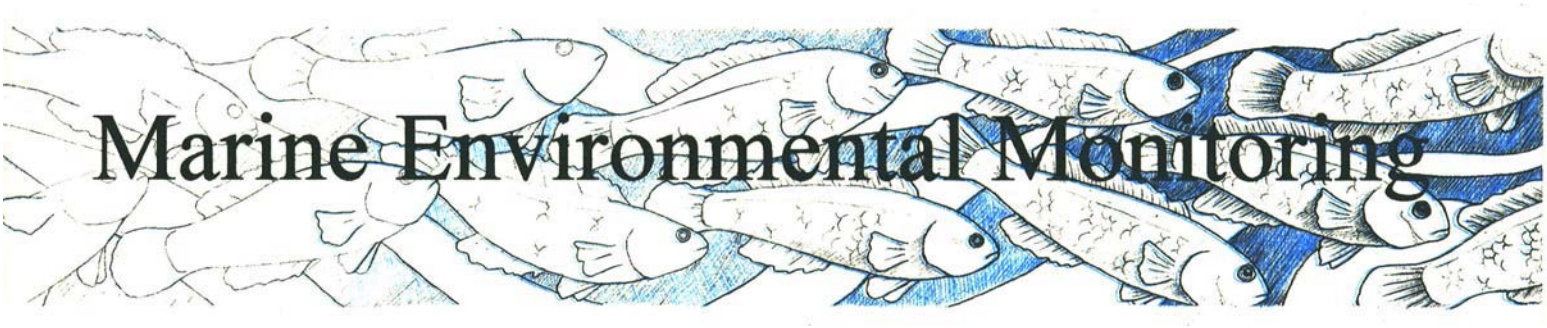

JNCC Report

No. 310

Bycatch of Marine Turtles in UK & Irish Waters

Chris Pierpoint

August 2000

Author
Chris Pierpoint
Marine Environmental Monitoring
Penwalk
Llechryd
Cardigan SA43 2PS

For further information please contact:
Joint Nature Conservation Committee
Dunnet House
7 Thistle Place
Aberdeen
AB10 1UZ

ISSN 0963-8091

Preface

This project has been undertaken to fulfil, in part, the obligations of the UK government as a signatory to the Rio Convention and the resultant Biodiversity Action Plan, (BAP), (Biodiversity: The UK Action Plan (DOE, 1994)), for turtles. It also partly fulfils requirements under the EC Habitats Directive 92/43/EEC in relation to marine turtles.

Paragraphs 4.1 and 4.2 of the BAP for turtles states that signatories must: 'Avoid accidental harm to, and by-catch of, marine turtles when present in UK waters' and 'Contribute to international measures for the conservation of marine turtles' The report, 'Bycatch of Marine Turtles in UK and Irish Waters', goes some way to addressing paragraph 4.1. Bycatch in fishing gear is the principal activity responsible for accidental harm to marine turtles. A study to identify those fishing practices and turtle species involved is an essential first step to producing policy to mitigate harmful practices and avoid harm to turtles. The bycatch study also goes some way to responding to the requirements of paragraph 5.5.4 of the BAP, that states 'Seeks to minimise by-catch of marine turtles by promoting research into fishing gear'.

To address paragraph 4.2 we need to be able to understand the value of UK waters to turtles. We are then able to contribute to greater understanding of the relative importance of UK waters to marine turtles to facilitate the implementation of international conservation measures. The establishment of the database is a first step towards achieving this as well as being a specific requirement under paragraph 5.5.1. The database is also needed to fulfil in part, paragraph 5.5.2 that requests amongst other things that all records be passed to a central UK database.

In addition the database and report go some way to addressing Article 12.4 of the Habitats Directive requires that EU Member States should monitor incidental capture and killing and, in the light of the information gathered, take further research or conservation measures to avoid significant impacts.

The work was funded by English Nature, Scottish Natural Heritage, The Countryside Council for Wales and Marine Environmental Monitoring and managed by the Joint Nature Conservation Committee. The database and report were produced by Marine Environmental Monitoring.

David Simmons
Joint Nature Conservation Committee
August 2000

Summary

Bycatch records of marine turtles are examined from the waters surrounding the UK and Eire. The primary sources of data for this region are records held in the database 'TURTLE' (Pierpoint & Penrose 1999). Additional data have been gathered from marine mammal and discard monitoring programmes. Fishery interactions in other regions are reviewed and mitigation measures taken to reduce bycatch are also discussed.

TURTLE currently holds 712 records of marine turtles in UK and Irish waters and includes 154 records of turtle bycatch. Most bycatch records involve the leatherback turtle (94% of records identified to species), the species most frequently reported from UK and Irish waters. There are a small number of records of loggerhead, Kemp's ridley and hawksbill turtles. The most common method of incidental capture for leatherback turtles is entanglement in rope, particularly those used in pot fisheries targeting crustaceans and whelk. Rope entanglement occurs predominantly between July and October, on the north, west and southwest coasts of the UK and the south and west coasts of Eire. Of 83 capture records since 1980, entanglement in rope accounts for 36 records, 62% of leatherback bycatch for which the method of capture was specified. Recorded mortality was 61%; 11 turtles are known to have been released alive (30.5%). There are no data on injury or post-release mortality.

The database also includes records of leatherback capture in driftnets, trawls, set gill nets, purse seines and in longline fisheries. Data from marine mammal and fisheries monitoring programmes suggest that turtle bycatch in pelagic and demersal trawls, and in set gill nets in UK and Irish waters is uncommon. Bycatch of leatherback and loggerhead turtles is reported from pelagic driftnet fisheries however. The number of animals captured by the French tuna driftnet fleet in 1993 was estimated at 100 turtles (Gougon *et al.* 1993; SMRU 1996), most of which were leatherbacks. Turtle bycatch was also recorded by observers in the smaller Irish and UK driftnet fleets (E Rogan pers. comm.; SMRU, 1996). All turtles taken by French vessels in 1992 and 1993 were reported to have been released alive; recorded mortality on UK and Irish vessels was 25% and 17% respectively. No data are available for vessels of pelagic longline fleets that target tuna *Thunnas* spp. and swordfish *Xiphias gladius* in approximately the same area as French, Irish and UK driftnetters. High capture rates are reported from longline fisheries elsewhere in the North Atlantic and in the Mediterranean Sea (e.g. Witzell 1984, Aguilar *et al.* 1992; Camiñas *et al.* 1992; Johnson *et al.* 1999; Ferreira *et al.* in prep.).

Hence, marine turtles are prone to accidental capture by a wide variety of fishing methods. The highest known incidence of bycatch in UK and Irish waters is recorded for leatherback turtles in inshore pot fisheries and pelagic driftnets. The significance of marine turtle bycatch in the region is not known. Leatherback turtles are globally endangered however, and Spotila *et al* 1996 suggest that the impact of bycatch on Atlantic leatherback populations may be unsustainable.

Recommendations are made to further monitor and address the impact of fishery interactions in this region.

Contents

List of Tables

List of Figures

Introduction

The aim of this investigation is to review current data on marine turtle bycatch in UK and Irish waters. The primary source of bycatch data for this region are records held in the database 'TURTLE' (Pierpoint & Penrose, 1999). This database is a collation of records from numerous published and unpublished sources. It was created under English Nature's Species Recovery Programme with support from Scottish Natural Heritage and the Countryside Council for Wales, under a contract managed by the Joint Nature Conservation Committee. Additional data are available from fishery observation and marine mammal bycatch programmes. An overview of the occurrence, ecology, status and fisheries interactions for those species known to visit UK & Irish waters is also provided here, with reference to these issues in the North Atlantic region as a whole.

1.1 Marine turtles in UK & Irish waters

Five species of marine turtle have been recorded in UK and Irish waters (Brongersma 1972; Penhallurick 1990; Langton *et al.*1996; Gaywood 1997; Pierpoint & Penrose 1999). Only one species however, the leatherback turtle *Dermochelys coriacea* is reported annually and is considered a regular and normal member of our marine fauna (Godley *et al.* 1998). Loggerhead turtles *Caretta caretta* and Kemp's ridley turtles *Lepidochelys kempii* occur less frequently, with most specimens thought to have been carried north from their usual habitats by adverse currents (Carr 1987; Penhallurick 1990; Mallinson 1991). Records of two other vagrant species, the hawksbill turtle *Eretmochelys imbricata* and the green turtle *Chelonia mydas* are very rare (Brongersma 1972; O'Riordan *et al.* 1984; Branson 1997).

1.2 The ecology of leatherback turtles

Leatherback turtles breed circumglobally within latitudes approximately 40°N and 35°S, but range widely to forage in temperate and boreal waters outside the nesting season (Eckert 1995). They are the only species of marine turtle to have developed adaptations to life in cold water (see for example: Greer *et al.*1973; Goff & Stenson 1988). Leatherbacks have been recorded at latitude 60°N in Alaskan waters (Hodge 1979), and to 71°N in the Atlantic (Prichard & Trebbau 1984).

The total number of leatherbacks nesting worldwide in 1995 was estimated at 34,529 (confidence interval 26,177 to 42,878) females (Spotila *et al.* 1996). About 80% of these animals were reported from sites in the Atlantic. Within this region, the largest nesting aggregations occur in French Guiana (Fretey & Girondot 1989) and Surinam (Reichart & Fretey 1993) in northern South America, and in Gabon on the West African coast (Fretey & Girardin 1988). There are other important nesting sites in the Caribbean (particularly Trinidad, the Dominican Republic and the US Virgin Islands) and leatherbacks also nest annually in southern Florida (National Marine Fisheries Service & Fish and Wildlife Service 1992). In French Guiana, the nesting season extends from March to mid-August (Girondot & Fretey 1996). Using data from a number of colonies, Spotila *et al.* (1996) assumed an inter-nesting interval of two and a half years. Only a small number of leatherbacks are thought to nest in the Mediterranean, occasionally in Israel and on the south coast of Sicily (Groombridge 1990). However, the species is present in the region throughout the year (Camiñas 1998).

Long-distance migration has been documented from tag returns and more recently using satellite telemetry. Turtles tagged in French Guiana have been recorded in Europe and north and west Africa (Girondot & Fretey 1996). An indication of the origin of

some leatherbacks recorded in British waters was provided by a female turtle found in Carmarthen Bay, South Wales, in September 1997, that had previously nested and been tagged in French Guiana (R Penrose, Marine Environmental Monitoring, pers. comm.). Satellite transmitters placed on two leatherbacks by Eckert (1998) functioned successfully for 12 months. The turtles were tagged in Trinidad and initially swam north-east beyond Barbados before diverging. One turtle remained in the central Atlantic until the end of November before migrating directly to the African coast. The second animal swam east and then north into the Bay of Biscay, just south of the present study area. At the end of November this turtle also turned south towards the African coast. Both turtles travelled over 11,000km during the year. Morreale *et al.* (1993) report that nesting cohorts use similar migration routes, generally following deep-water bathymetric contours.

There are distinct seasonal peaks in the occurrence of leatherback turtles in northern waters. Around the UK, most turtles are reported between August and October (Gaywood 1997; Godley *et al.* 1998). Using an expanded dataset, Pierpoint & Penrose (1999) report that leatherbacks have been reported from UK and Irish waters in every month, although live sightings peak in August. Strandings peak slightly later, in September and October. On the NW Atlantic coast, peak sightings in Cape Cod Bay also occur in August and September (Prescott 1988), with peak occurrence being progressively earlier in the year as one follows the eastern seaboard south (Epperly *et al.* 1995).

Leatherback turtles feed primarily on jellyfish. Their diet in temperate and boreal waters is known to include cnidarians (siphonophores as well as medusae) and tunicates (salps, pyrosomas) (den Hartog & van Nierop 1984; Davenport & Balazs 1991). In UK and Irish waters they are often reported in the vicinity of jellyfish swarms, and there are several observations of leatherbacks feeding on jellyfish at the surface (e.g. Brongersma 1970; Penhallurick, 1990; C Cronin, JNCC, *in litt.*). *Post- mortem* examinations have found jellyfish in the digestive tract of several bycaught animals (Berrow & Rogan 1994; R Collins, Scottish Agricultural College *in litt.)*, T Patterson, Scottish Agricultural College, *in litt.*). Prey items included *Rhizostoma*, *Cyanea*, *Aurelia* and *Chrysaora*.

1.3 The ecology of other marine turtle species reported from the region

Loggerhead turtles and Kemp's ridley turtles are most frequently recorded on the UK and Irish coasts during the winter and spring (Pierpoint & Penrose 1999). Most are juvenile animals (Brongersma 1972; Mallinson 1991; J. Mallinson, University of Southampton, *in litt.*) washed ashore on west and south-west coasts, during or following periods of stormy weather. Animals often appear cold-stunned, as are many turtles which strand on the NE coast of the USA at this time of year (Prescott 1982; Morreale *et al.* 1992). Multiple (region wide) strandings of loggerheads occur sporadically in the UK and Eire (e.g. 1938 (five records), 1945 (five records), 1990 (seventeen records) and 1992 (five records): Brongersma 1972; Penhallurick 1990; 1991; 1993; Mallinson 1991; Pierpoint & Penrose 1999). The 1990 'invasion' year was clearly exceptional. Most animals strand alive (n = 41; 69%) and several have now been released in warmer waters after receiving specialist, rehabilitative care at centres (J Mallinson, Southampton University, *in litt.*). Kemp's ridley turtles are reported less frequently, and although a high proportion of this species strand alive, there is high post-discovery mortality (Pierpoint & Penrose, 1999).

Loggerheads breed on NW Atlantic, Gulf of Mexico and Caribbean coasts. This is also the most common Mediterranean species with most nesting at sites in Greece, Turkey and Tunisia (Argano & Baldari 1983; Groombridge 1990. Animals from Atlantic populations are also present in the western Mediterranean during the spring and summer (Laurent & Lescure 1995).

In the USA, most nests are found in eastern Florida (Ehrhart 1989). Kemp's ridleys have a

far more restricted nesting range, with most animals breeding near Rancho Nuevo, Mexico (Weber 1995). The majority of individuals of both species found stranded on UK and Irish coasts are thought to originate from NW Atlantic populations (Hays & Clarke 1995). Younger age-classes spend several years associated with *Sargassum* drift lines, convergences, eddies and rings in the North Atlantic gyre (Carr 1986, 1987; Musick & Limpus 1997). The usual habitat for post-pelagic stage Kemp's ridley turtles is inshore or near-shore waters with seagrass beds or muddy benthic habitat, where they feed predominantly on crabs. Similarly, adult loggerheads inhabit relatively shallow coastal, estuarine and continental shelf waters, foraging on shellfish, molluscs and other benthic invertebrates.

Of the rarer visitors to UK and Irish waters, Atlantic hawksbills breed in central America (especially the Yucatan Peninsula), Cuba and the Caribbean, and sub-tropical Florida. This species forages on coral reefs, with some Caribbean animals specialising on certain species of sponge (Vincente 1994). Green turtles breed in the eastern Mediterranean as well as Florida, Surinam and Costa Rica. Unlike other turtle species, adults are herbivorous, their usual diet consisting of sea grass and algae (Mortimer 1982). Adult green turtles prefer inshore habitats.

1.4 Population Status & conservation designations

Marine turtles face a range of threats, both at nesting colonies and in the wider marine environment. Anthropogenic threats include: incidental capture in fishing equipment; beach development / nesting habitat destruction; disorientation of hatchlings by beachfront lighting; directed take; nest destruction by beach vehicles; dredging; ingestion of plastics / marine debris; boat collision; and oil spills (Plotkin 1995).

Leatherback numbers are declining rapidly throughout their range (Spotila *et al*. 1996). Populations in the Pacific and Indian Oceans have, crashed dramatically in recent years (Eckert 1997). Some important Atlantic colonies appear stable (French Guiana / Surinam: Girondot & Fretey 1996). Loggerhead populations are also threatened throughout their range. Numbers of adult animals returning to breed at sites in Georgia, South Carolina and North Carolina for example, are in severe decline (Ehrhart 1989; Frazer 1995). Kemp's ridley turtles are thought to be the most endangered species of marine turtle, although there have been recent signs of improvement (B Godley, Swansea University, pers. comm.). All species are listed as either Endangered or Threatened in the IUCN *Red Data Book* (Groombridge 1982). They receive federal protection in the USA under the US Endangered Species Act 1973, as amended, in which all species are again listed as either Endangered or Threatened (Plotkin, 1995).

Gaywood (1997) summarises legislative and international agreements concerning the conservation of marine turtles in British waters. Legislative coverage is provided for all species under: the EC Habitats and Species Directive 1992 (Annex IV; loggerheads are also listed under Annex II); and the Conservation Regulations 1994 (Schedule II); the Wildlife and Countryside Act 1981, as amended (Schedule 5); the Convention on the International Trade in Endangered Species 1975 (Appendix I). Conservation of marine turtles is further addressed under the Bern Convention on the Conservation of European Wildlife and Habitats 1979 (Appendix II), and the Bonn Convention on the Conservation of Migratory Species of Wild Animal 1980 (Appendix I & II). A UK Biodiversity Action Plan for Turtles was published in 1999.

1.5 The impact of fisheries bycatch

Incidental capture in fishing gear poses a wide-spread threat to marine turtles (Plotkin 1995). Turtles are trapped in set nets (e.g. bottom-set gill nets, stake nets, pound nets), in active nets (e.g. demersal and pelagic trawls, purse seines) and in driftnets (Eckert 1995). They are accidentally hooked and entangled in longline

fisheries (e.g. Witzell 1996). They also become entangled in buoy ropes used both in pot-based fisheries for shellfish and molluscs, and some net fisheries (e.g. Prescott 1998). The threat of bycatch therefore encompasses many fishing methods and may affect marine turtles throughout their range, close inshore as well as in deep-water pelagic fisheries.

1.5.1 NW Atlantic

In the coastal waters of the south-eastern USA there is a well documented bycatch of leatherback, loggerhead and Kemp's ridley turtles in shrimp trawls (e.g. National Research Council 1990). An estimated annual mortality of 9-10,000 loggerheads in shrimp trawls (Henwood & Stuntz 1987) is considered conservative (National Research Council 1990). In order to reduce mortality rates shrimp trawls are now required to include Turtle Excluder Devices (TEDs); there have been severe reductions in permissible trawl duration and temporary fishery closures have been introduced (Frazer 1995).

Bycatch has been documented in NW Atlantic pelagic longline fisheries (e.g. Witzell 1984, 1996, 1999). The estimated annual bycatch for the US Atlantic pelagic longline fleet from 1992-98, ranged from 664 to 3136 turtles (Johnson *et al.* 1999; Yeung 1999). Loggerheads and leatherbacks accounted for 52% and 42% of observed animals respectively (Johnson *et al.* 1999). Observed mortality ranged from 0-60 each year. The mode of capture in longline fisheries varies between species. Leatherbacks are frequently hooked on the carapace or flippers, or become entangled in main and branch lines. Loggerheads however, attempt to ingest the bait, and hooks become embedded in the mouth and throat (Witzell 1996; Ferreira *et al.* in prep.). Although many turtles are released alive, capture may result in serious and lethal injury (Eckert 1994). Post-release mortality was assessed in 1998 for the US pelagic longline fishery (Yeung 1999). Observers systematically assigned 'observed injury criteria' (Angliss & Demaster 1998) and of 20 animals released alive, 19[1] were presumed to have sustained lethal injuries.

Most bycatch in the US pelagic longline fishery occurs south and east of the Grand Banks with a disproportionate number of turtles captured in only a few sets (Hoey 1997). In 1995 for example, many turtles were caught on longlines set within a decaying warm-core ring of the Gulf Stream. There were multiple recaptures of some individuals. The National Oceanic and Atmospheric Administration are examining the use of time/area closures to reduce bycatch (NOAA 1999). In the Pacific, high bycatch of marine turtles has led to the recent closure of the Hawaiian-based longline fishery (P Plotkin *in litt.*).

Turtle mortality has also been observed in NW Atlantic driftnet fisheries (C Fanning, National Marine Fisheries Service, pers. comm.). Driftnets targeting swordfish and tuna in the North Pacific resulted in the capture of an estimated 1000 leatherbacks per year during the 1980s and early 1990s (Wetherall *et al.* 1993). This fishery was closed in 1993.

In coastal waters, 1078 turtles, mainly loggerheads and leatherbacks were recorded in the New York Bight, between 1984 and 1997 (Gerle & DiGiovanni 1997). Approximately 36% of these were caught in pound nets, for which there was no recorded mortality. Fifty-five were incidentally captured by a range of other fishing methods. Of these, 29 turtles were caught in trawls, ten in set gill nets, four on longlines and eleven were entangled in lobster pot ropes; mortality was 25% (twelve animals). Prescott (1988) implicated entanglement (mainly in lobster pot lines) in 51 of 57 (89%) adult leatherback strandings in Cape Cod Bay, between 1977 and 1987. Fourteen of 20 leatherbacks (70%) recorded off the coast of Newfoundland and Labrador in 1976-85, were entangled in fishing gear, including lobster pot lines, salmon nets, herring nets and trawls (Goff & Lien 1988).

[1] Three of four leatherbacks caught, fifteen loggerheads and a single hawksbill turtle.

1.5.2 NE Atlantic & the Mediterranean Sea

Bycatch of marine turtles, particularly loggerheads but also green turtles and occasionally leatherbacks, has been reported from the eastern Mediterranean region. For example, Lazar & Tvntkovic (1998) report incidental capture in demersal trawls in the Adriatic Sea. Suggett & Houghton (1998) report the entanglement of loggerhead turtles in gill nets off Kefalonia, Greece. Loggerhead turtles are also taken on longlines in the Ionian Sea (Panou 1992). The first leatherback recorded on the Aegean coast of Turkey was caught in a gill net (Taskavak *et al.* 1997). In the western Mediterranean loggerhead turtles are taken incidentally in surface longline (Aguilar *et al.* 1992, Camiñas *et al.* 1992), demersal trawl (Mayol *et al.* 1988) and gill net fisheries (Laurent 1991). Total captures of loggerhead turtles by the Spanish longline fleet exceeded 15,000 animals annually from 1986-90 (Camiñas 1997). Leatherbacks are also taken in this fishery, although far less frequently (Camiñas 1998).

There are many accounts of turtle bycatch in NE Atlantic waters (Brongersma 1972; Penhallurick 1990; Langton *et al.* 1996). Godley *et al.* (1998) discuss the cause of mortality of 35 leatherback and three loggerhead turtles recorded around the British coast from 1992-96. In at least six cases, leatherbacks were known to have drowned after having become entangled in fishing gear. Cause of death was not known for most stranded animals, but evidence suggestive of previous entanglement was present in several cases. Stranded animals were distributed widely around the coasts of northern and western Britain. A conspicuous clustering of strandings and bycatch was identified in Carmarthen Bay, SW Wales. This was thought to have been associated with the rapid expansion of a pot fishery for whelks.

Full necropsy examinations have been carried out on ten leatherbacks since 1990, including some of those reported by Godley *et al.* (1998). One leatherback was examined in Eire at University College Cork (Berrow and Rogan 1995); three in England at the Institute of Zoology, London and six in Scotland at the Scottish Agricultural College. A cause of death was assigned in six cases: the single leatherback examined in Eire and three in Scotland were found to have drowned in creel / pot ropes; two turtles in Scotland suffered starvation and chronic loss of condition following ingestion of plastics which obstructed the digestive tract. One of these emaciated animals also bore a necrotic shoulder wound caused by an imbedded fishing hook, and cuts and abrasions probably resulting from entanglement in a commercial longline. The three leatherbacks examined in England have not yet been assigned a cause of death. Two are thought to have died of infectious diseases (A Cunningham, Institute of Zoology, pers. comm.). One animal showed cuts and lesions consistent with prior entanglement in net or line, and had ingested a small piece of multifilament net (T Langton, Herpetofauna Consultants International, *in litt.*).

Turtle bycatch has been reported from NE Atlantic tuna driftnet fisheries. In 1995, the Sea Mammal Research Unit observed eight leatherbacks in 62 net hauls by English vessels (SMRU 1996). This represented a capture rate of eight leatherback turtles per 10,000 tuna. Observed mortality was 25%. In 1995, nine vessels participated in the UK tuna driftnet fishery.

Fishing effort by the French fleet, in both 1992 and 1993, was approximately 25 times greater than that of the UK fleet. Observers on French vessels recorded a catch of seven leatherbacks and one loggerhead in 1992, and 22 leatherbacks and four loggerheads in 1993. There was no recorded mortality in either year (Goujon *et al.* 1993). The catch rate per 10,000 tuna was 0.33 and 1.00 for 1992 and 1993 respectively (SMRU 1996). This was extrapolated to catch estimates of 30 and 100 turtles by the entire French fleet in these years.

Observations have also been carried out on vessels of the Irish tuna driftnet fleet. No turtles were caught in a single experimental set in 1991 (Berrow 1991). Observer coverage was increased in 1996 and 1998 (E Rogan, University College Cork, pers. comm.). In 1996, a catch of six turtles (including at least

one leatherback turtle) was recorded in 125 net hauls. Observed mortality was 17%. In 1998, no turtles were caught in 18 hauls, although one turtle was seen close to the nets. There were many anecdotal reports of leatherbacks being caught by Irish vessels during 1999 (K Flannery, Department of the Marine, pers. comm.; D Wall, University College Dublin, pers. comm.).

An incidental catch of turtles is also reported for longline fisheries in the Azores (Ferreira *et al.* in prep.). In 1998, surface longlines targeting swordfish captured at least 60 loggerhead turtles and 3 leatherbacks. The total capture and the mortality rate for loggerheads were estimated at 3716 animals and 3.11% respectively, for all vessels fishing the Azores EEZ between June and December. There are additional accounts of turtle bycatch in an experimental longline fishery in Irish waters (F Guilfoyle, Aberdeen University, pers. comm.; D Rihan, Bord Iascaigh Mhara, pers. comm.). There are no published data however, for Spanish vessels, which operate the largest longline fleet in the NE Atlantic. Spanish vessels target tuna and swordfish in approximately the same region that French, Irish and UK vessels use driftnets.

Several studies have investigated marine mammal bycatch in NE Atlantic waters, without reporting an incidental capture of turtle species (e.g. Tregenza & Collet 1998; Morizur *et al.*1999), although observer effort for some fisheries has been low. There was no recorded capture of turtles during observations of the following fisheries (sampling effort is shown in parentheses):

a) French tuna trawls (50 days: Aug-Oct)[2]
b) French set gill nets in the western English Channel[3]
c) Irish herring trawls (85 days: Oct-Jan)[4]
d) English and Irish bottom-set gill nets in the Celtic Sea (328 days)[5]
e) Dutch horse-mackerel trawls (102 days: Jan-Mar)[1]
f) French hake trawls (30 days: Feb, Apr–Jun, Sep - Nov)[1]
g) French sea bass trawls (9 days: Jan, Feb, Apr)[1]
h) French horse-mackerel trawls (9 days: Jan-Mar)[1]
i) French anchovy trawls (9 days: Mar, Jun)[1]
j) French black bream trawls (5 days: May-Jun)[1]
k) French pilchard trawl (2 days: May)[1]
l) UK mackerel trawl (59 days: Nov-Mar)[1]
m) UK pilchard trawl (17 days: Oct-Dec)[1]

The Sea Mammal Research Unit has also employed observers in several UK fisheries. For data collected since 1996, no turtle bycatch has been recorded in bottom-set gill nets targeting cod and monkfish in the North Sea and off western Scotland or in salmon drift nets off the central North Sea coast. No turtles have been observed during a recently initiated monitoring programme for pelagic trawls in Scottish waters (S Northridge, Sea Mammal Research Unit, pers. comm.).

Sea Fish Technology use observers to monitor discards in English Channel and Irish Sea trawl fisheries, and English set net fisheries. Again, no turtle bycatch has been recorded (W Lart, Sea Fish Technology, *in litt.*). In the English Channel and Irish Sea from 1993-98, there were 731h observer effort on vessels using otter trawls; 1201h using beam trawls and 254h using French and spring dredges. In the Irish Sea there were an additional 226h onboard *Nephrops* trawlers and 25h on anchor seiners. Observer effort in English set net fisheries on the NE, SE and SW coasts was 32 days, 16 days and 27 days respectively.

The Scottish Executive's Marine Laboratory, Aberdeen, has operated a discard monitoring programme for approximately 25 years, and aims to observe 60-70 trips on demersal trawlers each year in the North Sea and west of Scotland. Non-fish bycatch is not recorded systematically, but there have been no reports of turtle bycatch in 2045 fishing trips since 1975 (P Kunzlik, Marine Laboratories, pers. comm.).

The incidental capture of turtles is clearly rare in many NE Atlantic fisheries. In addition

[2] Morizur *et al.* 1999
[3] Morizur *et al.* 1992
[4] Berrow *et al.* 1998
[5] Tregenza *et al.* 1997a, 1997b

to published data from observer programmes however, there are also individual records of turtle bycatch from a variety of fisheries. These data are included in the 'TURTLE' database (Pierpoint & Penrose 1999) and are the primary source of data considered in the present investigation.

Materials & Methods

Records of turtle sightings, strandings and bycatch in UK and Irish waters, are held in the database 'TURTLE' (Pierpoint & Penrose 1999). Version 1 was released in MS Access 97 format, in October 1999 and contained 712 records of five species of turtle. These data have been investigated using GIS software and are the primary source of data presented here.

Additional information has been gathered from published sources. Although data has been presented on marine turtle bycatch recorded during dedicated monitoring programmes elsewhere in the Atlantic, there are few similar data from the NE Atlantic region. There has been extensive monitoring effort of some fisheries however, during both marine mammal and fisheries science programmes. The investigators of these studies have kindly provided unpublished data on the observed incidence of turtle interactions.

Results

Version 1 (Oct. 1999) of TURTLE holds 712 records of marine turtles. This includes 104 records of entanglement, for which details of the gear type and fishery involved are often available. In addition there are 52 records of animals reported as 'captured'; the majority of these data were provided by King (1984). Although it is unclear whether the records refer to turtles that were caught incidentally or captured deliberately, the author confirms that the majority, at least, are records of bycaught animals (G King pers. comm.). Known records of deliberate capture are rare: TURTLE includes two only, both from pre-1955. This investigation therefore, considers a dataset of 154 bycaught animals (22% of all records). These data no doubt represent a minimum number of turtles caught incidentally in fishing gear.

Of 141 bycatch records for which the turtles were identified to species, 94% were leatherback turtles, the species reported most frequently and regularly from UK waters (Brongersma 1972). This report naturally focuses on the leatherback, although the small number of records available for other species are also discussed.

3.1 The occurrence of leatherback turtles

Leatherbacks have been recorded annually since the 1950s. The number of live sightings and the number of strandings reported varies greatly between years. However, since 1980 there have been an average of ten sightings of live leatherbacks (mean = 10.3, sd = 6.40, n = 206 animals) and six reports of dead animals (mean = 5.6, sd = 5.15, n = 116 animals) each year (Fig. 1).

There is a positive and significant correlation between the numbers of strandings and sightings each year ($r_s = 0.6997$, df = 20, $p < 0.01$). However, years with a relatively high total of records (e.g. 1983, 1988, 1990) are sporadic. Relatively high numbers have been reported in each year from 1995 to 1999. It is difficult to attribute counts in recent years to improved reporting networks or greater observer effort alone. The data suggest a corresponding increase in the numbers of animals visiting the waters of the UK and Eire.

Overall, most leatherback sightings have been made in August, with 95% of all sightings reported between June and October (Fig. 2). Strandings tend to peak later in this period, in September and October (Fig. 2).

The distribution of 451 leatherback records, assigned to geographical regions, is shown in Fig. 3. The majority of records are from the western coasts of the UK and Eire: west of Eire, the west and north coasts of Scotland, the Irish Sea and especially the waters of the Celtic Sea and western English Channel. There are far fewer records from the North Sea coasts of England and east Scotland, and the eastern English Channel.

A sub-set of sighting data (live animals) for which the month in which the sighting occurred is known (n = 257), are shown in Table 1. The peak month for sightings in all regions, except central North Sea and south east England, is August. However, data showing the months in which 75% of sightings are made suggest that in general, leatherbacks occur later in Scottish waters (August – October) than further south (July – September). Sightings in the central and southern North Sea and the eastern English Channel occur later still, with 75% of sightings made in October and November. The data imply that leatherbacks move into British and Irish waters from the south and west, and pass northwards up western coasts and the Irish Sea. Some leatherbacks enter the central North Sea in autumn. A paucity of sightings in the southern North Sea earlier in the year, suggest that it is unlikely that many turtles enter the North Sea via the English Channel.

3.2 Records of dead leatherback turtles

The distribution of records of dead leatherback turtles is shown in Fig. 4 and includes records of all animals for which there are location data of sufficient precision (n = 131). Additional records are included of animals that were found alive but later died (n = 24). The number of records is shown for each geographical region. Records of dead leatherbacks are distributed widely throughout the region, but again most are from SW England, southern Eire and Wales. The cluster of recent records identified by Godley *et al.* (1989) is evident in Carmarthen Bay, SW Wales, from where 17 dead leatherbacks have been reported since 1995.

3.3 Bycatch records

As previously mentioned, most records of turtle bycatch or capture in British and Irish waters refer to leatherback turtles. Of 154 capture records, 129 are of leatherbacks (83%; 94% of records of turtles identified to species). There are a small number of bycatch records for other species however: four loggerhead turtles are known to have been bycaught, all taken in nets: one in a stake net (Edward 1861; Stephen 1953; Brongersma 1972); one in a 'salmon net' (Edward 1861; Stephen 1953; Brongersma 1972); one in a pilchard seine net (Penhallurick 1990); and one in an unspecified net fishery (Brongersma 1972). There is a single record a of Kemp's ridley turtle having been caught in fishing gear, also an unspecified type of net (Brongersma 1972; Penhallurick 1990). The only confirmed record of a hawksbill turtle in British and Irish waters was a bycaught animal, taken in herring nets off Cork harbour in 1983 (O'Riordan *et al.* 1984).

The method of capture assigned to records of all species is shown in Table 2. In 50 cases leatherbacks were found entangled in rope, usually buoy ropes used in pot fisheries for crustaceans or whelk. This mode of capture therefore represents 58.3% of leatherback bycatch records for which gear type was specified. There are a further 30 records of entanglement (35.7%) in net fisheries (including driftnets[6], pelagic and demersal trawls, set nets and purse seines). There are three records of entrapment by hook and line (3.6%): two of which were commercial longlines, the third that of a recreational fisherman.

A breakdown by gear type for incidental capture records for leatherback turtles recorded since 1980, is shown in Fig. 5. During this period there were 83 records. The method of capture was specified in 58 cases. Of these, 36 turtles (62%) were found entangled in buoy ropes. Of twenty turtles found in nets (34%), eight were caught in the NE Atlantic tuna drift net fishery (14%). Five were caught in trawls including one in a 'prawn trawl', one in a 'mid-water trawl' and two in a 'beam trawl'. One turtle was caught in a gill net targeting hake. There are six records from unspecified types of net. In addition, one leatherback was foul-hooked by a recreational fisherman and another became entangled in the anchor warp of a small dingy; both were released alive. Hence, the most significant known bycatch of leatherback turtles during the last twenty years, that can be attributed to specific fisheries or fishing methods, has been recorded in inshore pot fisheries and in pelagic drift nets.

Over the same time period, in addition to the single hawksbill turtle, two unidentified turtles were caught: one in 'nets', another on hook and line by a recreational fisherman. There has therefore been no significant bycatch of turtle species other than leatherbacks, recorded in UK and Irish waters since 1980.

3.4 Bycatch mortality and release rates

The fate of 83 leatherback turtles incidentally captured since 1980 is shown in Table 3. The number of animals known to have been caught incidentally does not equate to recorded mortality, as a significant proportion of turtles

[6] Data from the English fleet only (SMRU 1996) is included in TURTLE (Version 1).

captured were found alive and successfully released. Of 36 animals found entangled in pot buoy ropes, for example, seventeen were found alive and at least eleven were released. Four animals found alive died later. Recorded mortality in this fishery was therefore, 61% (22 of 36 animals). All five leatherbacks captured in trawls were released alive, and six of eight turtles found in tuna drift nets were released alive (75%) (SMRU 1996).

Overall, at least 43 of 83 bycaught turtles (52%) were found alive and 32 (38.5%) were released. Recorded mortality was 30 animals (46% of 65 leatherbacks for which mortality and released data were recorded). There are no data regarding post-release mortality.

There is a significant positive correlation between month totals for leatherback bycatch in pot fisheries and the number of non-bycaught live sightings ($R_s = 0.9007$, $n = 12$, $p < 0.01$). Shellfish pots are fished throughout the year although effort and landings are generally highest from April to October (Jacklin & Lart 1995; Pfeiffer *et al.* 1996). Leatherback bycatch occurs mostly in the months in which the species appears most abundant (Fig. 6).

Bycatch in pot fisheries also reflects the geographical distribution of sighting records. The highest rates of bycatch are reported from SW England, S and SE Ireland and south Wales (SW region); NW Scotland (NW region); N and NE Scotland including the Northern Isles (NW region) (Table 4). In these regions, bycatch records contribute 12-18% of all leatherback records. In other regions, the percentage ranges from 0-7%.

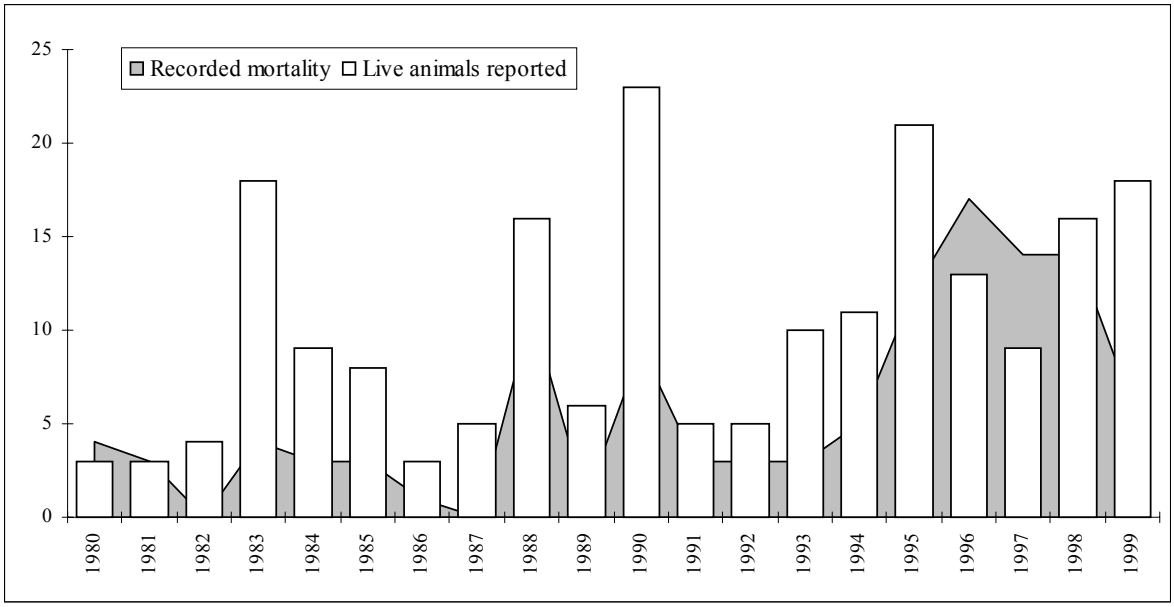

Figure 1 Annual variation in reporting rates for leatherback turtles: sightings of live animals and recorded mortality 1980-99.

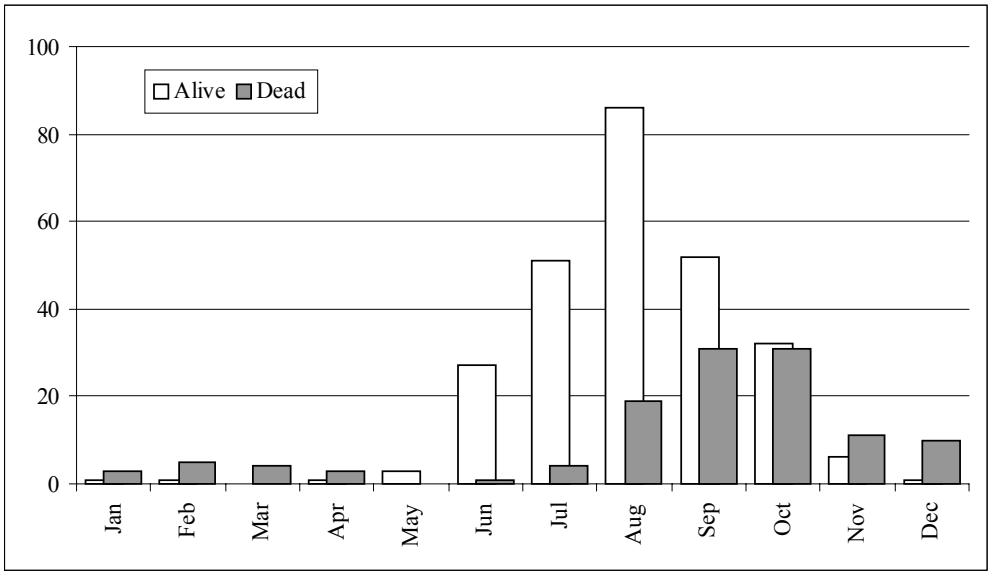

Figure 2 Total number of leatherback sightings and strandings in each month (n = 383 records for which the month is known precisely).

Table 1 Regional variation in the months in which most leatherback sightings have been recorded.

Region	*Sightings*	*Peak Month*	*75% of sightings*
SW (SW England, S Wales, S Eire)	140	Aug	Jul - Sep
WS (W Eire)	7	Aug	Aug
IS (Irish Sea)	26	Aug	Jul - Sep
NW (W & NW Scotland)	45	Aug	Aug - Oct
NE (N & NE Scotland)	24	Aug	Aug - Oct
EC (SE Scotland, E England)	10	Oct	Oct
SE (SE England)	5	Nov	Nov

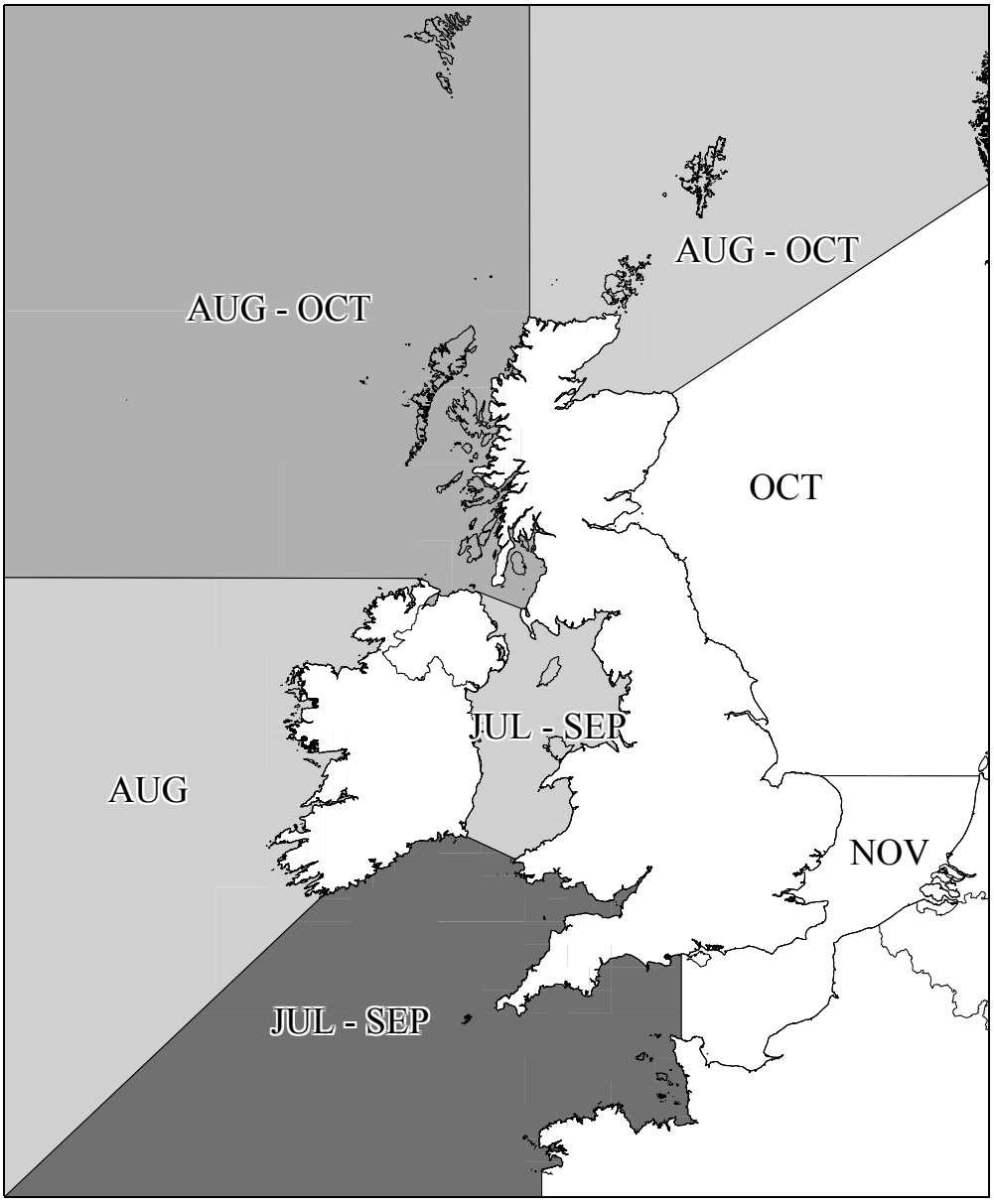

Figure 3 Distribution of leatherback turtle records by region. The months in which 75% of have been recorded are also shown.

Key: >210 60-90 30-60 <30 records

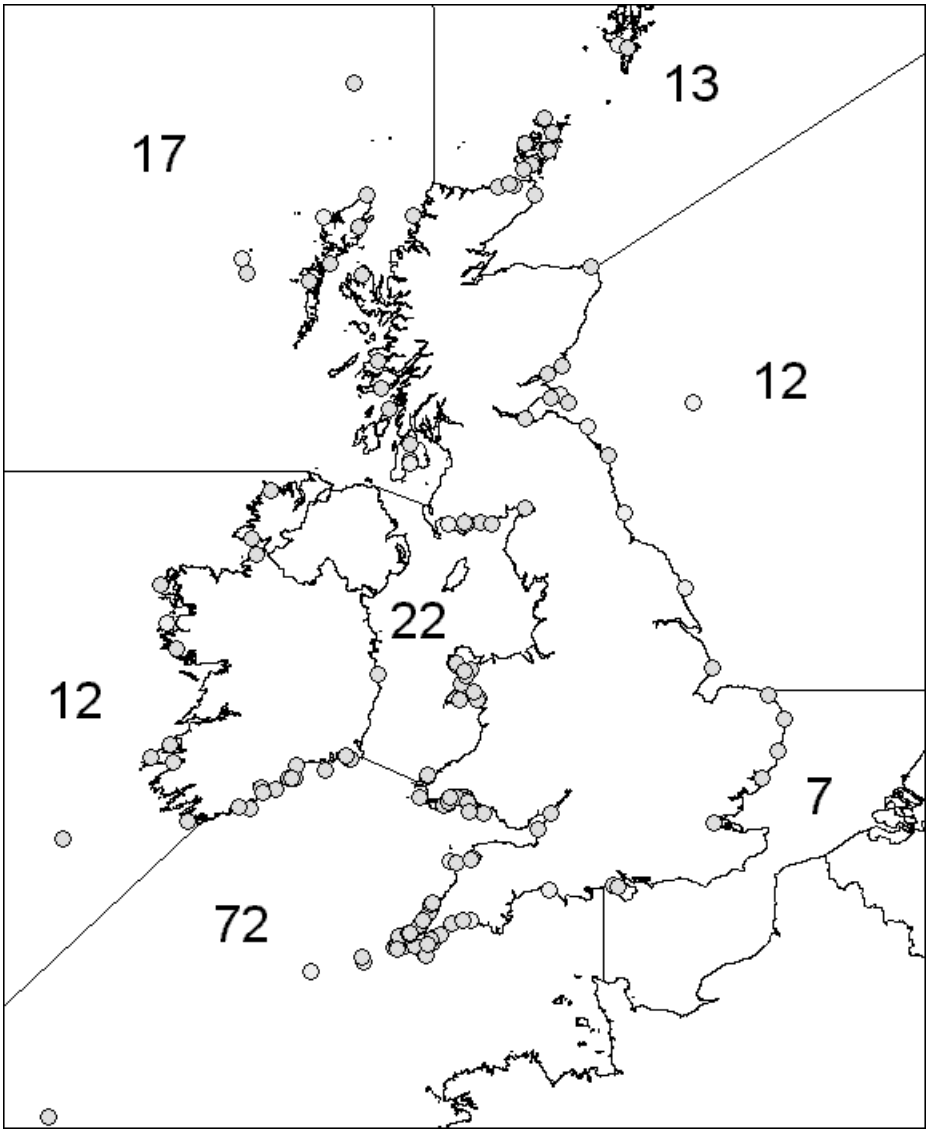

Figure 4 Records of dead Leatherback turtles in UK & Irish waters (n = 155).

Table 2 Methods of incidental and deliberate capture of turtles in UK and Irish waters.

Gear type	*LBT*	*LOG*	*KR*	*HB*	*UNI*
Incidental capture[7]					
Rope	4				
Pot rope	1				
Pot rope (crab or lobster)	42				1
Pot rope (whelk)	2				
Net buoy ropes	1				
Net	8	1	1		1
Net (herring)				1	
Net (salmon)	2	1			
Set net (hake)	1				
Stake net		1			
Purse-seine / ring net	2				
Seine (pilchard)		1			
Trawl	3				
Trawl (herring)	1				
Trawl (mid-water)	1				
Trawl (prawn)	1				
Trawl (beam)	2				
Drift net (herring)	1				
Drift net (pilchard)					1
Drift net (tuna)	8				
Hook & line (recreational)	1				1
Hook & line (cod)					1
Hook & line (shark)	1				
Anti-submarine net	1				
Anchor warp	1				
Not specified	45	5	1		10
Deliberate capture					
Harpoon	1				
Not specified	1				
Suspected bycatch					
Pot rope	2				
Herring nets	2				

[7] Includes 52 records for which capture is assumed to have been incidental. For 51 of these records gear type was not specified.

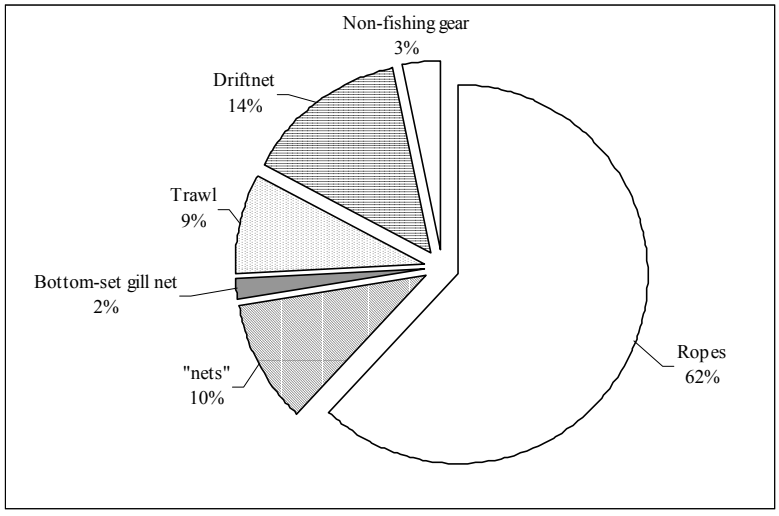

Figure 5 Fishery bycatch records for leatherback turtles since 1980, for which a gear type was specified (n = 56).

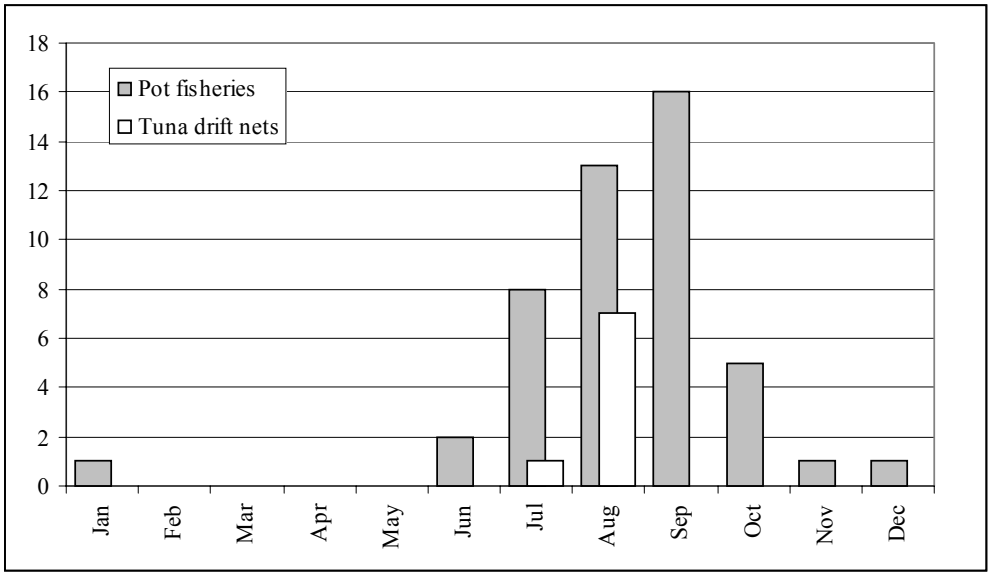

Figure 6 Monthly bycatch of leatherback turtles in pot fisheries (n = 47 records for which the month was reported) and in tuna drift nets (n = 8).

Table 3 Incidental capture of leatherback turtles since 1980: total found alive, total found dead, and if found alive: numbers released and numbers which died later.

Gear type	*Total records*	*Found dead*	*Found alive*	*Not known*	*Found alive*		
					Released	Died later	Not known
Ropes	36	18	17	1	11	4	1
"nets"	6	2	4		3	1	
Bottom set gill net	1		1		1		
Trawl	5		5		5		
Drift net	8	2	6		6		
Non-fishing gear	2		2		2		
Not Specified	25		8	17	4	3	1
Total	***83***	***22***	***43***	***18***	***32***	***8***	***2***

Table 4 Bycatch of leatherback turtles as a proportion of the total leatherback records in different regions.

Region	*Total leatherback turtle records*	*Entanglement in pot buoy ropes*	*% records caught in pot fisheries*
SW	219	26	12%
NW	70	10	14%
NE	40	7	18%
IS	55	4	7%
EC	18	1	6%
WC	37	1	3%
SE	12	0	0
Total	***451***	***49***	***10.9%***

Discussion

Marine turtles are prone to accidental capture in fishing gear throughout their range and have been caught in British and Irish waters by a wide variety of fishing methods (e.g. Brongersma 1972; Penhallurick 1990). The database 'TURTLE' holds 154 records of bycatch (Pierpoint & Penrose 1999). This no doubt, represents the minimum number of animals taken. Most records involve leatherback turtles (94% of records in which the species was identified), which is the species most frequently reported from the region. There are however, capture records for nine loggerhead turtles, two Kemp's ridleys and one hawksbill turtle also.

Leatherbacks range widely in cold temperate and boreal waters (Brongersma 1972). In UK and Irish waters they have been observed foraging amongst swarms of jellyfish. This species is now accepted as a regular member of the UK and Ireland's marine fauna. The number of animals reported each year varies considerably however. This is due in part to the efficiency of reporting networks, but the influence of biological factors (e.g. prey density) on their abundance is not yet well understood. The occurrence of loggerhead, and Kemp's ridley turtles is thought in most cases to result from the displacement of animals from their normal habitat by adverse currents or weather conditions.

Most records of leatherback bycatch implicate entanglement in ropes (n = 50 records), particularly those used to tether marker buoys in pot fisheries for lobster, crab and whelk. Since 1980, these fisheries have accounted for 62% of reported bycatch (for which gear type is known). The reason why leatherbacks become entangled in this way is not known, although it is possible that they sometimes mistake buoys for jellyfish, their preferred prey. The presence of long lengths of slack rope over low tide may increase the risk of entanglement. There are no records of other species having been captured in pot fisheries. Of 36 leatherbacks found entangled in ropes since 1980, recorded mortality was 61%; 11 turtles are known to have been released alive (30.5%). Injuries sustained whilst entangled and during release may however, cause additional, unrecorded, mortality (B Godley, pers. comm.). The risk of injury to the turtle during release may be reduced if, whenever possible, animals are cut free without being removed from the water, thereby avoiding additional pressure being placed on limbs and internal organs.

Most bycatch in pot fisheries occurs in the west and south-west, north and north-west of the region, from July to September. This closely reflects the areas and months in which most live sightings of leatherbacks are also made. Although pot fisheries are ubiquitous (Jacklin & Lart 1995; Pfeiffer *et al*. 1996), there is little bycatch reported from the eastern coasts of Britain which, it is clear, leatherbacks visit less frequently.

Turtle bycatch is also reported from pelagic tuna driftnet fisheries to the south-west of the region. Gougon *et al.* (1993) estimate that 30 and 100 turtles, mainly leatherbacks, were caught by the French fleet 1992 and 1993 respectively. The capture rate was 0.33 and 1.0 turtles per 10,000 tuna. SMRU (1996) recorded a bycatch of eight leatherback turtles in 62 net hauls observed on UK vessels in 1995: a capture rate of 8.0 leatherbacks per 10,000 tuna. Fishing effort by UK vessels in 1995 was approximately 25 times less that that of the French fleet in both 1992 and 1993. Mortality in the English study was 25%. There was no recorded mortality during the French study. Bycatch is also reported for Irish driftnet vessels (E Rogan pers. comm.). There were six turtles taken in 125 net hauls in 1996 and recorded mortality was 17%. No turtles were caught in 18 hauls observed in 1998. There were however, many anecdotal reports of bycatch from Irish vessels in 1999 (K Flannery pers. comm.; D Wall pers. comm.). As a result of high bycatch rates of cetaceans and other non-target species, pelagic driftnet fisheries in European waters are due to be phased out, under EU legislation, by 2002.

Despite extensive observer effort in several other NE Atlantic fisheries, no bycatch of marine turtles has been recorded during programmes to monitor pelagic trawls (Morizur *et al.* 1999; Berrow *et al.* 1999), demersal trawls (B Lart *in litt.*; P Kunzlik pers. comm.) and bottom-set gill nets (Tregenza *et al.* 1997b; Morizur 1992). These methods of fishing are known to occasionally catch turtles in British and Irish waters, however: leatherbacks have been taken incidentally by trawl (eight records), in purse seines (two records), in set gill nets (one record), and also by hook and line (two records). There are several additional records of capture in unspecified net fisheries (ten records). In 45 cases, 35% of all leatherback capture records, details of the method by which the turtle was taken are not given. Records of loggerhead turtles and other species specify that these turtles were taken in nets.

The proportion of records which state that bycaught turtles were released alive is high for some capture methods. Since 1980 for example, all records of leatherback turtles caught in trawls, set nets and non-commercial fishing gear indicate that the animals were later released alive. Three of six leatherbacks caught in unspecified net types were also released alive. It is, of course, possible that a bias exists towards reporting successful releases rather than dead animals.

Elsewhere in the Atlantic and the Mediterranean high bycatch rates are reported for longline fisheries (e.g. Witzell 1984, Aguilar *et al.* 1992; Camiñas *et al.* 1992; Johnson *et al.* 1999; Ferreira *et al.* in prep.). Vessels of the Spanish Atlantic longline fleet target swordfish and tuna in approximately the same waters that French, Irish and English driftnetters operate. There are currently no published data on turtle bycatch by the Spanish fleet, although capture rates may be significant and require further investigation. Very little longlining is carried out by UK and Irish vessels at present. However, an experimental fishery operated recently off the Irish coast, as a possible alternative to driftnetting. One leatherback was caught and released during trials (F Guilfoyle pers. comm.). It must be assumed from experience elsewhere, that the adoption of pelagic longlining in the south-west of the region during summer, is likely to result in further bycatch of marine turtles. Pair trawling is also being trialed as an alternative to pelagic driftnetting (D Rihan pers. comm.).

In summary, the current data confirm that marine turtles are prone to incidental capture by a wide range of fishing methods. The leatherback turtle is the only species likely to be significantly affected in UK and Irish waters. In this region, entanglement in ropes associated with inshore pot fisheries accounts for a high proportion (>60%) of bycatch records. These data were gathered from numerous and diverse sources however, as turtle bycatch in pot fisheries is not monitored systematically, and it is not possible to estimate total annual captures or mortality. Many records specify that turtles were able to be released alive. The degree to which the health of released animals is compromised following entanglement in rope and rates of post-release mortality are not known. Published data also highlight pelagic drift nets as another known source of bycatch. French, UK and Irish driftnet fleets operate to the southwest of UK waters. Leatherback bycatch in these fisheries may exceed 100 animals per year with observed mortality reported to vary from 0-25% (Gougon *et al.* 1993; SMRU 1996). The significance of bycatch in UK and Irish fisheries on Atlantic leatherback populations is not known. This species is however, globally endangered; Spotila *et al.* (1996) on the basis of bycatch rates in the NW Atlantic alone, suggest that present levels of bycatch may be unsustainable. Many leatherbacks observed in British and Irish waters appear to be adult or large immature animals (e.g. Morgan 1989). In declining populations of marine turtles, these size / age classes are thought likely to make the greatest contribution to the survival of the population (Crouse *et al.* 1987; Limpus & Reimer 1995). Present bycatch rates of leatherback turtles in UK and Irish waters may therefore prove important.

Mitigation measures employed to address turtle bycatch in the inshore trawl fisheries of the south-eastern USA, include the required use of Turtle Exclusion Devices (TEDs);

restrictions on fishing effort (trawl duration) and time / area closures. Physical devices that prevent turtles becoming entangled in pot buoy ropes are not available. However, local time / area fishing restrictions may provide a method by which rates of entanglement in some fisheries can be reduced, at times when leatherbacks are particularly abundant. A Leatherback Conservation Area has been established in the south-east USA. Within this area, the National Marine Fisheries Service is obliged to close the shrimp fishery for two weeks when turtle density, determined by repeated aerial surveys, exceeds ten turtles per 50nm of surveyed track line. During 1997, MAFF Sea Fisheries Patrol in collaboration with Marine Environmental Monitoring, carried out surveillance flights in the area of Carmarthen Bay, in an attempt to assess the seasonal abundance of leatherback turtles. It was only possible to carry out two flights however, before inshore fishery patrol flights were discontinued (R Penrose pers. comm.).

There is no evidence that mitigation measures developed to reduce cetacean bycatch in driftnets ('dolphin doors'), reduce turtle bycatch in these fisheries (N Tregenza pers. comm.). However, results from experiments in the Atlantic and Pacific suggest that modifying the depth at which nets are set may be effective. In a limited number of experiments, setting the headline 2m below the surface, rather than on the surface, consistently resulted in fewer turtles, marine mammals and seabirds being caught (J Wetherall pers. comm.). This fishing method proved unpopular with fishermen during trials carried out in NE Atlantic driftnet fisheries in 1991 (Y Morizur pers. comm.; S Berrow pers. comm.) and was not adopted. Biological results of these limited trials were inconclusive. However, the method was thought to reduce bycatch of dolphins and blue sharks *Prionace glauca* considerably (Berrow 1991). As a result of high bycatch rates of cetaceans and other non-target species, pelagic driftnet fisheries in European waters are due to be phased out, under EU legislation, by 2002.

It is important to recognise the limitations of the data available on bycatch in UK and Irish waters. The majority of both turtle sighting and capture records are reported haphazardly via a number of informal networks. The proportion of bycaught animals that are subsequently reported is not known, and is likely to vary between areas. Wildlife Trusts in the south-west of England for example, have established a popular system for reporting marine mammals and other interesting marine fauna (Sea Quest South West); sightings are publicised on the Internet. Scottish Natural Heritage and the Countryside Council for Wales have both distributed a 'Turtle Code' which includes information on how to identify and report turtles. Reporting networks in Northern Ireland and on the west coast of Eire however, are less well developed. Gabriel King recently documented numerous bycatch and sighting records for Eire that had not previously been reported (G King pers. comm.). These records are not currently included in the TURTLE database and bycatch and sighting rates in Eire are therefore under-represented.

Stranded animals are perhaps more likely to be reported than sightings at sea, as often the opportunity exists for them to be seen by a greater number of people. Also, nation-wide projects to record and respond to marine strandings have operated in the UK and Eire for many years[8]. Despite this, it is not possible to accurately assess the cause of death for the majority of stranded turtles however, as few are ever subject to detailed *post- mortem* examination (Godley *et al.* 1998). Cetaceans found in a suitably fresh condition, are routinely examined by experienced clinicians, and specimens showing signs of entanglement in fishing gear are identified (Baker & Martin 1992; Kirkwood *et al.* 1997). An assessment of the impact of fisheries interaction on marine turtles would greatly benefit from systematic, detailed necropsy of stranded animals. Drowning, as a result of entanglement, was reported for three of only five animals for which cause of death has been determined by

[8] It should be noted that government-backed projects in the UK are concerned primarily with strandings of marine mammals; no funding allocation is made for marine turtles and these are presently dealt with on a purely voluntary basis.

necropsy since 1995. There was evidence of previous entanglement for one of the remaining animals, both of which died as a result of ingesting plastics.

Leatherback strandings in SW Wales perhaps illustrate the inadequacy of the present system. Only three of 17 turtles found dead in Carmarthen Bay since 1995, were found entangled in fishing gear. These were therefore, the only turtles recorded as bycatch. Others animals also showed signs of entanglement however (R Penrose *in litt.*), and *post- mortem* examination may have implicated incidental capture in fishing gear. High levels of mortality in the area between 1995 and 1997 are believed to have resulted from the rapid expansion of a pot fishery for whelks (Godley *et al.* 1998). It is recommended that the leatherback turtle is incorporated into existing systems of stranding response that routinely present cetaceans for detailed *post- mortem* examination.

It is recommended that information provided by fishermen concerning marine turtles is recorded routinely on fisheries inspection visits, and that voluntary reporting of turtle bycatch is encouraged. Fisheries inspectors and liaison officers have day-to-day opportunities to record this information. Fishery inspection vessels and aircraft may be able to identify times and areas when the risk of incidental capture is high.

Further monitoring is also required in pelagic fisheries. No data, for example, are currently available for some fisheries, including pelagic longline fleets, that may impact turtles close to UK and Irish waters. Alternative fisheries are expected to replace driftnets in the NE Atlantic, which are due to be phased out by 2002. Future monitoring will be an essential element of assessing the impact of these fisheries on endangered species of marine turtle.

Acknowledgements

The author would like to thank the following people for their help, information and advice: Cynthia Yeung, Brendan Godley, Bill Lart, Darryl Christenson, Nick Tregenza, Simon Berrow, Yvon Morizur, Juan Antonio Camiñas, Martin Gaywood, Stella Turk, Jenny Mallinson, Andrew Cunningham, Pablo Valdes, Dave Wall, Fergal Guilfoyle, Simon Northridge, Rogério Ferreira, Phil Kunzlik, Gabriel King, Patrick O'Leary, Blaise Bullimore, Trisha Clayton, Craig Heberer, Jonathan Gordon, Dominic Rhian, Christopher Fanning, Gerry Scott, Ignacio Olaso, Liz Vang, Jack Frazier, Jerry Wetherall, Jaime Mejuto, Alberto González-Garcés, Bram Couperus, Emer Rogan & John Penrose.

This project was managed by Rod Penrose at Marine Environmental Monitoring. It was supervised by David Simmons (JNCC). Mark Tasker (JNCC) commented on a draft report. I thank the statutory nature conservation agencies, English Nature, Scottish Natural Heritage, The Countryside Council for Wales and the Joint Nature Conservation Committee for their funding of the project.

References

Aguilar R, Mas J & Pastor X 1992 Impacts of the Spanish swordfish longline fisheries on the loggerhead sea turtle Caretta caretta population in the western Mediterranean. In: *Proceedings of the 12th Annual Conference on Sea Turtle Biology and Conservation*, compiled by JI Richardson & TH Richardson, 119-120, *US Dep. Commer. NOAA Technical Memorandum. NMFS-SEFSC-361*.

Angliss RP, & Demaster DP 1998 Differentiating serious and non-serious injury of marine mammals taken incidental to commercial fishing operations: report of the serious injury workshop 1-2 April 1997, Silver Spring, Maryland. *US Dep. Commer. NOAA Technical Memorandum NMFS-OPR-13*.

Argano, R, & Baldari, F 1983 Status of western Mediterranean sea turtles. *Rapp. Comm. int. Mer Medit. 28*: 5.

Baker, JR, & Martin, AR 1992 Causes of mortality and parasites and incidental lesions in harbour porpoises (*Phocoena phocoena*) from British waters. *Veterinary Record*, *130*: 554-558.

Berrow, S 1991 *Cetacean by-catch in the 1991 Irish tuna fishery*. (Contractor : University College Cork.) Unpublished report to An Bord Iascaigh Mhara.

Berrow, S, & Rogan, E 1994 Stomach contents of a leathery turtle *Dermochelys coricea* L. caught off south-west Ireland. *Irish Naturalists' Journal, 25(1)*: 36-37.

Berrow, SD, & Rogan, E 1998 Incidental capture of cetaceans in Irish waters. *Irish Naturalists' Journal, 26(1/2)*: 22-31.

Berrow, SD, O'Neill, M, & Brogan, D 1998 Discarding practices and marine mammal bycatch in the Celtic Sea herring fishery. *Proceedings of the Irish Academy, 98B(1)*: 1-8.

Branson, A 1997 Cetaceans and sea life. *British Wildlife*, *8(4)*: 250.

Brongersma, LD 1972 *European Sea Turtles. Zoologische Verhandelingen - uitgegeven door het rijksmuseum van natuurlijke te Leiden, Nr. 121*, Leiden, E.J. Brill.

Camiñas, JA, Serna, JM de la & Alot, E 1992 Loggerhead (*Caretta caretta*) frequency observed in the Spanish surface long-line fishery in the western Mediterranean Sea during 1989. *Rapp. Comm. Int. Mer Medit, 33*.

Camiñas, JA 1997 Capturas accidentales de tortuga boba (*Caretta caretta*, L. 1758) en el Mediterráneo occidental en la pesquería de palangre de superficie de pez espada (*Xiphias gladius* L.). *ICCAT Collective Volume of Scientific Papers XLVI (4)*: 446-454.

Camiñas, JA 1998 Is the leatherback (*Dermochelys coriacea* Vandelli, 1761) a permanent species in the Mediterranean Sea? *In: Proceedings of the XXXV Congres CIESM, Dubrovnik*.

Camiñas, JA & Serna, JM de la. 1996 The loggerhead distribution in the Western Mediterranean Sea as deduced from captures by the Spanish Long Line Fishery. *In: Scientia Herpetologica 1995*, ed. by Lloernte *et al.*, 316-323.

Carr, AF 1986 Rips, FADS and little loggerheads. *BioScience, 36*: 92-100.

Carr, AF 1987 New perspectives on the pelagic stage of marine turtle development. *Cons. Biol., 1(2)*: 103-121.

Coles, WC 1999 *Aspects of the biology of sea turtles in the Mid-Atlantic Bight*. PhD Thesis, College of William and Mary in Virginia.

Crouse, DT, Crowder, LB, & Caswell, H 1987 A stage-based population model for loggerhead sea turtles and implications for their conservation. *Ecology, 68*: 1412-1423.

Davenport, J, & Balazs, GH (in press) 'Fiery bodies' – are pyrosomas an important component part of the diet of leatherback turtles?

Eckert, KL 1995 Leatherback sea turtle, *Dermochelys coriacea*. *In: National Marine Fisheries Service and US Fish and Wildlife Service status reviews for sea turtles listed under the Endangered Species Act of 1973*, ed. by PT Plotkin, 37-75, Silver Spring, Maryland, USA, National Marine Fisheries Service.

Eckert, SA 1994 Evaluating the post-release mortality of sea turtles incidentally caught in pelagic longline fisheries. In: Research plan to assess marine turtle hooking mortality: results of an expert workshop held in Honolulu, Hawaii, November 16-18, 1993, eds. By GH Balazs & SG Pooley, 106-110, *US Dep. Commer. NOAA Technical Memorandum NMFS-SEFSC-201*.

Eckert, SA 1997 Distant fisheries implicated in the loss of the world's largest leatherback nesting population. *Marine Turtle Newsletter, 78*: 2-7.

Eckert, SA 1998 Perspectives on the use of satellite telemetry and other electronic technologies for the study of marine turtles, with reference to the first year long tracking of leatherback sea turtles. *In: Proceedings of the 17th Annual Sea Turtle Symposium*, compiled by SP Epperly & Braun, J, 46-48, *US Dep. Commer. NOAA Technical Memorandum NMFS-SEFSC-415*.

Edward, T 1861 Occurrence of the hawk's bill turtle (*Testudo imbricata*) at Banff. *Zoologist, 19*: 7713-7715.

Ehrhart, LM 1989 Status report of the loggerhead turtle. *In: Proceedings of the 2nd Western Atlantic Turtle Symposium*, ed. By L Ogren, *US Dep. Commer. NOAA Technical Memorandum. NMFS-SEFSC-226*: 122-139.

Epperly, SP, Veishlow, A, Braun, J, & Chester, AJ 1990 *Sea turtle species composition and distribution in the inshore waters of North Carolina, January-December 1989.* US Fish and Wildlife Service and US National Marine Fisheries Service. Unpublished report.

Ferreira, RL, Martins, HR, Silva, AA, & Bolton, AB (in prep.) *Impact of longline fisheries on sea turtles in the Azores*.

Frazer, NB 1995 Loggerhead sea turtle, *Caretta caretta*. *In: National Marine Fisheries Service and US Fish and Wildlife Service status reviews for sea turtles listed under the Endangered Species Act of 1973*, ed. by PT Plotkin, 1-23, Silver Spring, Maryland, USA, National Marine Fisheries Service.

Fretey, J & Girondot, M 1989 L'activité de ponte de la tortue luth, *Dermochelys coriacea* (Vandelli 1761), pendant la saison 1988 en Guyane Française. *Rev. Ecol. (Terre Vie), 44*: 261-274.

Gaywood, MJ 1997 Marine turtles in British and Irish waters. *British Wildlife, 9(2)*: 69-77.

Gerle, E, & DiGiovanni, R 1997 An evaluation of human impacts and natural versus human induced mortality in sea turtles in the New York Bight. *In: Proceedings of the 17th Annual Sea Turtle Symposium*, compiled by SP Epperly & Braun, J, *US Dep. Commer. NOAA Technical Memorandum. NMFS-SEFSC-415*: 187-189.

Girondot, M, & Fretey, J 1996 Leatherback turtle, *Dermochelys coriacea*, nesting in French Guiana, 1978-1995. *Chelonian Conservation and Biology, 2*: 204-208.

Godley, B, Gaywood, M, Law, R, McCarthy, C, McKenzie, C, Patterson, I, Penrose, R, Reid, R, & Ross, H 1998 Patterns of Marine Turtle Mortality in British Waters 1992-96 with reference to tissue contaminant levels. *Journal of the Marine Biological Association UK, 78*: 973-984.

Goff, GP, & Stenson, GB 1988 Brown adipose tissue in leatherback sea turtles: a thermogenic organ in an endothermic reptile? *Copeia 1988*: 1071-1075.

Goff, GP, & Lien, J 1988 Atlantic leatherback turtle, *Dermochelys coriacea*, in cold water off Newfoundland and Labrador. *Canadian Field Naturalist, 102(1)*: 1-5.

Goujon, M, Antoine, L, Collet, A, & Fifas, S 1993 Approche de l'impact écologique de la pêche thonnière au filet maillant dérivant en Atlantique nord-est. *IFREMER RIDRV-93034*, RH-Brest.

Grant, GS, Malpass, H, & Beasley, J 1996 Correlation of leatherback turtle and jellyfish occurrence. *Herpetological Review, 27*: 123-125.

Greer, AE, Lazell, JD, & Wright, RM 1973 Anatomical evidence for counter-current heat exchanger in the leatherback turtle (*Dermochelys coriacea*). *Nature, 244*: 181.

Groombridge, B 1982 *The IUCN Amphibia – Reptilia Red Data Book Part 1: Testudines Crocodylia Rhynchocephalia.* Gland, Switzerland, International Union for the Conservation of Nature.

Groombridge, B 1990 *Marine turtles in the Mediterranean: distribution, population status, conservation*. Report to the Council of Europe, Environmental Conservation and management Division.

Hartog, JC den, & Nierop, MM van 1984 A study of the gut contents of six leathery turtles *Dermochelys coriacea* (Linnaeus) (Reptilia: Tesudines: Dermochelydae) from British waters and from the Netherlands. *Zoologische Verhandlingen, 200*. Leiden, Rijksmuseum van Natuurlijke Historie.

Hays, GC, & Clarke, BT 1995 The origin of ovigerous loggerhead turtles (*Caretta caretta*) recorded in northern Europe. *Herpetological Journal, 5*: 323-324.

Henwood, TA, & Stuntz, WE 1987 Analysis of sea turtle captures and mortality during commercial shrimp trawling. *Fisheries Bulletin, 85*: 813-817.

Hodge, RP 1979 *Dermochelys coriacea schlegeli* (Pacific leatherback) USA: Alaska. *Herpetological Review, 10(3)*: 102.

Hoey, JJ 1997 A summary of pelagic longline-sea turtle interactions based on US observer data. *In: Proceedings of the 17th Annual Sea Turtle Symposium*, Compiled by SP Epperly & Braun, J, *US Dep. Commer. NOAA Technical Memorandum NMFS-SEFSC-415*: 209-212.

Johnson, R, Yeung, C, & Brown, CA 1999 Estimates of marine mammal and marine turtle bycatch by the U.S. Atlantic pelagic longline fleet in 1992-97. *NOAA Technical Memorandum NMFS-SEFSC-418*.

Jacklin, MS, & Lart, WJ 1995 Review of potting and creeling in coastal waters around Great Britain. *JNCC Consultancy Report CR95*.

King, G 1985 *A provisional list of the occurrence of the leathery turtle,* Dermochelys coriacea *(L), for the British Isles since 1971.* Unpublished manuscript.

Kirkwood, JK, Bennett, PM, Jepson, PD, Kuiken, T, Simpson, VR, & Baker, J 1997 Entanglement in fishing gear and other causes of death in cetaceans stranded on the coasts of England and Wales. *Veterinary Record, 141*: 94-98.

Langton, TES, Beckett, CL, King, GL, & Gaywood, MJ 1996 Distribution and status of marine turtles in Scottish waters. *Scottish Natural Heritage Research, Survey and Monitoring Report, No. 8*.

Laurent, L 1991 Les Tortues Marines des Côtes Françaises Méditerranéennes Continentales*. Faune de Provence (C.E.E.P.), 12*: 76-90.

Laurent, L & Lescure, J 1995 Attempt of spatial-temporal pattern distribution of Loggerhead Turtle in the Mediterranean. *Scientia Herpetologica , 1995*: 324-327.

Lazar, B, & Tvrtkovic, N 1997 Results of marine turtle research and conservation program in Croatia. *In: Proceedings of the 17th Annual Sea Turtle Symposium*, compiled by SP Epperly & Braun, J, 70, *US Dep. Commer. NOAA Technical Memorandum NMFS-SEFSC-415*.

Mayol, X, Muntaner, J & Aguilar, R 1988 Incidencia de la pesca accidental sobre las tortugas marinas en el Mediterráneo español. *Boll. Soc. Hist. Nat. Balears, 32*: 19-31.

Mallinson, JJ 1991 Stranded juvenile loggerheads in the United Kingdom. *Marine Turtle Newsletter, 54*: 14-16.

Morgan, PJ 1989 Occurrence of leatherback turtles (Dermochelys coriacea) in the British Isles in 1988 with reference to a record specimen. In: *Proceedings of the 9th Annual Conference on Sea Turtle Biology and Conservation*, compiled by KL Eckert & TH Richardson, 119-120, *US Dep. Commer. NOAA Technical Memorandum. NMFS-SEFSC-232*.

Morizur, Y, Guénolé, A, & Pouvreau, S 1992 *Etude des rejets occasionnés par la pêche artisanale Française en Manche Ouest.* Brest, France, IFREMER.

Morizur, Y, Berrow, SD, Tregenza, NJC, Couperus, AS, & Pouvreau, S 1999 Incidental catches of marine mammals in pelagic trawl fisheries of the Northeast Atlantic. *Fisheries Research, 41*: 297-307.

Morreale, SJ, Meylan, A, Sadove, SS, & Standora, EA 1992 Annual occurrence and winter mortality of marine turtles in New York waters. *Journal of Herpetology, 26*: 301-308.

Morreale, S, Standora, E, Paladino, F, & Spotila, J 1993 Leatherback migrations along deepwater bathymetric contours. *In: Proceedings of the 13th Annual Symposium on Sea Turtle Biology and Conservation*, compiled by BA Schroeder & BE Witherington, 109-110, *US Dep. Commer. NOAA Technical Memorandum NMFS-SEFSC-341*.

Musick, JA, & Limpus, CJ 1997 Habitat utilisation and migration in juvenile sea turtles. *In: The biology of sea turtles*, ed. by PL Lutz & JA Musick, 137-164, Boca Raton, USA, CRC Press.

Mortimer, JA 1982 *Feeding ecology of sea turtles. In: Biology and conservation of sea turtles*, ed. by KA Bjorndal, 103-109, Washington DC, USA, Smithsonian Institution Press.

National Marine Fisheries Service and Fish and Wildlife Service 1992 *Recovery plan for leatherback turtles in the US Caribbean, Atlantic and Gulf of Mexico*. Washington DC., USA, National Marine Fisheries Service.

National Oceanic and Atmospheric Administration 1999 Atlantic Highly Migratory Species (HMS) Fisheries; supplementary Environmental Impact Statement; Notice of Intent. *Federal Register, 64(211)*, p59162-59163

National Research Council 1990 *Decline of the sea turtles: causes and prevention*. Washington DC, USA, National Academy Press.

O'Riordan, CE, Holmes, JMC, & Sleeman, DP 1984 First recorded occurrence of the Hawksbill Turtle (*Eretmochelys imbricata* (L)) in Irish waters, *Irish Naturalists Journal, 21(6)*: 274-5.

Panou *et al.* 1992 Incidental catches of loggerhead turtles *Caretta caretta* in swordfish long lines in the Ionian Sea, Greece. *Testudu, 3 (4)*: 47-57.

Penhallurick, RD 1990 *Turtles off Cornwall, the Isles of Scilly and Devonshire*. Truro, Cornwall, Dyllansow Pengwella, ISBN 0-9515785-0-2.

Penhallurick, RD 1991 Turtle occurrences off Cornwall & Scilly in 1990 with a note on newly discovered reports of earlier date. *Zoological Cornwall and the Isles of Scilly, 1*: 6-10.

Penhallurick, RD 1993 Turtle occurrences off Cornwall & Scilly in 1991& 1992. *Zoological Cornwall and the Isles of Scilly, 2*: 25.

Pfeiffer, N, Magee, E, Ball, B, Munday, B, & Lawler, I, (compilers) 1996 Review of shellfish pot fisheries on the west coast of Ireland. *Report to the EC Directorate General for Fisheries, Contract 1994/076*.

Pierpoint, C & Penrose, R 1999 *TURTLE A Database of Marine Turtle Records for the United Kingdom & Eire, Version 1 (Oct. 1999): Introduction, Data Summary & User Notes.* (Contractor: Marine Environmental Monitoring, Llechryd.) Unpublished report to English Nature.

Plotkin, PT *ed.* 1995 *National Marine Fisheries Service and US Fish and Wildlife Service status reviews for sea turtles listed under the Endangered Species Act of 1973*, Silver Spring, Maryland, USA, National Marine Fisheries Service.

Prescott, RL 1982 *A study of sea turtle mortality in Cape Cod Bay*. Final report to the National Marine Fisheries Service. Unpublished report.

Prescot, RL 1988 Leatherbacks in Cape Cod Bay, Massachusetts, 1977-1987. *In: Proceedings of the 8th Annual Symposium on Sea Turtle Biology and Conservation*, compiled by BA Schroeder, 83-84, *US Dep. Commer. NOAA Technical Memorandum NMFS-SEFSC-214*.

Prichard, PCH and Trebbau, P 1984 *The turtles of Venezuela*. Society for the Study of Amphibians and Reptiles.

Reynolds, DP, & Sadove, SS 1997 Wild captures of sea turtles in New York: species composition shift examined. *In: Proceedings of the 17th Annual Sea Turtle Symposium*, compiled by SP Epperly & J Braun, 269-270, *US Dep. Commer. NOAA Technical Memorandum NMFS-SEFSC-415*.

Sea Mammal Research Unit 1995 *Cetacean bycatch in the UK tuna driftnet fishery in 1995*. Interim contract report to MAFF P639.2/11, 95. Science & Environment Section, House of Commons Library.

Spotila, JR, Dunham, AE, Leslie, AJ, Steyermark, AC, Plotlin, PT, & Paladino, FV 1996 Worldwide population decline of Dermochelys coriacea: are leatherback turtles going extinct? *Chelonian Conservation and Biology, 2*: 209-222.

Stephen, AC 1953 Scottish turtle records previous to 1953. *Scottish Naturalist, 65*: 108-14.

Suggert, DJ, & Houghton, JDR 1997 Possible link between sea turtle bycatch and flipper tagging in Greece. *Marine Turtle Newsletter, 81*: 10-11.

Taskavak, E, Boulton, RH, & Atatur, MK 1998 An unusual stranding of a leatherback turtle in Turkey. *Marine Turtle Newsletter, 80*: 13.

Tregenza, NJC, & Collet, A 1998 Common dolphin *Delphinus delphis* bycatch in pelagic trawl and other fisheries in the Northeast Atlantic. *Report of the International Whaling Commission, 48*: 453-459.

Tregenza, NJC, Berrow, SD, Hammond, PS, & Leaper, R 1997a Common dolphin, *Delphinus delphis* L., bycatch in bottom set gillnets in the Celtic Sea. *Report of the International Whaling Commission, 47*: 835-839.

Tregenza, NJC, Berrow, SD, Leaper, R, & Hammond, PS 1997b Harbour porpoise *Phocoena phocoena* bycatch in set gillnets in the Celtic Sea. *ICES Journal of Marine Science, 54*: 896-904.

Vincente, VP 1994 Spongivory in Caribbean hawksbill turtles, *Eretmochelys imbricata*: data from stranded specimens. *In: Proceedings of the 13th Annual Sea Turtle Symposium on Biology and Conservation*, compiled by BA Schroeder &

BE Witherington, 185-189, *US Dep. Commer. NOAA Technical Memorandum NMFS-SEFSC-341*.

Weber, M 1995 Kemp's ridley sea turtle, *Lepidochelys kempii*. *In: National Marine Fisheries Service and US Fish and Wildlife Service status reviews for sea turtles listed under the Endangered Species Act of 1973*, ed. by PT Plotkin, 109-122, Silver Spring, Maryland, USA, National Marine Fisheries Service.

Wetherall, JA, Balazs, GH, Tokunaga, RA, & Yong, MY 1993 Bycatch of marine turtles in North Pacific high-seas driftnet fisheries and impacts on the stocks. *In: INPFC Symposium on biology, distribution, and stock assessment of species caught in the high seas driftnet fisheries in the North Pacific Ocean*, eds. by J Ito *et al*., 519-538, *Bulletin 53(III)*, Vancouver, Canada, International North Pacific Fisheries Commission.

Williams, P, Anninos, PJ, Plotkin, PT, & Salvini, KL *compilers* 1996 Pelagic longline fishery–sea turtle interactions. *Proceedings of an industry, acedemic and government experts, and stakeholders workshop, Silver Spring, Maryland, 24-25 May 1994, US Dept. Commer. NOAA Technical Memorandum NMFS-OPR-7.*

Wizell, WN 1984 The incidental capture of sea turtles in the Atlantic US Fishery Conservation Zone by the Japanese tuna longline fleet, 1979-81. *Marine Fisheries Review, 46*: 56-58.

Witzell, WN 1996 The incidental capture of sea turtles by the US pelagic longline fleet in the western Atlantic Ocean. *In: Pelagic longline fishery–sea turtle interactions*, compiled by P Williams, PJ Anninos, PT Plotkin, & KL Salvini, 32-33, *Proceedings of an industry, acedemic and government experts, and stakeholders workshop, Silver Spring, Maryland, 24-25 May 1994, US Dept. Commer. NOAA Technical Memorandum. NMFS-OPR-7.*

Witzell, WN 1999 Distribution and relative abundance of sea turtles caught incidentally by the U. S. pelagic longline fleet in the western North Atlantic Ocean, 1992-1995. *Fisheries Bulletin, 97*: 200-211.

Yeung C 1999 Estimates of marine mammal and marine turtle bycatch by the U.S. Atlantic pelagic longline fleet in 1998. *NOAA Technical Memorandum NMFS-SEFSC-430*.