enever *et al.*, 2010). This study estimated that, of the 162 fish examined for periods of up to 72 h, the short-term survival was approximately 55%, and was related to codend weight, species and sex. Survival was higher for *R. clavata* than for some other species, which may be due to them having a more spinulose and thorny skin. No reliable estimates of longer-term survival were available from these studies.

Tagging studies have been used to verify longer-term survival of discarded fish, although such studies may not allow exact levels of survivorship to be assessed, as tag returns can be influenced by a variety of factors. Nevertheless, studies on inshore fisheries in the Greater Thames Estuary (Ellis *et al.*, 2008) have indicated that *R. clavata* should have reasonably high longer-term survival, as indicated by the return rates of fish tagged from commercial operations (8–19% returned, depending on the gear) being of a comparable magnitude to earlier tagging programmes, which would have focused on the capture and tagging of healthy animals. For example Walker *et al.* (1997) reported return rates of 23–30% for thornback rays tagged and released in the North Sea and English Channel, with these data collected over a much greater time period. Although recent studies were undertaken on board a number of inshore vessels using commercial techniques, and so tow durations for the three studies were generally short (due to the amount of weed on the inshore fishing grounds), and soak times were short for both gillnets (overnight soaks) and longline (2–4 hours), and so such good potential for discard survival may not extend to other fisheries.

Ongoing studies are currently examining other fisheries taking skates, including undulate ray, in order to better understand potential discard survival and which factors may influence survival. Further studies have been undertaken with gillnet, although the first sampling period also had 24 hour soak times, due to the amount of weed in the water. Of the 120 skates captured, 118 (98.3%) were considered to be in good condition to justify tag and release, and only two fish (1.7%) were dead, with one of these showing signs of having been predated on in the net. Although the fish have not been at liberty for a sufficiently long period to understand longer-term survival, there have been some returns.

Whereas many demersal longline fisheries use a 2–4 hour soak time, longliners operating off the Channel Islands have a longer, overnight soak time. Recent studies undertaken off Guernsey examined the health state of skates caught in this fishery. Although relatively few skates were captured (n = 22), most of these were considered to be in lively condition (73%), six (24%) were considered to be sluggish, and none were dead on capture. However, longline-caught fish can have jaw damage and so longer-term mortality may be an important issue. Once again, those fish tagged and released have not been at liberty for sufficiently long to validate that they are surviving capture and discarding in this fishery.

Beam trawlers operate extensively in northern European waters, have close ground contact and can also retain rocks, shell debris and other abrasive catch components. Additionally, these fisheries often have long tow durations. Preliminary studies on beam trawl, using on-board survival tanks, indicated that 17 (63%) of 27 fish kept in survival tanks survived for periods of 53-82 h prior to release. More extensive studies on beam trawl caught fish are currently in progress.

8. Summary

The Ecosystem Approach is an increasingly important issue in fisheries management, although the assessments of fishery resources are still often based on the single species assessments of the putative stocks. Indeed, most of the stock assessments undertaken by the ICES assessment working groups are single-species assessments, and even the assessments undertaken by the multispecies working groups are generally either exploratory or based on a restricted number of species. Skates have been subject to much more than 100 years of exploitation in European seas, although management at an EC level was only introduced in most areas in recent years. The skate complex of the ICES region is diverse, differs regionally (Table 9) and the biology and ecology of the majority of skate species are poorly known.

Traditionally, the lack of species-specific information on skates may be due to their perceived low market value (and so lower importance to managers) and problems in identifying what can be problematic groups of taxa. The aggregation of 'skate and ray' catch data, which has hampered analyses of catch data for the individual species (e.g. Figueiredo *et al.*, 2007) is also an international issue (e.g. Stevenson and Lewis, 2010).

Fishery-independent trawl surveys have provided the most reliable species-specific data (although even these data sources contain some identification problems), and so our perspectives of the current statuses of the most main species are guided by (a) recent trends in catch rates, and (b) qualitative considerations about the longer-term changes in distribution, ubiquity or abundance from comparisons between recent and historical information. In terms of the perceived states of the various skate stocks/species, these range from some stocks in which catch rates in fishery-independent trawl surveys are stable or increasing, to species such as white skate which are considered near extirpated. Hence, there is a need to move to management that is more targeted to the stocks of concern.

Fortunately, species-specific landings information for skates is slowly improving, both in terms of the extent of data recorded and, hopefully, the quality. There are now requirements to report some of the main skate species to species-level in many ICES eco-regions. Such data may allow quota management systems to be better allocated to the main species in the future, although, in the short-term, there has to be due consideration with regards the data quality. Many laboratories have undertaken market sampling of skates to better understand the species (and length and sex) compositions of landed skates (e.g. Machado *et al.*, 2004; ICES, 2009, 2010), and information from observer programmes can also provide useful information on the species composition. It is important that such data are contrasted to reported landings data in order to gain some confidence in the data quality, or to highlight potential mismatches in the species compositions. For example, observed discrepancies in the proportions of *R. brachyura* and *R. montagui* are considered to exist in some commercial landings data (see ICES, 2010), indicating that either improved training in species identification or dedicated market sampling is required. Alternatively, if it is felt that data for some species-pairs will always be confounded to a certain extent, are there options for assessing and advising on such species within a species-pair?

It is important to recognise that the management of (often data-poor) species complexes is not unique to skates and other elasmobranchs (e.g. deep-water sharks). For example the rockfish (Scorpaenidae) complexes off the western coasts of North America are highly diverse. These species also have life-history characteristics that can make them susceptible to fishing pressure, including a high longevity and late age at maturity, and some species have restricted spatial distributions. Given the large number of species in this complex, species-specific catch data are also limited for many of the species (see Parker *et al.*, 2000; Heifetz *et al.*, 2007). Indeed comparatively few rockfish have had full stock assessments and, although some of the main species (or species-pairs) are now assessed, the majority of species are simply categorised within assemblage-based complexes (e.g. near shore, shelf or slope rockfish; or demersal shelf, pelagic shelf, and 'other' slope rockfish).

ICES has only advised on elasmobranchs in recent times, and species-specific advice for skates only provided in 2008. Whereas formal stock assessments have not yet been undertaken to underpin this advice, the examination of fishery-independent data has enabled ICES to provide a general evaluation of the stocks for the main inner-shelf species encountered in existing surveys. However, survey data are limited for many species of skate found in some parts of the ICES area (e.g. further offshore). Although managers should aspire for more species-specific assessments in the future, the ICES community may need to consider the merits of evaluating some of the lesser-known skate species within ‘assemblage groupings’ as an interim measure, as this may help enable management advice to be provided for those fisheries operating over the distributions of such assemblages.

Although there are obvious improvements to the data that are now available with which to monitor, evaluate and advise on the current status of some stocks of skate, there are still several important issues that need to be addressed. Although there have been tagging and/or genetic studies on some of the more common inshore species, our knowledge of the stock structure and stock units for most species is lacking. Many of the scientific trawl surveys coordinated by ICES expert groups collect information on maturity, although most laboratories do not have the resource and/or expertise to age skates and data on fecundity are limited. There may be ecologically important habitats for some skate species, and spatial management targeted to those species or stocks of concern could be a useful option for managers, although there is incomplete information on the distributions of nursery and spawning grounds, and sites of importance to spatially-restricted species.

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Table 1: Taxonomic list of skates (Rajidae) occurring around the British Isles (including adjacent deep-water habitats in the North-east Atlantic). Main skate species that are normally reported from the continental shelf are highlighted with an asterix. Further deep-water skates may be expected to occur[2] . Adapted from Wheeler (1969, 1978, 1992), Stehmann and Bürkel (1984), Edwards and Davis (1997) and Wheeler *et al.* (2004).

		Scientific name and authority	**Common name**	**Source**
	1	*Amblyraja hyperborea* (Collett, 1879)	Arctic skate	Wheeler *et al.* (2004)
	2	*Amblyraja jenseni* (Bigelow & Schroeder, 1950)	Short-tail skate	Wheeler *et al.* (2004)
*	3	*Amblyraja radiata* (Donovan, 1808)	Starry ray	Wheeler (1992)
	4	*Bathyraja pallida* (Forster, 1967)	Pale ray	Wheeler *et al.* (2004)
	5	*Bathyraja richardsoni* (Garrick, 1961)	Richardson's ray	Wheeler *et al.* (2004)
	6	*Bathyraja spinicauda* (Jensen, 1914)	Spinetail ray	Wheeler *et al.* (2004)
	-	*Dipturus batis* (Linnaeus, 1758)	Common skate	
*	7	= *Dipturus* cf. *flossada*	= Blue skate	Wheeler, 1992; Griffiths *et al.*, 2010, Iglésias *et al.*, 2010
*	8	= *Dipturus* cf. *intermedia*	= Flapper skate	
	9	*Dipturus linteus* (Fries, 1838)	Sailray	Fishbase (2010)[3]
	10	*Dipturus nidarosiensis* (Storm, 1881)	Norwegian skate	Wheeler *et al.* (2004)
*	11	*Dipturus oxyrinchus* (Linnaeus, 1758)	Long-nosed skate	Wheeler (1992)
*	12	*Leucoraja circularis* (Couch, 1838)	Sandy ray	Wheeler (1992)
*	13	*Leucoraja fullonica* (Linnaeus, 1758)	Shagreen ray	Wheeler (1992)
*	14	*Leucoraja naevus* (Müller & Henle, 1841)	Cuckoo ray	Wheeler (1992)
	15	*Malacoraja kreffti* (Stehmann, 1977)	Krefft's ray	Wheeler *et al.* (2004)
	16	*Malacoraja spinacidermis* (Barnard, 1923)	Soft skate	Fishbase (2010)[4]
	17	*Neoraja caerulea* (Stehmann, 1976)	Blue ray	Wheeler *et al.* (2004)
*	18	*Raja brachyura* Lafont, 1873	Blonde ray	Wheeler (1992)
*	19	*Raja clavata* Linnaeus, 1758	Thornback ray	Wheeler (1992)
*	20	*Raja microocellata* Montagu, 1818	Small-eyed ray	Wheeler (1992)
*	21	*Raja montagui* Fowler, 1910	Spotted ray	Wheeler (1992)
*	22	*Raja undulata* Lacepède, 1802	Undulate ray	Wheeler (1992)
	23	*Rajella bathyphila* (Holt & Byrne, 1908)	Deepwater ray	Wheeler *et al.* (2004)
	24	*Rajella bigelowi* (Stehmann, 1978)	Bigelow's ray	Wheeler *et al.* (2004)
*	25	*Rajella fyllae* (Lütken, 1887)	Round skate	Wheeler (1992)
	26	*Rajella kukujevi* (Dolganov, 1985)	Mid-Atlantic skate	Wheeler *et al.* (2004)
*	27	*Rostroraja alba* (Lacepède, 1803)	White skate	Wheeler (1992)

[2] Wheeler *et al.* (2004) also referred to a deep-water skate that was tentatively identified as either smoothback skate *Rajella ravidula* (Hulley, 1970) or ghost skate *Rajella dissimilis* (Hulley, 1970)
[3] Based on museum specimens collected from near Faroe islands
[4] Based on museum specimen (MNHN 1999-1157) from 55°27' N; 10°1' W

Table 2: Introduction of management measures for skates and rays.

Year	EC waters of North Sea (IV) and Norwegian Sea (IIa)	EC waters of IIIa	EC waters of VIId	EC waters of VIa-b and VIIa-c, e-k	EC waters of VIII and IX	Source
1999	6060 t					CEC (1999a)
2000	6060 t					CEC (1999b)
2001	4848 t					CEC (2000)
2002	4848 t					CEC (2001)
2003	4121 t					CEC (2002)
2004	3503 t					CEC (2003)
2005	3220 t					CEC (2004)
2006	2737 t					CEC (2005)
2007	2190 t (1)					CEC (2006)
2008	1643 t (2)					CEC (2008)
2009	1643 t(3-5)	68 t (3,5)	1044 t (3,8)	15748 (6-7)	6423 t (9,10)	CEC (2009)
2010	1397 t (3-5)	58 t (3,5)	887 t (3,8,12)	13387 t (6,7,11)	5459 t (9,10)	CEC (2010)

(1) By-catch quota. These species shall not comprise more than 25 % by live weight of the catch retained on board.
(2) Catches of Cuckoo ray (*Leucoraja naevus*) (RJN/2AC4-C), Thornback ray (*Raja clavata*) (RJC/2AC4-C), Blonde ray (*Raja brachyuran*) (RJH/2AC4-C), Spotted ray (*Raja montagui*) (RJM/2AC4-C), Starry ray (*Amblyraja radiate*) (RJR/2AC4-C) and Common skate (*Dipturus batis*) (RJB/ 2AC4-C) shall be reported separately.
(3) Catches of Cuckoo ray (*Leucoraja naevus*) (RJN/2AC4-C), Thornback ray (*Raja clavata*) (RJC/2AC4-C), Blonde ray (*Raja brachyura*) (RJH/2AC4-C), Spotted ray (*Raja montagui*) (RJM/2AC4-C) and Starry ray (*Amblyraja radiata*) (RJR/2AC4-C) shall be reported separately.
(4) By-catch quota. These species shall not comprise more than 25 % by live weight of the catch retained on board. This condition applies only to vessels over 15 m length overall.
(5) Does not apply to Common skate (*Dipturus batis*). Catches of this species may not be retained on board and shall be promptly released unharmed to the extent practicable. Fishers shall be encouraged to develop and use techniques and equipment to facilitate the rapid and safe release of the species.
(6) Catches of Cuckoo ray (Leucoraja naevus)) (RJN/67AKXD), Thornback ray (Raja clavata) (RJC/67AKXD), Blonde ray (Raja brachyura) (RJH/67AKXD), Spotted ray (Raja montagui) (RJM/67AKXD), Smalleyed ray (Raja microocellata) (RJE/67AKXD), Sandy ray (Leucoraja circularis)(RJI/67AKXD) and Shagreen ray (Leucoraja fullonica) (RJF/67AKXD) shall be reported separately.
(7) Does not apply to Undulate ray (Raja undulata), Common skate (Dipturus batis), Norwegian skate (Raja (Dipturus) nidarosiensis) and White skate (Rostroraja alba). Catches of these species may not be retained on board and shall be promptly released unharmed to the extent practicable. Fishers shall be encouraged to develop and use techniques and equipment to facilitate the rapid and safe release of the species.
(8) Does not apply to Common skate (Dipturus batis) and Undulate Ray (Raja undulate). Catches of this species may not be retained on board and shall be promptly released unharmed to the extent practicable. Fishers shall be encouraged to develop and use techniques and equipment to facilitate the rapid and safe release of the species.
(9) Catches of Cuckoo ray (*Leucoraja naevus*) (RJN/8910-C), Thornback ray (*Raja clavata*) (RJC/8910-C) shall be reported separately.
(10) Does not apply to Undulate ray (*Raja undulata*), Common skate (*Dipturus batis*) and White skate (*Rostroraja alba*). Catches of these species may not be retained on board and shall be promptly released unharmed to the extent practicable. Fishers shall be encouraged to develop and use techniques and equipment to facilitate the rapid and safe release of the species.
(11) Of which up to 5 % may be fished in EU waters of VIId
(12) Of which up to 5 % may be fished in EU waters of VIa, VIb, VIIa-c and VIIe-k

Table 3: Major landings of skates by UK (England, Wales and Northern Ireland) in 2009, by gear and area

ICES Division	Broad gear category	Landings (t)	% total skate landings
VIIf	Otter trawl	406.4	20.2
VIIe	Otter trawl	200.8	10.0
VIIa	*Nephrops* trawl	124.3	6.2
VIIe	Gillnet	121.9	6.1
VIIh	Beam trawl	118.5	5.9
IVc	Otter trawl	118.2	5.9
VIIf	Gillnet	103.3	5.1
IVc	Gillnet	89.3	4.4
VIId	Gillnet	78.8	3.9
VIIe	Beam trawl	75.2	3.7
VIIj-k	Otter trawl	74.9	3.7
IVa-b	Otter trawl	68.0	3.4
VIIa	Otter trawl	60.4	3.0
VIIg	Otter trawl	51.7	2.6
VIId	Beam trawl	40.8	2.0
VIIh	Otter trawl	39.3	2.0
VIIf	Beam trawl	32.0	1.6

Table 4(a): Species composition of batoids in the Northern and Central North Sea (IVa-b)

Species	Beam trawl	Gillnet	Longline	*Nephrops* trawl	Otter trawl	Other
Amblyraja hyperborea	-	-	-	-	<0.1	-
Amblyraja radiata	-	-	-	4.1	<0.1	4.3
Dipturus batis	-	-	-	1.5	-	-
Leucoraja naevus	-	0.1	-	24.5	2.3	2.3
Raja clavata	24.4	97.4	100.0	57.6	92.2	90.0
Raja montagui	59.3	-	-	11.2	4.7	-
Raja brachyura	16.3	2.5	-	1.1	0.3	3.4
Raja microocellata	0.1	-	-	-	0.4	-
Total landings (t)	22.814	1.697	0.814	2.775	67.957	0.376
Landings to species (t)	22.809	1.088	0.814	2.528	62.058	0.351
ID to species (%)	99.98%	64.1%	100%	91.1%	91.3%	93.4%

Table 4(b): Species composition of batoids in the Southern North Sea (IVc)

Species	Beam trawl	Gillnet	Longline	Otter trawl	Other
Amblyraja hyperborea	2.5	-	-	-	-
Raja clavata	60.8	96.8	95.8	99.4	100.0
Raja montagui	27.3	-	-	0.1	-
Raja brachyura	8.6	3.2	4.2	0.5	-
Raja microocellata	0.7	-	-	-	-
Total landings (t)	24.176	89.312	21.331	118.192	0.098
Landings to species (t)	23.307	42.775	21.248	105.421	0.035
ID to species (%)	96.4%	47.9%	99.6%	89.2%	*35.7%*

Table 4(c): Species composition of batoids off NW Scotland (VIa)

Species	*Nephrops* trawl	Otter trawl
Raja clavata	100	100
Total landings (t)	0.604	2.908
Landings to species (t)	0.168	1.971
ID to species (%)	*27.8%*	67.8%

Table 4(d): Species composition of batoids in the Irish Sea (VIIa)

Species	Beam trawl	Gillnet	Longline	*Nephrops* trawl	Otter trawl	Other
Dipturus batis	-	-	-	0.8	0.1	-
Leucoraja naevus	0.4	-	-	0.3	0.1	-
Raja clavata	88.3	99.9	100.0	98.6	94.6	91.8
Raja montagui	4.2	-	-	0.0	2.0	-
Raja brachyura	4.0	0.1	-	0.2	3.3	8.2
Raja microocellata	3.1	-	-	-	-	-
Total landings (t)	1.061	16.771	0.026	124.323	60.374	12.063
Landings to species (t)	1.052	16.61	0.006	72.611	52.594	11.383
ID to species (%)	99.2%	99.0%	*23.1%*	58.4%	87.1%	94.4%

Table 4(e): Species composition of batoids west of Ireland and Porcupine bank (VIIb-c)

Species	Gillnet	Otter trawl
Dipturus nidarosiensis	-	1.8
Leucoraja fullonica	-	1.9
Leucoraja naevus	-	59.4
Raja clavata	-	33.7
Raja brachyura	100.0	3.0
Total landings (t)	0.269	14.648
Landings to species (t)	0.269	14.602
ID to species (%)	*100 %*	99.7%

Table 4(f): Species composition of batoids in the eastern English Channel (VIId)

Species	Beam trawl	Gillnet	Longline	Otter trawl	Other
Dipturus batis	<0.1	-	-	-	-
Dipturus oxyrinchus	-	0.1	-	-	-
Leucoraja fullonica	-	<0.1	-	-	-
Leucoraja naevus	0.5	<0.1	-	-	-
Raja clavata	47.7	73.9	53.9	77.0	65.8
Raja montagui	4.5	3.0	5.7	3.7	8.7
Raja brachyura	43.8	20.2	33.9	16.6	23.7
Raja microocellata	2.8	2.6	6.5	2.0	1.8
Raja undulata	0.6	0.1	-	0.7	-
Rostroraja alba	-	0.2	-	-	-
Total landings (t)	40.814	78.818	1.052	30.264	1.915
Landings to species (t)	34.198	52.09	1.039	22.819	1.323
ID to species (%)	83.8%	66.1%	98.8%	75.4%	69.1%

Table 4(g): Species composition of batoids in the western English Channel (VIIe)

Species	Beam trawl	Gillnet	Longline	Otter trawl	Other
Amblyraja radiata	-	<0.01	-	<0.01	-
Dipturus batis	<0.01	0.1	-	0.1	-
Leucoraja circularis	<0.01	0.1	-	0.2	0.4
Leucoraja fullonica	0.2	0.1	-	0.3	-
Leucoraja naevus	28.4	24.0	3.1	7.2	12.9
Raja clavata	8.7	24.5	19.4	29.2	39.2
Raja montagui	7.6	1.4	0.4	5.8	14.9
Raja brachyura	48.7	47.5	75.5	50.9	26.1
Raja microocellata	4.3	2.3	1.5	6.2	6.4
Raja undulata	2.1	-	-	0.1	-
Rostroraja alba	-	-	-	<0.01	-
Torpedo marmorata	-	<0.01	-	-	-
Total landings (t)	75.171	121.92	2.385	200.788	6.666
Landings to species (t)	55.286	106.9	1.394	153.046	3.645
ID to species (%)	73.6%	87.7%	58.5%	76.2%	54.7%

Table 4(h): Species composition of batoids in the Bristol Channel (VIIf)

Species	Beam trawl	Gillnet	Longline	Otter trawl	Other
Dipturus batis	-	<0.1	-	-	-
Leucoraja circularis	0.5	2.6	-	2.0	3.2
Leucoraja fullonica	-	2.9	-	1.0	-
Leucoraja naevus	28.5	11.8	4.6	0.4	1.0
Raja clavata	5.2	23.0	-	31.7	43.6
Raja montagui	10.6	0.8	-	5.2	3.8
Raja brachyura	45.8	43.7	93.0	23.7	25.9
Raja microocellata	9.4	15.2	2.3	35.9	22.5
Torpedo nobiliana	<0.1	-	-	0.01	-
Total landings (t)	32.02	103.345	1.933	406.405	2.236
Landings to species (t)	22.333	73.092	0.56	324.154	2.149
ID to species (%)	69.8%	70.7%	*29.0%*	79.8%	96.1%

Table 4(i): Species composition of batoids in the northern Celtic Sea (VIIg)

Species	Beam trawl	Gillnet	*Nephrops* trawl	Otter trawl	Other
Dipturus batis	-	<0.1	-	-	-
Dipturus nidarosiensis	-	-	-	1.8	-
Dipturus oxyrinchus	-	2.1	-	0.4	-
Leucoraja circularis	8.0	-	-	6.1	-
Leucoraja fullonica	0.5	-	-	6.5	-
Leucoraja naevus	10.9	33.2	-	17.4	-
Raja brachyura	24.0	13.1	-	14.4	27.3
Raja clavata	41.7	14.2	5.6	33.8	72.7
Raja microocellata	14.2	30.1	-	18.0	-
Raja montagui	0.5	7.3	94.4	1.8	-
Torpedo nobiliana	0.1	-	-	-	-
Total landings (t)	18.75	7.414	3.365	51.68	0.011
Landings to species (t)	16.185	5.577	0.054	49.81	0.011
ID to species (%)	86.3%	75.2%	*1.6%*	96.4%	*100%*

Table 4(j): Species composition of batoids in the southern Celtic Sea (VIIh)

Species	Beam trawl	Gillnet	Otter trawl
Amblyraja radiata	0.6	-	-
Dipturus batis	0.6	-	-
Dipturus oxyrinchus	-	-	12.5
Leucoraja circularis	<0.01	-	-
Leucoraja fullonica	1.9	0.5	34.7
Leucoraja naevus	88.3	53.5	50.0
Raja clavata	0.6	3.3	2.6
Raja montagui	0.4	0.1	-
Raja brachyura	3.0	32.0	0.2
Raja microocellata	4.6	10.6	-
Total landings (t)	118.49	4.335	39.27
Landings to species (t)	115.857	4.187	39.201
ID to species (%)	97.8%	96.6%	99.8%

Table 4(k): Species composition of batoids in South-west of Ireland (VIIj-k)

Species	Gillnet	Otter trawl
Dipturus nidarosiensis	-	5.0
Dipturus oxyrinchus	-	4.8
Leucoraja fullonica	-	10.2
Leucoraja naevus	35.2	66.6
Raja clavata	-	12.5
Raja montagui	-	0.3
Raja brachyura	39.6	0.6
Raja microocellata	25.2	-
Total landings (t)	0.512	74.936
Landings to species (t)	0.512	74.570
ID to species (%)	*100%*	99.5%

Table 4(l): Species composition of batoids in the Bay of Biscay (VIII)

Species	Gillnet	Otter trawl
Leucoraja fullonica	0.3	-
Raja clavata	83.3	-
Raja montagui	16.4	27.3
Raja brachyura	-	72.7
Total landings (t)	0.319	0.011
Landings to species (t)	0.311	0.011
ID to species (%)	*97.5%*	*100%*

Table 5: Number of trips observed by gear type and ICES division (2009 data) (for trips containing skates and rays)

ICES division	Beam Trawl	Gillnet	*Nephrops* Trawl	Otter Trawl	Total by area
IIa	-	-	-	1	**1**
IVa	-	-	1	2	**3**
IVb	-	-	13	17	**30**
IVc	1	17	-	-	**18**
VIIa	-	-	6	2	**8**
VIId	2	2	-	6	**10**
VIIe	26	8	-	28	**62**
VIIf	3	3	-	13	**19**
VIIg	-	1	-	2	**3**
VIIh	5	-	-	-	**5**
Total by gear	**37**	**31**	**20**	**71**	

Table 6: Batoids sampled and their occurrence (discarded and retained) in observer trips in 2009 by gear type showing the number of trips where species occur (N) and raised number of individuals recorded (n). (Raising factors for sub-sampling ranged from 1–31.5, with the majority less than 10)

Common Name	Scientific Name	Beam Trawl		Gillnet		*Nephrops* Trawl		Otter Trawl	
		N	n	N	n	N	n	N	n
Starry ray	*Amblyraja radiata*	-		-		4	514	9	689
Common skate	*Dipturus batis*	4	55	1	3	-		-	
Long-nosed skate	*Dipturus oxyrinchus*	-		-		-		1	1
Shagreen ray	*Leucoraja fullonica*	4	65	-		-		-	
Cuckoo ray	*Leucoraja naevus*	20	2249	8	138	12	97	26	362
Thornback ray	*Raja clavata*	15	602	19	528	7	91	42	1658
Spotted ray	*Raja montagui*	27	424	6	17	2	10	45	1084
Blonde ray	*Raja brachyura*	25	519	6	129	-		26	726
Smalleyed ray	*Raja microocellata*	5	26	2	27	-		23	2008
Undulate ray	*Raja undulata*	10	167	1	18	-		4	13
Marbled electric ray	*Torpedo marmorata*	12	87	-		-		-	
Sting ray	*Dasyatis pastinaca*	2	6	-		-		-	

Table 7: Relationships between total weight (W) and total length (L) for nine skate species used to estimate the biomass (kg)

Species	Acronyms	*n*	Length range	Length-weight relationship	r-sq
Amblyraja radiata	SYR	453	8–49 cm	$W = 0.0105.L^{2.9374}$	0.963
Dipturus batis	SKT	61	20–156 cm	$W = 0.0024.L^{3.2318}$	0.994
Leucoraja fullonica	SHR	118	14–101 cm	$W = 0.0044.L^{3.0286}$	0.948
Leucoraja naevus	CUR	1098	10–69 cm	$W = 0.0038.L^{3.1284}$	0.993
Raja brachyura	BLR	420	12–102 cm	$W = 0.0025.L^{3.2764}$	0.995
Raja clavata	THR	4096	10–98 cm	$W = 0.0042.L^{3.1093}$	0.992
Raja microocellata	PTR	1015	12–83 cm	$W = 0.0031.L^{3.2039}$	0.995
Raja montagui	SDR	2209	10–74 cm	$W = 0.0037.L^{3.1456}$	0.991
Raja undulata	UNR	69	15–81 cm	$W = 0.0053.L^{3.0611}$	0.961

Table 8: Species composition of retained skates in 2009 by ICES division and gear for some of the more important UK skate fisheries, as inferred from observer data and reported landings

Gear Type	ICES Div.	Data	*A. hyperborea*	*A. radiata*	*R. brachyura*	*L. naevus*	*D. oxyrinchus*	*R. microocellata*	*D. nidarosiensis*	*L. circularis*	*R. montagui*	*L. fullonica*	*D. batis*	*R. clavata*	*R. undulata*
Otter Trawl	7f	Observer			17.0%	0.4%		58.2%			4.0%			20.5%	
		Landings			23.7%	0.4%		35.9%		2.0%[5]	5.2%	1.0%		31.8%	
Beam Trawl	7h	*Observer*[6]				*93.9%*					*1.0%*	*4.5%*		*0.6%*	
		Landings		0.6%[7]	3.0%	88.3%		4.6%		<0.1%	0.4%	1.9%	0.6%	0.6%	
Gillnet	7f	*Observer*[5]			*90.1%*	*0.4%*		*8.7%*			*0.8%*				
		Landings			43.7%	11.8%		15.2%		2.6%[4]	0.8%	2.9%[8]	<0.1%	23.0%	
Otter Trawl	7g	*Observer*[5]			*9.1%*			*41.0%*			*6.6%*			*43.3%*	
		Landings			14.4%	17.4%	0.4%	18.0%	1.8%	6.1%	1.8%	6.5%		33.8%	
Beam Trawl	7e	Observer			75.9%	14.5%		0.5%			6.9%			2.3%	
		Landings			48.7%	28.4%		4.3%		<0.1%	7.6%	0.2%	<0.1%	8.7%	2.1%
Gillnet	4c	Observer			0.4%[9]									99.6%	
		Landings			3.2%									96.8%	
Otter Trawl	4b	Observer			0.3%	3.8%					13.1%			82.8%	
	4ab	Landings	<0.1%[10]	<0.1%	0.3%	2.3%		0.4%			4.8%			92.2%	

[5] No reliable records of sandy ray *Leucoraja circularis* from the Bristol Channel, and these nominal landings probably refer to small-eyed *Raja microocellata*, given that the latter species is known locally as 'sandy ray'

[6] Limited number of observer trips, and so species composition may not be accurate

[7] This may be an erroneous record

[8] Questionable record and may be misidentified small-eyed ray

[9] Fisheries for blonde ray can be both localised and seasonal, and so observer trips may under (or over) represent such species if sampling effort is low

[10] Considered to be an unreliable record

Table 9: Nominal occurrence of skates around the British Isles by ICES Division (● = Present, ○ = absent; ◉ = occasional vagrants in area, or distribution may extend to this division). Adapted from Whitehead *et al.* (1984), Ellis *et al.* (2005a); ICES (2007; Table 1.4) and FishBase.

Scientific name	I	IIa	IIb	Va	Vb	IIIa	IVa	IVb	IVc	VIa	VIb	VIIa	VIIb	VIIc	VIId	VIIe	VIIf	VIIg	VIIh	VIIj	VIIk	VIIIa	VIIIb	VIIIc	VIIId	VIIIe	IXa	IXb	X	XII	XIV
A. hyperborea	●	●	●	●	●	○	◉	○	○	◉	◉	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	?	●
A. jenseni	○	?	?	●	●	○	○	○	○	◉	◉	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	●	●	●
A. radiata	●	●	●	●	●	●	●	●	◉	●	●	○	◉	◉	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	●	●
B. pallida	○	○	○	○	○	○	○	○	○	○	○	○	?	?	○	○	○	○	●	●	●	◉	◉	?	●	●	○	?	?	?	○
B.richardsoni	○	○	○	○	○	○	○	○	○	○	○	○	?	?	○	○	○	○	●	●	●	◉	◉	?	●	●	○	?	?	?	○
B. spinicauda	●	●	●	●	●	○	●	○	○	●	●	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	●	●
"Dipturus batis"	◉	●	○	●	●	●	●	●	◉	●	●	●	●	●	◉	●	●	●	●	●	●	●	●	●	●	?	●	●	●	●	●
D.linteus	?	●	?	●	●	●	◉	○	○	◉	◉	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	●	?
D. nidarosiensis	?	●	?	●	●	?	●	○	○	●	●	○	●	●	○	○	○	○	○	●	●	?	?	○	●	●	○	○	○	?	?
D. oxyrinchus	?	●	?	?	●	●	●	○	○	●	●	○	●	●	○	○	○	◉	●	●	●	●	●	●	●	?	●	●	?	?	?
L. circularis	○	●	○	○	◉	◉	●	◉	○	●	●	○	●	●	○	○	○	◉	●	●	●	●	●	●	●	?	●	●	?	?	?
L. fullonica	●	●	?	●	●	●	●	◉	○	●	●	◉	●	●	○	◉	◉	●	●	●	●	●	●	●	●	?	●	●	?	?	?
L.naevus	○	●	○	?	?	●	●	●	◉	●	●	●	●	●	◉	●	●	●	●	●	●	●	●	●	●	?	●	●	?	?	?
M. kreffti	○	○	○	●	●	○	○	○	○	◉	◉	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
M. spinacidermis	○	○	○	●	●	○	○	○	○	◉	◉	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
N. caerulea	○	○	○	○	○	●	○	○	○	●	●	○	●	●	○	○	○	○	○	●	●	○	○	○	?	?	○	○	○	?	○
N. iberica	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	●	○	?	●	●	?	○	○
Raja asterias	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	●	○	○	○	○
R. brachyura	○	◉	○	○	○	○	●	●	●	●	◉	●	●	◉	●	●	●	●	●	●	○	●	●	●	◉	○	●	◉	○	○	○
R. clavata	○	◉	○	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	◉	●	●	●	●	◉	●	◉	●	○	○
R. microocellata	○	○	○	○	○	○	○	○	◉	◉	○	◉	●	○	●	●	●	●	◉	●	○	●	●	●	○	○	●	○	○	○	○
R.miraletus	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	◉	○	○	●	◉	○	○	○
R. montagui	○	◉	○	○	◉	◉	●	●	●	●	●	●	●	◉	●	●	●	●	●	●	◉	●	●	●	●	○	●	◉	○	○	○
R. undulata	○	○	○	○	○	○	○	○	◉	○	○	◉	●	○	●	●	◉	◉	◉	●	○	●	●	●	○	○	●	○	○	○	○
Rajella bathyphila	○	○	○	●	●	○	○	○	○	●	●	○	●	●	○	○	○	○	○	●	●	○	○	○	?	?	○	○	?	●	●
R. bigelowi	○	○	○	○	○	○	○	○	○	●	●	○	●	●	○	○	○	○	○	●	●	○	○	○	?	?	○	?	●	●	○
R.fyllae	●	●	●	●	●	●	●	○	○	●	●	○	●	●	○	○	○	○	●	●	●	●	○	○	●	●	○	○	○	●	●
R. kukujevi	○	○	○	?	○	○	○	○	○	○	?	○	○	?	○	○	○	○	○	○	?	○	○	○	○	?	○	?	●	●	?
Rostroraja alba	○	○	○	○	○	○	○	○	◉	○	○	◉	●	○	◉	●	◉	◉	◉	●	○	●	●	●	○	○	●	○	○	○	○

Figure 1: Landings of skates and rays (Rajidae) in UK fisheries

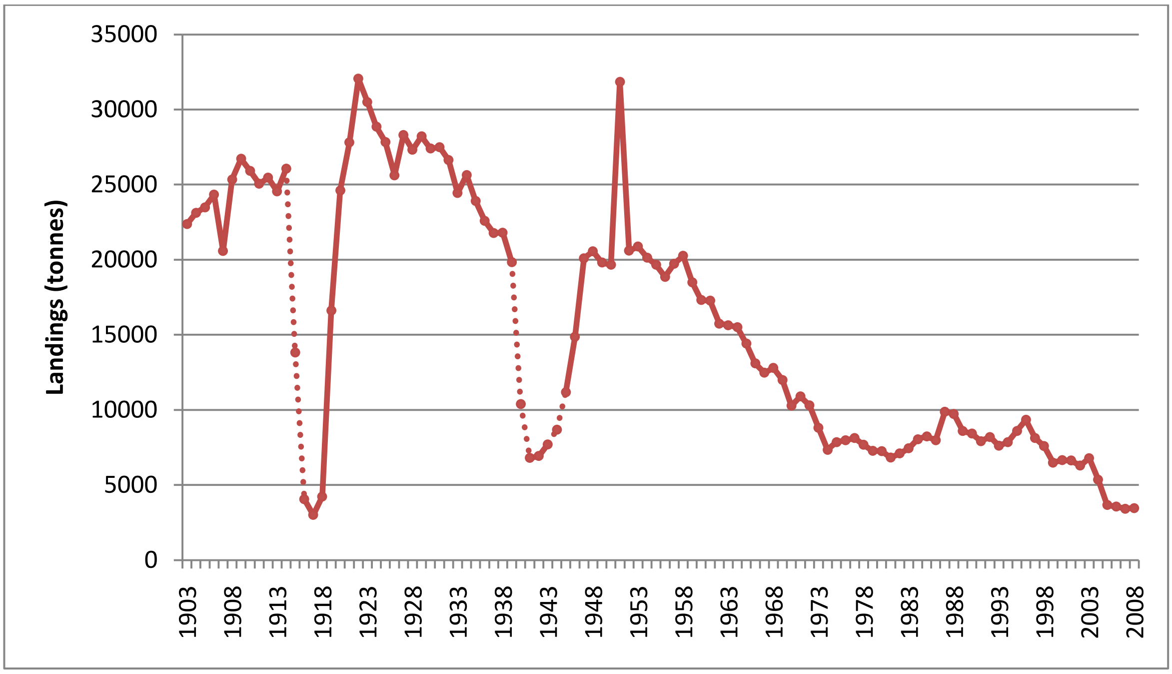


Figure 2: UK (England and Wales) landings of skates by species in 2009. Data for *R. brachyura* and *R. montagui* may be confounded; data for *L. circularis* may include landings of *R. microocellata*.

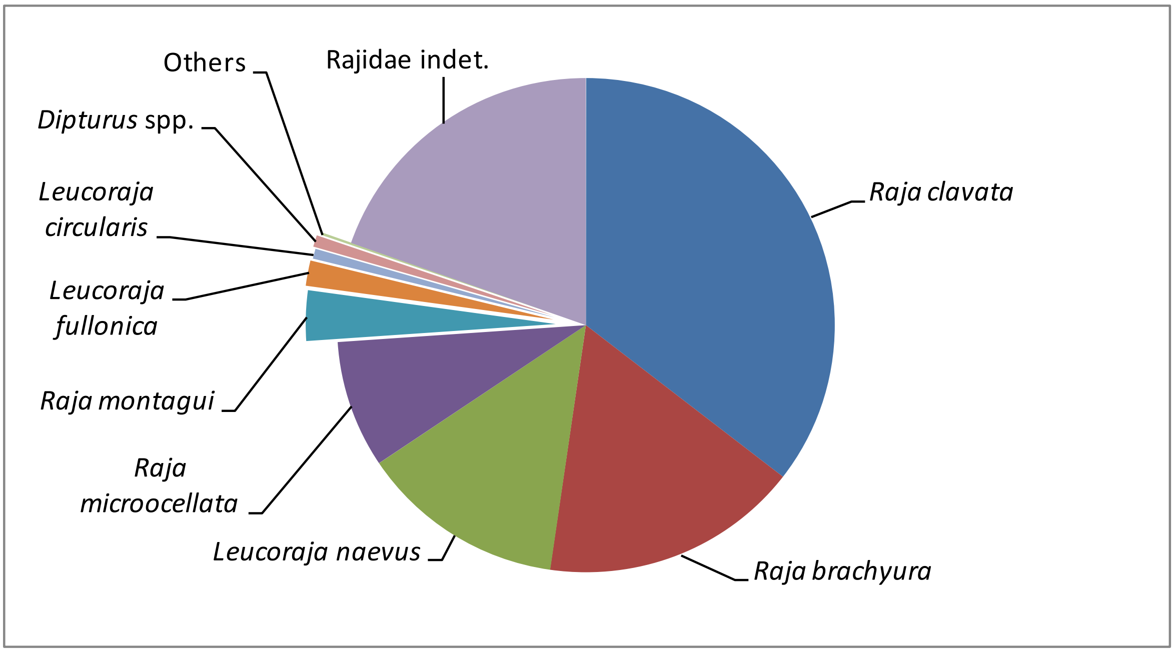


Figure 3: UK (England and Wales) landings of skates by gear in 2009.

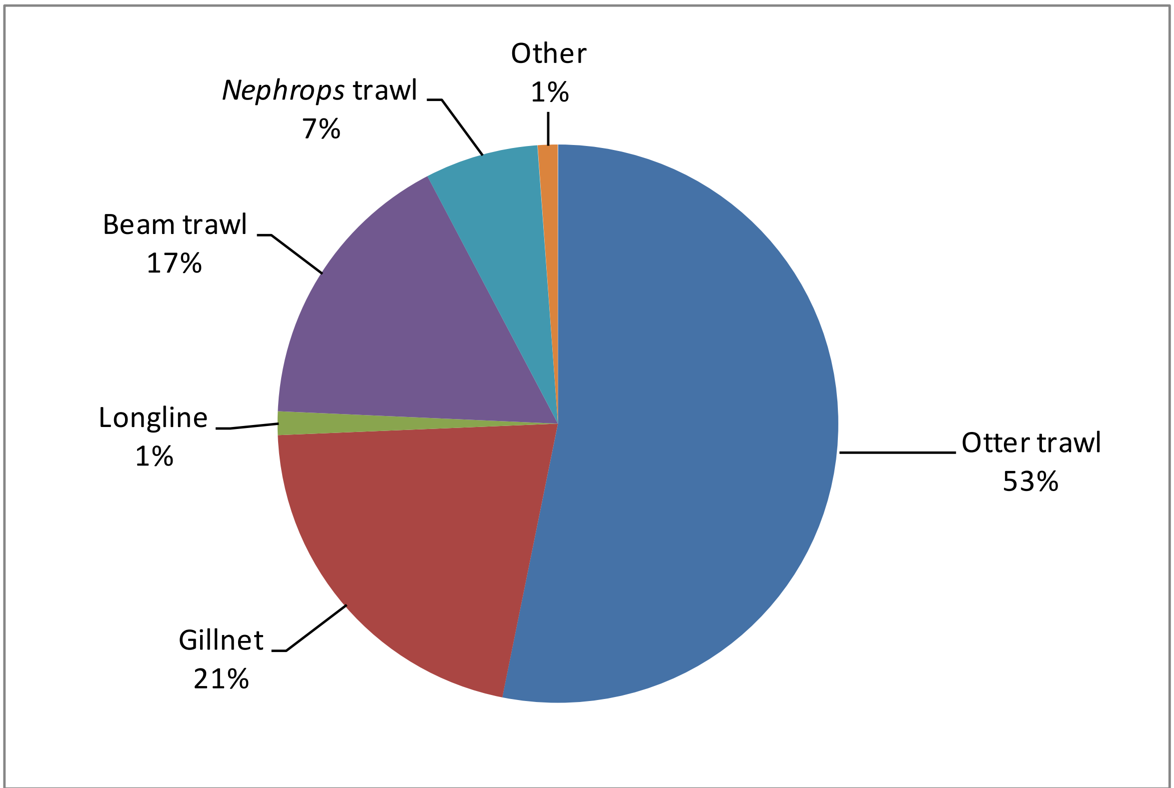


Figure 4: Spatial distribution in reported landings of skates by UK (England and Wales) landings in 2009.

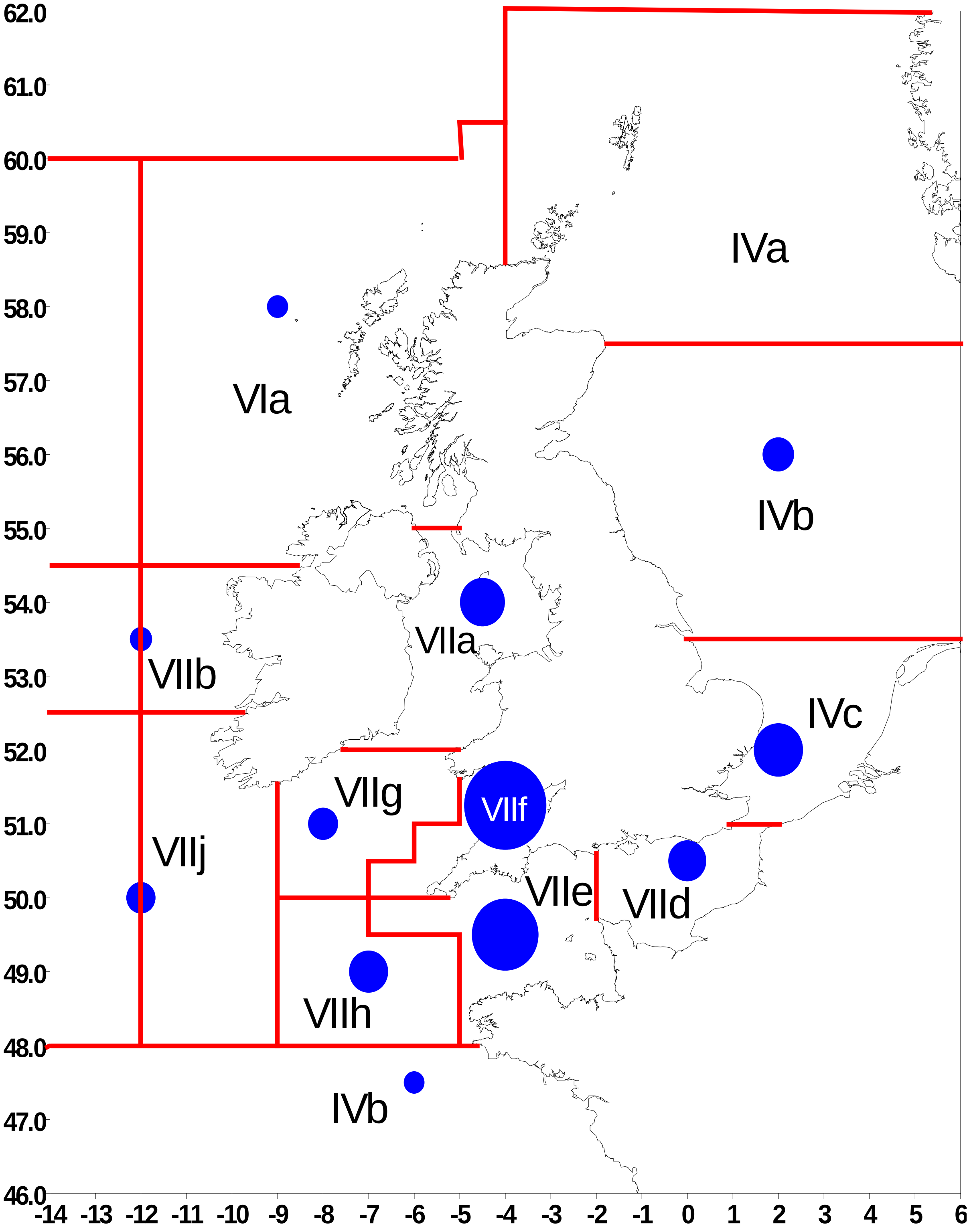


Figure 5: UK (England and Wales) landings of skates by area and gear in 2009 for otter trawl (blue), gillnet (red), longline (green), beam trawl (purple), *Nephrops* trawl (turquoise) and other gears (orange).

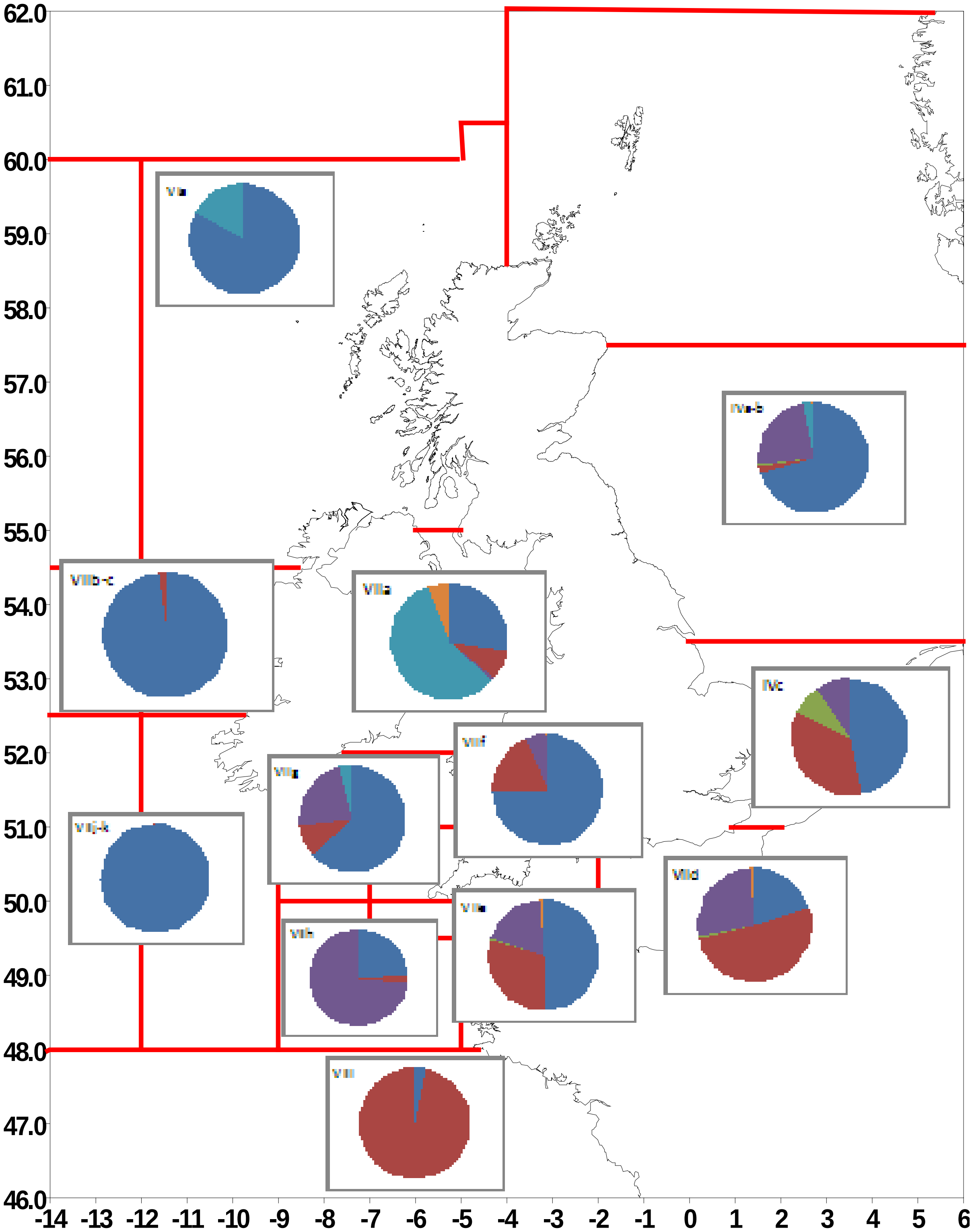


Figure 6: Length-frequency of (a) Blonde ray, (b) Cuckoo ray, (c) Smalleyed ray, (d) Spotted ray, (e) Shagreen ray and (f) Thornback ray discarded and retained across all gears

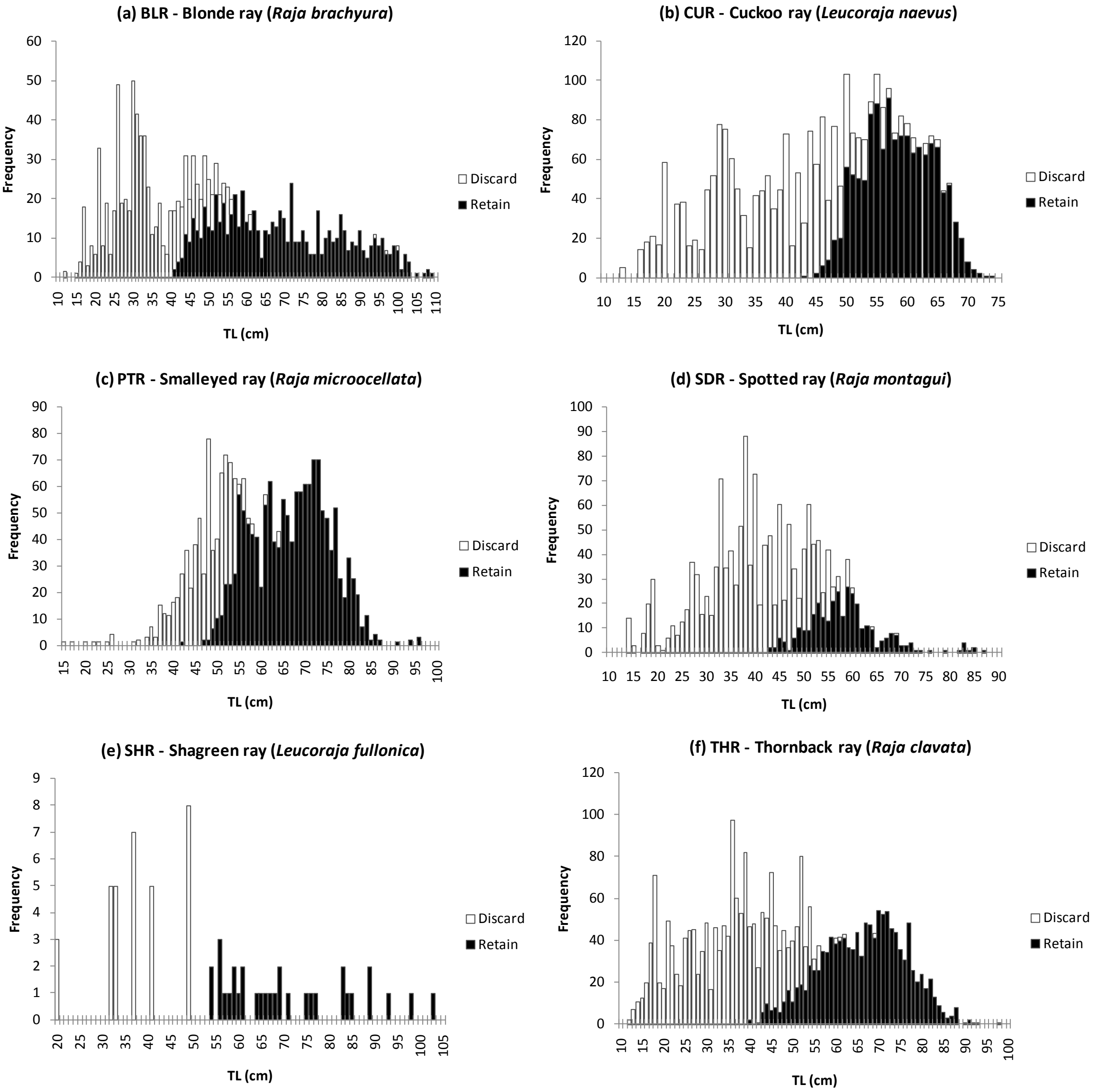
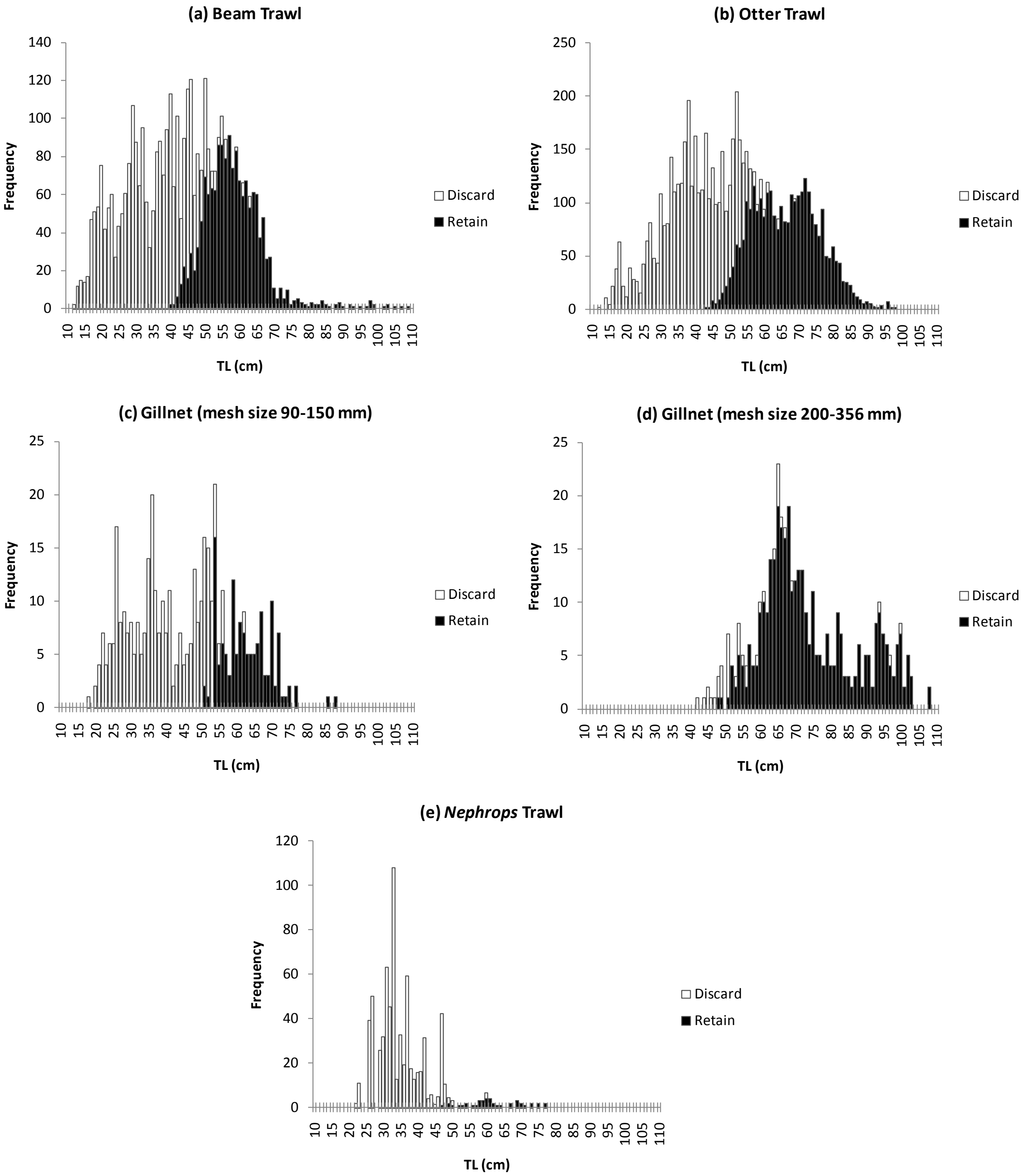


Figure 7: Length-frequency across main *Rajidae* spp. (excluding common skate and undulate ray) discarded and retained by gear type



Annex I: Taxonomic list of skates and how they were treated in general ichthyological works

Arctic skate *Amblyraja hyperborea* (Collett, 1879)
Raja hyperborea (Wheeler, 1978, p. 41)

Starry ray *Amblyraja radiata* (Donovan, 1808)
Raia radiata (Yarrell, 1841, p. 585)
Raia radiata (Couch, 1862, p. 103)
Raia radiata (Day, 1880-1884, p. 347)
Raia radiata (Moreau, 1881, p. 394)
Raja radiata (Poll, 1947, p. 90)
Raja radiata (Wheeler, 1978, p. 40)

Blue skate *Dipturus flossada*
Raia batis (Yarrell, 1841, p. 561)
Raia batis (Couch, 1862, p. 87)
Raia batis (Day, 1880-1884, p. 336)
Raia batis (Moreau, 1881, p. 409)
Raia batis (Le Danois, 1912, p. 27)
Raja batis (Poll, 1947, p. 104, in part)
Raja batis (Wheeler, 1978, p. 42, in part)

Flapper skate *Dipturus intermedia*
Raia intermedia (Yarrell, 1939, p. 66; 1841, p. 558)
Raia intermedia (Couch, 1862, p. 95)
Raia macorhynchus (Day, 1880-1884, p. 338)
Raia macorhynchus (Moreau, 1881, p. 405)
Raja batis (Poll, 1947, p. 104, in part)
Raja batis (Wheeler, 1978, p. 42, in part)

Norwegian skate *Dipturus nidarosiensis* (Storm, 1881)
Raja nidarosiensis (Wheeler, 1978, p. 44)

Long-nosed skate *Dipturus oxyrinchus* (Linnaeus, 1758)
Raia mucronata (Yarrell, 1841, p. 550)
Raia rostrata (Yarrell, 1841, p. 550)
Laeviraja oxyrhynchus (Yarrell, 1841, p. 550)
Raia vomer (Yarrell, 1841, p. 550)
Raia acus (Couch, 1862, p. 93)
Raia oxyrhynchus (Day, 1880-1884, p. 341)
Raia oxyrhynchus (Moreau, 1881, p. 403)
Raja oxyrhynchus (Poll, 1947, p. 107)
Raja oxyrinchus (Wheeler, 1978, p. 44)

Sandy ray *Leucoraja circularis* (Couch, 1838)
Raia radula (Yarrell, 1839, p. 69)
Raia circularis (Couch, 1862, p. 115)
Raia circularis (Moreau, 1881, p. 397)
Raja circularis (Poll, 1947, p. 101)
Raja circularis (Wheeler, 1978, p. 46)

Shagreen ray *Leucoraja fullonica* (Linnaeus, 1758)
Raia fullonica (Yarrell, 1841, p. 578)

Raia chagrinea (Yarrell, 1841, p. 578)
Raia aspersa (Yarrell, 1841, p. 578)
Raia chagrinea (Couch, 1862, p. 117)
Raia fullonica (Couch, 1862, p. 117)
Raia fullonica (Day, 1880-1884, p. 342)
Raia chagrinea (Moreau, 1881, p. 401)
Raia fullonica (Moreau, 1881, p. 432)
Raja fullonica (Poll, 1947, p. 103)
Raja fullonica (Wheeler, 1978, p. 45)

Cuckoo ray *Leucoraja naevus* (Müller & Henle, 1841)
Raia spinosa (Yarrell, 1841, p. 574)
Raia radula (Yarrell, 1841, p. 574)
Raia circularis (Yarrell, 1841, p. 574)
Raia falsavela (Yarrell, 1841, p. 574)
Raia miraletus (Couch, 1862, p. 112)
Raia circularis (Day, 1880-1884, p. 348)
Raia miraletus (Le Danois, 1912, p. 33)
Raja naevus (Poll, 1947, p. 99)
Raja naevus (Wheeler, 1978, p. 46)

Blonde ray Raja *brachyura* Lafont, 1873
[i]*Raia miraletus* (Yarrell, 1841, p. 570, in part)
Raia maculata (Yarrell, 1841, p. 570, in part)
Raia maculata (Couch 1862, p. 104, in part)
Raia maculata (Day, 1880-1884, p. 345, in part)
Raia brachyura (Moreau, 1881, p. 420)
Raia asterias (Le Danois, 1912, p. 33)
Raja brachyura (Poll, 1947, p. 95)
Raja brachyura (Wheeler, 1978, p. 35)

Thornback ray *Raja clavata* Linnaeus, 1758
Raia clavata (Yarrell, 1841, p. 582)
Raia rubus (Yarrell, 1841, p. 582)
Raia clavata (Couch, 1862, p. 99)
Raia clavata (Day, 1880-1884, p. 343)
Raia clavata (Moreau, 1881, p. 391)
Raia clavata (Le Danois, 1912, p. 30)
Raja clavata (Poll, 1947, p. 88)
Raja clavata (Wheeler, 1978, p. 36)

Small-eyed ray *Raja microocellata* Montagu, 1818
Raia microcellata (Yarrell, 1841, p. 567)
Raia microcellata (Couch, 1862, p. 107)
Raia microcellata (Day, 1880-1884, p. 346)
Raia microcellata (Moreau, 1881, p. 417)
Raia microcellata (Le Danois, 1912, p. 31)
Raja microocellata (Wheeler, 1978, p. 38)

Spotted ray *Raja montagui* Fowler, 1910
Raia miraletus (Yarrell, 1841, p. 570, in part)
Raia maculata (Yarrell, 1841, p. 570, in part)
Raia maculata (Couch 1862, p. 104, in part)

Raia maculata (Day, 1880-1884, p. 345, in part)
Raia punctata (Moreau, 1881, p. 426?)
Raia asterias (Moreau, 1881, p. 429?)
Raia punctata (Le Danois, 1912, p. 32)
Raja montagui (Poll, 1947, p. 93)
Raja montagui (Wheeler, 1978, p. 38)

Undulate ray *Raja undulata* Lacepède, 1802
Raia undulata vel mosaica (Moreau, 1881, p. 434)
Raia undulata (Le Danois, 1912, p. 31)
RaJa undulata (Poll, 1947, p. 97)
Raja undulata (Wheeler, 1978, p. 52)

Round skate *Rajella fyllae* (Lütken, 1887)
Raja fyllae (Wheeler, 1978; p. 48)

White skate Rostroraja alba (Lacepède, 1803)
Raia oxyrhynchus (Yarrell, 1841, p. 556, adults)
Raia marginata (Yarrell, 1841, p. 556, juveniles)
Raia oxyrhynchus (Couch, 1862, p. 97, adults)
Raia marginata (Couch, 1862, p. 110, juveniles)
Raia alba (Day, 1880-1884, p. 339)
Raia alba (Moreau, 1881, p. 412)
Raia macrorhyncha (Le Danois, 1912, p. 27)
Raja alba (Wheeler, 1978, p. 50)

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[i] Blonde ray and spotted ray were not distinguished at the time, and species descriptions clearly indicate both species were confounded