Contents

22 Angel shark *Squatina squatina* in the Northeast Atlantic

22.1 Stock distribution

Angel shark *Squatina squatina* was historically distributed from the British Isles southwards to western Africa, including the Mediterranean Sea (Roux, 1986). As such the species distribution covers parts of ICES Subareas 4 and 6–9.

Stock structure is not known, but available data for this and other species of angel shark indicate high site specificity and possibly localized stocks. Mark–recapture data for *S. squatina* have shown that a high proportion of fish are recaptured from the original release location (Quigley, 2006), although occasional individuals can undertake longer-distance movements. The failure of former populations in the southern North Sea and parts of the English Channel to re-establish is also suggestive of limited mixing. Studies on other species of angel shark elsewhere in the world have also indicated that angel sharks show limited movements and limited mixing (e.g. Gaida, 1997; Garcia *et al.*, 2015). STECF (2003) noted that angel sharks "*should be managed on smallest possible spatial scale*".

Given that this species is considered to be extirpated from parts of its North Atlantic range and highly threatened both in the ICES area and elsewhere in European waters, ICES provide advice at the species level.

22.2 The fishery

22.2.1 History of the fishery

Angel shark is thought to have been the subject of exploitation for much of the 19th century and parts of the 20th century, and was exploited for meat, liver and skin. This species was the original fish termed 'monkfish' until catches declined and anglerfish *Lophius piscatorius* became a marketable species. As catches declined over the course of the 20th century, it was landed occasionally as a 'curio' for fish stalls.

Given the coastal nature of the species, it was also subject to fishing pressure from recreational fishing in parts of its range (e.g. the coasts of Ireland and Wales).

The species has been extirpated from parts of its former range, and most reports of this species in the ICES area are now from occasional bycatch records.

22.2.2 The fishery in 2017

No new information. There are no target fisheries for angel shark and, although they may be a very occasional bycatch in some trawl and gillnet fisheries (Tully, 2011), these captures should be released.

22.2.3 ICES Advice applicable

In 2008, ICES advised that angel shark in the North Sea eco-region was "*extirpated in the North Sea. It may still occur in Division VIId*" (ICES, 2008a). For the Celtic Seas, ICES advised that it "*has a localized and patchy distribution, and is extirpated from parts of its former range. It should receive the highest possible protection. Any incidental bycatch should not be landed, but returned to the sea, as they are likely to have a high survival rate*" (ICES, 2008b).

In both 2010 and 2012, ICES advised that it should remain on the list of Prohibited Species (ICES, 2012).

In 2015, ICES advised that "*when the precautionary approach is applied for angel shark in the Northeast Atlantic, no targeted fisheries should be permitted and bycatch should be minimized. ICES considers that this species should remain on the EU prohibited species list. This advice is valid for 2016 to 2019*".

22.2.4 Management applicable

Council Regulation (EC) 43/2009 stated that "*Angel shark in all EC waters may not be retained on board. Catches of these species shall be promptly released unharmed to the extent practicable*".

It was subsequently included on the list of Prohibited Species, under which it is prohibited for EU vessels to fish for, to retain on board, to tranship and to land angel shark in EU waters (Council Regulations (EC) 2018/120).

Angel shark is listed on the Wildlife and Countryside Act and protected in UK waters.

22.3 Catch data

22.3.1 Landings

Angel shark became increasingly rare in landings data over the available time period, and was reported only rarely prior to it being listed as a Prohibited Species (Table 22.1; Figure 22.1). It is believed that the peak in UK official landings in 1997 from Divisions 7.j-k were either misreported anglerfish (also called monkfish) or hake, given that angel shark is a more coastal species. These figures have been removed from the WGEF estimates of landings. French landings declined from >20 t in 1978 to less than 1 t per year prior to the prohibition on landings.

Whilst some nominal records were available in French national landings data for 2012 and 2013, the reliability of these data is uncertain, due to the areas and quantities reported, and catch gears. Further analyses and clarification of these data are required, and as such they are not included here.

There are no data available for the numbers of angel shark landed during the recreational fisheries that existed in parts of their range.

22.3.2 Discards

Limited data are available. Analyses of the main discard observer programme for the English and Welsh fleets found that no angel sharks had been observed (Silva *et al.*, 2013), whilst observer trips conducted by the Sea Mammal Research Unit (SMRU) recorded three individuals over the period 2011–2014 (Allen Kingston, pers. comm. 2015). These specimens were caught on 29 April 2011 (50.93°N, 6.65°W, 95 m water depth) and 19 September 2014 (53.40°N, 3.60°W and 53.40°N, 3.63°W, 15–16 m water depth). All were caught in tangle or trammel nets (soak times of 64–78 hours), were of estimated individual weights of 15–25 kg, and were all dead.

Examination of data collected under the French discard observer programme (2003–2013) indicated that only two individuals were observed (both in 2012) in the ICES area. According to observations from French fish markets and catches reported by fishermen, four additional individuals (two in 2007 and two in 2010) were also caught (S. Iglésias, pers. comm.). All these six individuals were caught off Pembrokeshire (Wales) at the southern entrance to St George's Channel.

WKSHARKS3 also reviewed available information on angel sharks observed during on-board observer programmes, also concluding this species was only observed very occasionally (ICES, 2017).

22.3.3 Quality of catch data

Catch data are incomplete, as data are unavailable for the periods when angel shark was more abundant. There are some concerns over the quality of some of the landings data (see above). The listing as a 'Prohibited Species' will result in commercial landings data nearing zero. Further studies of possible bycatch and fate of discards in known areas of occurrence would be needed to better estimate commercial catch.

Following the WKSHARKS data call in 2016, landings data-from 2005–2015 were re-assessed by WGEF. There were no major differences between previous landings and the new figures.

22.3.4 Discard survival

Limited data exist for the discard survival of angel shark caught in European fisheries. All three specimens observed by SMRU observers after capture by tangle- or trammel net were dead; soak times were 64–78 hours.

Other species have been studied elsewhere in the world (Ellis *et al.*, 2017). Fennessy (1994) reported at-vessel mortality (AVM) of 60% for African angel shark *Squatina africana* caught by South African prawn trawlers. Braccini *et al.* (2012) reported AVM of 25% for Australian angel shark *S. australis* caught by gillnet (where soak times were <24 h).

22.4 Commercial catch composition

No data available.

22.5 Commercial catch and effort data

No data available for commercial fleets.

22.5.1 Recreational catch and effort data

Information from Inland Fisheries Ireland (IFI) was used by WGEF 2015 to inform on the status of angel shark (ICES, 2010).

The numbers of specimen fish caught by recreational fishers and reported to the specimen fish committee declined over the period 1958–2005 (Table 22.2), with an overall decline in the numbers caught (Figure 22.2).

Other data from the IFI National Marine Sport Fish Tagging Programme confirm the scarcity of angel shark. Tagging of angel sharks has declined markedly in the last 25 years. A total of 1029 individuals have been tagged since 1970, but only a single individual has been tagged since 2006, and no recaptured specimens reported since 2004 (Roche and O'Reilly, 2013 WD; Wögerbauer *et al.*, 2014 WD). Angel shark is now only caught by anglers very occasionally in Tralee Bay, estimated at <3 per year. Effort data for the recreational fisheries are not available.

22.6 Fishery-independent data

Angel shark is encountered very rarely in trawl surveys, which may reflect the low abundance of the species, poor spatial overlap between surveys and refuge populations and their preferred habitats, and low catchability in some survey gears.

Occasional individuals have been captured in the UK beam trawl survey in Cardigan Bay, but the gear used (4 m beam trawl with chain mat) is not thought to be suitable for catching larger angel sharks.

Existing surveys are not considered appropriate for monitoring the status of this species. Dedicated, non-destructive inshore surveys in areas of known or suspected presence could usefully be initiated.

22.7 Life-history information

Limited life-history data are available (Table 22.3). Most recent biological data have come from studies in the Canary Islands (e.g. Meyers *et al.*, 2017), where this species is found regularly.

22.7.1 Habitat

Angel shark is a coastal species that has often been reported from sand bank habitats and similar topographic features. This ambush predator buries into the sand for camouflage. In terms of recent information on their habitats, a potential over-wintering area may occur off Pembrokeshire (51°30' to 52°00'N and 5°03' to 6°03'W; Figure 22.3), small specimens have been reported in Cardigan Bay (summer) and the western coast of Ireland (particularly Tralee Bay) may be important "summer areas" for the species (Wögerbauer *et al.*, 2014 WD). Angel sharks are thought to be nocturnally active (Standora and Nelson, 1977).

22.7.2 Spawning, parturition and nursery grounds

No specific information. Angel sharks giving birth have been reported from parts of the North Sea (e.g. Patterson, 1905) and small specimens have been found in the inshore waters or Cardigan Bay. Information from other angel shark species elsewhere in the world suggests that there may be an inshore migration in early summer, with parturition occurring during the summer.

22.7.3 Age and growth

No information available for *Squatina squatina*. Studies on other species of angel shark have reported problems using vertebrae for validated age determination (Natanson and Cailliet, 1986; Baremore *et al.*, 2009), with tagging studies providing some data (Cailliet *et al.*, 1992).

22.7.4 Reproductive biology

Angel sharks give birth to live young. Patterson (1905) reported on a female (ca. 124 cm long) that gave birth to 22 young. Capapé *et al.* (1990) reported a fecundity of 8–18 (ovarian) and 7–18 (uterine) for specimens from the Mediterranean Sea. Embryonic development takes one year, but the reproductive cycle may be two (or more) years, as indicated by other members of the genus (Bridge *et al.*, 1998; Colonello *et al.*, 2007; Baremore, 2010).

22.7.5 Movements and migrations

Tagging data indicate high site fidelity (Capapé *et al.*, 1990; Quigley, 2006; ICES, 2013). More than half of tagged angel sharks were recaptured less than 10 km from their original location, but individuals are capable of travelling longer distances within a relatively short window (Figure 22.4; Wögerbauer *et al.*, 2014 WD). Occasional longer-distance movements have been reported, with fish tagged off Ireland being recaptured off the south coast of England and in the Bay of Biscay (Quigley, 2006).

Seasonal migrations are suspected, with fish moving to deeper waters in the winter before returning to inshore waters for the summer. Other species of angel shark have also been shown to move into coastal waters in the summer, typically to give birth (Vögler *et al*., 2008).

The uncommon landing of about ten large individuals observed in 2000 from a French trawler fishing off southern Ireland, provide further evidence for localized aggregation of the species (S. Iglésias, *pers. comm*.).

22.7.6 Diet and role in the ecosystem

Angel shark is an ambush predator that predates on a variety of fish (especially flatfish) and various invertebrates (Ellis *et al.*, 1996).

22.8 Exploratory assessment models

An exploratory stock assessment of the Tralee Bay (ICES Division 7.j) population, using data from the IFI Marine Sportfish Tagging Programme (Section 22.5.1), was undertaken (Bal *et al.*, 2014 WD; ICES, 2014). This was updated after review (Bal *et al.*, 2015 WD), with the approach, results and a discussion of the current state of the assessment summarized below.

22.8.1 Data used

The capture–mark–recapture database used is based on 1000 angel shark caught and released year-round by recreational fisheries over the period 1970–2014. There were 164 individual recapture records, although some fish were recaptured several times (180 recaptures in total). Observed recaptures come from both recreational and commercial fisheries.

As the aim of this study was to get first estimates of the size of the population of angel shark in the Tralee bay area, it was necessary to get estimates of capture efficiency and fish survival so as to used catch numbers (new catch plus recaptures) together with parameters to feed a population dynamic model. To reach this goal it was necessary for the data to have a discrete structure. Captures and recaptures that occurred from Mid-June to Mid-August were therefore considered for estimating population size. This period corresponds with the seasonal occurrence and is long enough to ensure having sufficient data for analyses. Fish first captured outside this period were used to help estimating survival and captures probabilities only, and did not enter population estimates. As capture data were from recreational anglers only, recapture data from other fisheries were used only to get information about the state of sharks through time (i.e. dead or alive, 78 recaptures). All fisheries besides recreational angling are assumed to result in dead removals from the stock. Nonetheless if a shark is caught during the reference period by a commercial fishery, it was considered as alive on the reference period and susceptible to being recaptured by anglers. Fish with unknown recapture gears were assumed to have been recaptured by anglers if the recapture date was between May and September and if the recapture location was near the Irish shore. Other unknown recaptures were assumed to correspond to commercial gears. The capture and recapture data used in the study are summarized in Figure 22.5.

22.8.2 Methodology

22.8.2.1 Cormack-Jolly-Seber Model

22.8.2.1.1 Generalities

To disentangle capture probability from survival probability, a Cormack-Jolly-Seber (CJS) model was applied to the capture–recapture data that can be summarized for each fish in capture-recapture histories.

The corresponding state–space model and data structures are summarized in Figure 22.6. State–space models are hierarchical models that decompose an observed time-series of observed response into a process (here, survival rate) and an observation error component (here, capture probability) (After Kery and Schaub, 2012).

In this exploratory assessment, the authors defined the latent variable $A_{i,y}$ which takes the value 1 if an individual i is alive and value 0 if an individual is dead year y.

Conditionally on being alive at occasion y, individual i may survive until occasion $y+1$ with probability $\Phi_{i,y}(y = 1, ..., Y)$. The following equation defines the state process:

(1) $A_{i,y+1} \mid A_{i,y} \sim \text{Bernouilli}(A_{i,y} * \Phi_{i,y})$

The Bernoulli success is composed of the product of the survival and the state variable z. The inclusion of z insures that an individual dead remain dead and has no further impact on estimates.

If individual i is alive at occasion y, it may be recapture (R) with probability $p_{i,y}(y = 2, ..., Y)$. This can again be modelled as a Bernoulli trial with success probability $p_{i,y}$:

(2) $R_{i,y} \mid A_{i,y} \sim \text{Bernouilli}(A_{i,y} * p_{i,y})$

the inclusion of the latent variable A insures that an individual dead cannot be modelled again afterwards.

22.8.2.1.2 Specific modelling

To allow for more flexibility, survival is assumed vary per year based on a random walk structure in the logit scale. Equation (2) is changed for the following equation starting on occasion 2:

(3) $A_{i,y+1} \mid A_{i,y} \sim \text{Bernouilli}(A_{i,y} * \Phi_y)$
$\text{logit}(\Phi_y) \sim \text{Normal}(\text{logit}(\Phi_{y-1}), \sigma_\Phi)$

with the following uninformative priors

$\Phi_1 \sim \text{Unif}(0, 1)$ and $\sigma_\Phi \sim \text{Unif}(0, 10)$

The capture probability of individuals as a fixed parameter in equation (1) thus change into the following equation:

(4) $R_{i,y} \mid A_{i,y} \sim \text{Bernouilli}(A_{i,y} * p)$

In the case of angel shark, there is not always a well-defined period of tagging and recapture, as recreational anglers can fish year round. On the other hand, the CJS approach needs the data to be discrete and a reference period over which the population is considered closed is necessary. Not to lose information coming from sharks first caught outside the reference period chosen, they were included in the model to get better estimates of survival and recapture probabilities. To do so, the first year survival is corrected by the deviation (Δd_i) between the date the individual i was captured at and the following 15th of July (i.e. middle of the reference period chosen):

(5) $\Phi_{i,1} = \Phi_1^{\Delta d_i / 365}$

22.8.2.2 Deriving population size: the Jolly Seber approach

The best way of deriving population size estimates would be to add a third population dynamic components to the model described above and to fit the whole model in one go. This is called a Jolly Seber (JS) model (Kery and Schaub, 2012).

Focusing on untagged fish population sizes (for computation cost only), the population size (N) may be derived as follows for occasion 1:

(6) $C_1 \sim \text{Binomial}(p, N_1)$ with uninformative prior for $N_1 \sim \text{Unif}(0, 300\,000)$

Then a population dynamic can be built using the probability of survival coming from the CJS model described above together on top of the estimate of catch probability. For the occasions following occasion 1, with S referring to survivors from the previous occasion N and E the new entrants to the population, N is estimated as follows:

(7) $S_y \sim \text{Binomial}(\Phi_y, N_{y-1})$
$N_y = S_y + E_y$

The series of E is given a Gamma random walk prior structure (gamma distribution in jags are parameterised with shape (α) and rate (β)) to capture rather smooth evolutions. Starting on occasion 3, the following applies:

(8) $E_y \sim \text{Gamma}(\alpha_{Ey}, \beta_{Ey})$
$\alpha_{Ey} = E_{y-1} \times \beta_{Ey}$
$\beta_{Ey} = E_{y-1} / \sigma_y^2$

with the following uninformative priors

$E_2 \sim \text{Unif}(0, 300\,000)$ and $\sigma_y \sim \text{Unif}(0, 30\,000)$

Trials made so far to fit the model in one go have been unsuccessful, revealing a mismatch between the CJS and dynamic parts of the model. This may be due to the fact that a fixed *p* for the whole time-series is not realistic.

As a consequence, population estimates are given in two ways:

a) The underlying population dynamics were neglected and *N* was derived in the Bayesian model using parameter *p* and the total number of sharks captured the corresponding year,

b) The CJS model was first fitted. Posteriors were then used as informative priors to sequentially fit the population dynamic model described above, breaking feedbacks between the two parts. The figures are provided for illustrative purposes only.

22.8.3 Computation details

Bayesian fitting, forecasting and the derivations were implemented using Markov Chain Monte Carlo algorithms in JAGS (Just Another Gibbs Sampler, Plummer, 2003; http://mcmc-jags.sourceforge.net) through the R software (R Development Core Team, 2013). Three parallel MCMC chains were run and 20 000 iterations from each were retained after an initial burn-in of 20 000 iterations. Chains thinning used equalled 5. Convergence of chains was assessed using the Brooks-Gelman-Rubin diagnostic (Gelman *et al.*, 2015).

22.8.4 Results

Results are composed of the following figures showing posterior density function of capture rate (Figure 22.7), yearly survival (Figure 22.8) and population size estimates from method a (Figure 22.9) and b (Figure 22.10).

22.8.5 Quality of the assessment

It is clear that the current population of angel shark around Ireland is very low compared to the whole historical time-series, although the actual population size remains uncertain, as shown by the scale difference coming from the two method used to infer population size (Figures 22.9 and 22.10). Nonetheless trends are robust and suggest an important decline starting in the 1980s. This result concurs with anecdotal reports on angel shark abundance (Table 22.4).

Although some size and/or weight data were originally available, they were not considered in this study as they appeared unreliable.

For now, this approach has been unsuccessful in fitting a proper JS model in one go. Expert opinion on tagging and recapture effort may help by alleviating the fitting issues linked to some apparent mismatch between the CJS and population dynamic parts of the model. Additionally, this would result in a more realistic model with annual variations in both survival and capture probabilities. So far models are ready to do so. Information on the variability in fishing effort for commercial fisheries may also be included and should allow us to better differentiate natural survival variability from anthropogenic causes. Planned improvements in the Bayesian capture-recapture model for tope should also have application for angel shark, but catch and tagging rates close to zero will strongly limit on-going assessment.

22.9 Stock assessment

Whilst no quantitative stock assessment has been benchmarked, due to data limitations, the WGEF perception of the stock is based largely on analyses of historical and contemporary trawl surveys.

Historically, coastal trawl surveys around the British Isles often reported angel shark, especially in the western English Channel (Garstang, 1903; Rogers and Ellis, 2000) and Bay of Biscay (Quéro and Cendrero, 1996). In contrast, contemporary surveys encounter this species only very infrequently, if at all. Such patterns have been reported elsewhere in the biogeographic range of angel shark (e.g. Jukic-Peladic *et al.*, 2001).

The apparent scarcity of angel sharks in contemporary trawl surveys is in stark contrast to early texts on British fishes, which generally considered that angel shark were encountered regularly in British seas. Indeed, Yarrell (1836) stated that "*It is most numerous on the southern coast of our island; but it is occasionally taken in the Forth, and some other parts of the east coast, particularly around Cromer and Yarmouth. It is common on the coasts of Kent and Sussex …It is also taken in Cornwall*". Similarly, Day (1880–1884) wrote "*In the Firth of Clyde it is by no means uncommon… In fact it is common in the North Sea and Bristol Channel. Occasionally taken off Yorkshire and is common on the Dogger Bank… taken on the coasts of Kent and Sussex, Hampshire and common at all times along the south coast…Common in Cornwall*". Similar examples are also evident in other accounts (Table 22.4).

WGEF considers that the comparisons of historical data with the near-absence in recent data (landings, surveys, observer programmes, angling data) are sufficient to consider the species to be severely depleted in the Celtic Seas ecoregion and possibly extirpated from the North Sea ecoregion. Whilst its status in the Bay of Biscay and Iberian coastal waters is unknown, it is considered very rare, with only occasional individuals reported.

22.10 Quality of the assessment

No formal stock assessment has been undertaken.

22.11 Reference points

No reference points have been proposed for this stock.

22.12 Conservation considerations

Angel shark is listed as Critically Endangered on the IUCN Red List (Gibson *et al.*, 2008), is listed on the OSPAR List of Threatened and Declining Species (OSPAR Commission, 2010) and is protected on the UK's Wildlife and Countryside Act.

Various organisations (including conservation bodies and academic departments) are developing an Eastern Atlantic and Mediterranean Conservation Strategy for angel sharks (see www.angelsharknetwork.com).

In 2017, angel shark was added to Appendix I and Appendix II of the Convention on the Conservation of Migratory Species of Wild Animals (CMS). This means it is considered an endangered migratory species, and requires international conservation agreements

22.13 Management considerations

Angel shark is thought to have declined dramatically in the northern parts of the ICES area and Mediterranean Sea, as evidenced from landings data, survey information and

the decline in the numbers tagged in Irish waters. The status of angel shark and magnitude of any decline in the southern parts of the ICES area and northwest Africa remain uncertain.

Since ICES advised that this species should receive the highest protection possible, it has been listed as a prohibited species on European fishery regulations.

Dedicated, non-destructive surveys of areas of former local abundance would be needed to inform on current habitat and range, and to assess the possibilities of spatial management.

Given the perceived low productivity of this species and that they have shown high site fidelity, any population recovery would be expected to occur over a decadal time frame.

Improved liaison and training with the fishing industry is required to ensure that any specimens captured are released. National observer programmes encountering this species could usefully collect information on the vitality of discarded individuals.

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Table 22.1a. Angel shark in the Northeast Atlantic. Reported landings (t) for the period 1978–2004. French landings from ICES and Bulletin de Statistiques des Peches Maritimes. UK data from ICES and DEFRA. Belgian data from ICES. UK landings for 1997 considered to be misreported fish.

	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
Belgium	.	.	.	.	.	.	.	.	.	.	.
France	8	3	32	26	29	24	19	18.7	19.5	18	13
UK	.	.	.	.	.	.	.	.	.	.	.
Total	8	3	32	26	29	24	19	18.7	19.5	18	13

	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
Belgium	.	.	.	.	.	.	.	.	.	.	.
France	9	13	14	12	11	2	2	1	1	1	1
UK	.	.	.	.	.	2	1	1	.	.	.
Total	9	13	14	12	11	4	3	2	1	1	1

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Belgium	.	.	.	.	.	.	.	.	.	.
France	2	1	2	+	1	+	+	+	+	+
UK	.	.	(47)	.	.	.	.	.	.	.
Total	2	1	2	0	1	0	0	0	0	0

Table 22.1b. Angel shark in the Northeast Atlantic. Reported landings (t) for the period 2005–2018, following WHSHARK2 (ICES, 2016) and subsequent data calls.

	2005	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**
Belgium	.	.	.	.	.	.	.	.	.	.	.	.
France	1.03	0.40	0.74	0.27	1.60	1.40	0.97	1.22	0.02	0.01	0.53	0.03
UK	0.06	0.04	0.01	.	.	.	.	.	.	.	.	.
Total	**1.09**	**0.44**	**0.75**	**0.27**	**1.60**	**1.40**	**0.97**	**1.22**	**0.02**	**0.01**	**0.53**	**0.03**

	2017
Belgium	.
France	0.02
UK	0.13
Total	**0.15**

Table 22.2. Angel shark in the Northeast Atlantic. Numbers of specimen angel shark (total weight >22.68 kg) reported to the Irish Specimen Fish Committee from 1958–2005.

YEAR	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969
No. specimen fish reported	3	1	0	0	4	1	15	13	5	13	0	2
Year	**1970**	**1971**	**1972**	**1973**	**1974**	**1975**	**1976**	**1977**	**1978**	**1979**	**1980**	**1981**
No. specimen fish reported	1	3	3	1	4	2	1	5	4	10	5	10
Year	**1982**	**1983**	**1984**	**1985**	**1986**	**1987**	**1988**	**1989**	**1990**	**1991**	**1992**	**1993**
No. specimen fish reported	7	3	2	2	0	1	1	2	2	2	1	3
Year	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**
No. specimen fish reported	2	1	0	1	1	0	0	0	2	0	0	0

Table 22.3. Angel shark in the Northeast Atlantic. Summary of life-history parameters for *Squatina squatina*.

Common name	Angel shark			
Scientific name	*Squatina squatina*			
Stock unit	Unknown			
The stock structure is unknown, but available data for this and other species of angel sharks indicates high site fidelity, possibly with localized stocks. STECF (2003) noted that angel sharks "*should be managed on smallest possible spatial scale*". However, given that angel shark is perceived as highly threatened throughout the ICES area (and elsewhere in European waters), ICES provide advice at the species level.				
Length–weight relationship	$W = 0.0346.L^{2.7079}$ (n = 8)			Coull *et al.* (1989)
Reproductive mode	Aplacental viviparity			Capapé *et al.* (1990)
Reproductive cycle	Possibly biennial, based on data for congeneric species			Baremore (2010)
Spawning season	Parturition: Summer (possibly June to July)			Quigley (2006)
Fecundity (ovarian)	8–18 (mode = 13)			Capapé *et al.* (1990)
Fecundity (uterine)	8–18 (mode = 13) in the Mediterranean Up to at least 22 in the Atlantic			Capapé *et al.* (1990) Patterson (1905)
Development (months)	Annual			Capapé *et al.* (1990)
Length at birth/hatching	25–28 cm			Capapé *et al.* (1990)
Maximum length	244 cm			Quigley (2006)
	Female	Male	Combined	
Length of smallest mature fish	128 cm	80 cm (?)	–	Capapé *et al.* (1990)
Length at 50% maturity	–	–	–	–
Length of largest immature fish	–	–	–	–
Age at 1st maturity	–	–	–	–
Age at 50% maturity	–	–	–	–
Age at 100% maturity	–	–	–	–
L_{inf}	–	–	–	–
K	–	–	–	–
t_0	–	–	–	–
Maximum age (years)	–			–
Trophic role	Ambush predator that feeds on fish, including flatfish, and larger crustaceans (Ellis *et al.*, 1996)			

Table 22.4. Angel shark in the Northeast Atlantic. Regional chronology of perceived status of angel shark.

Area	Description
Southern North Sea	Laver (1898) "*This frequents the entire Essex coast. It is usually caught in nets. Though occasionally eaten by fishermen, it is according to my taste, far too rank in flavour for a more delicate palate*"
	Murie (1903) "*The 'fiddlers' are got all round the Kent coast in moderate quantity, but Webb regards it as somewhat of a rarity just at Dover. It is not a common fish in the Thames estuary, in one sense, though there are seasons when it is very frequently got in the trawlers' nets. In 1893 they were unusually plentiful during the summer months in the neighbourhood of the Oaze, Girdler, Gilman, and so called S. Channel generally. From June till August there were few boats but had examples among their catch, and some of the specimens were of large size*"
	Patterson (1910) "*has been brought into* (Lowestoft) *on several occasions*"
	Poll (1947) wrote "*Espècie commun, surtout en été*" [A common species, especially in summer]
English Channel	Buckland (1881) "*found in the North Sea, the British Channel, the Mediterranean … It is taken on the 'long lines' which are set for ray, &c … It is common on the bays of Archachon and, I believe, on the sandy banks all along the Bay of Biscay. They are frequently seen in the markets of Dieppe, and are not uncommon at Brighton and Hastings*"
	Aflalo (1904) "*familiar on most parts of the coast, and is a frequent object of unintentional capture on the long-lines, as well as in both trawl and drift-nets … Small examples of from 12 to 18"are common in many south coast estuaries, notably at Teignmouth, where a few are brought ashore almost every week during May in the sand-eel seines worked just outside the bar*"
	Le Danois (1915) "*à Roscoff, assez commun vers la fin de l'été*" [At Roscoff, it is quite common in late summer]
	Cooper (1934) "*Several specimens of this species are caught every year by anglers, usually when Tope fishing, but it appears to have been more common on the south coast of England some twenty or thirty years ago than it is today*"
	MBA (1957) "*A haul of the trawl in Cawsand Bay will generally yield several specimens. Occasionally trawled on other grounds*"
Irish Sea Ireland	Herdman and Dawson (1902) "*common off our coasts in spring and summer. It occurs not infrequently in the trawl net in the Lancashire district. We have taken it as near Liverpool as the Rock and Horse Channels, and the Deposit Buoy. We have also taken it near Piel in the Barrow Channel, and off Maughold Head. Mr Walker records it from Rhos weir and Colwyn Bay, and Professor White from the Menai Straits. It has been frequently taken off the Isle of Man, one is recorded from Port Erin, and we have taken it also in the Ribble, and have seen it taken on the offshore grounds by the trawlers*"
	Forrest (1907) "*… frequently met with it off Aberffraw … from Barmouth … not uncommon in the Menai Straits, Colwyn Bay and along the north coast …* (taken in) *St Tudwal's Roads, Red Wharf Bay, and other places*"
	Williams (1954) "*Taken rather infrequently off Strangford Bar. Said to be common off the north shore of Ireland"*
	Went & Kennedy (1976) listed it as common noting that it was "*more often caught on rod and line than by any other method*"

Table 22.4. (continued). Angel shark in the Northeast Atlantic. Regional chronology of perceived status of angel shark.

Area	Description
France (Bay of Biscay and Mediterranean)	Moreau (1881) "*L'Ange se trouve sur toutes nos côtes, mais il paraît plus commun dans l'ocean que dans la Méditerranée, il est même assez rare à Cette*" [Angel shark is on all our coasts, but it seems more common in the (Atlantic) ocean than in the Mediterranean, it is quite rare at Séte] Quéro *et al*. (1989) recorded individual fish from trawl surveys, including one from coastal waters near Pornic (just south of the Loire Estuary) in 1973 and one further offshore south-west of the mouth of the Gironde in 1975
Spain	Lozano Rey (1928) reported that angel shark "*vive en todo el litoral ibérico, aunque parece más frecuente en las costas del Atlántico que en las del Mediterráneo, pero en este tampoco es rara … Los individuos jóvenes se pescan en la misma orilla. Nosotros hemos capturadao ejemplares de este especie, de menos de treinta centímetros de longitude, en la bahía de Santander, a un par de metros de profundidad*" [lives all along the Iberian coast, although it seems more common in the Atlantic coasts than in the Mediterranean, but this is not unusual ... Young individuals are caught in the same bank. We have captured specimens of this species, less than 30 cm long, in the Bahía de Santander, in waters a few meters deep] In relation to the Bahía de Santander, García-Castrillo Riesgo (2000) noted "*Hoy en día, esta especie de angelote no está presente en el entorno de la Bahía. La última referencia que tenemos data de 1985, cuando se recogió un ejemplar adulto y moribundo en el Puntal. Por el contrario a principios de siglo, según los datos de la Estación Biólogica de Santander, los jovenes eran frecuentes en los arenales del Puntal, el sable de Afuear, Enmedio y el fondeadero de la Osa, siendo aún más abundantes en al Abra del sardinero y las Quebrantas*". [Today, this kind of angelfish is not present in the environment of the Bahía. The last reference we have dates from 1985, when a dying adult specimen was collected in the Puntal. Rather early in the century, according to data from the Biological Station of Santander, the young were frequent off the beach at Puntal, saber Afuear, Enmedio and the anchorage of the Osa, still more abundant in the Abra del Sardinero and Quebrantas]
Portugal	Nobre (1935) wrote "*Esta espécie aparece freqüentemente no norte do País, sendo apanhada nas rêdes de fundo*" [This species appears frequently in the north of the country, where it is caught in bottom nets]
Italy	Tortonese (1956) stated it was "*Più o meno commune in tutti i nostri mari*" [more or less common in all our seas]

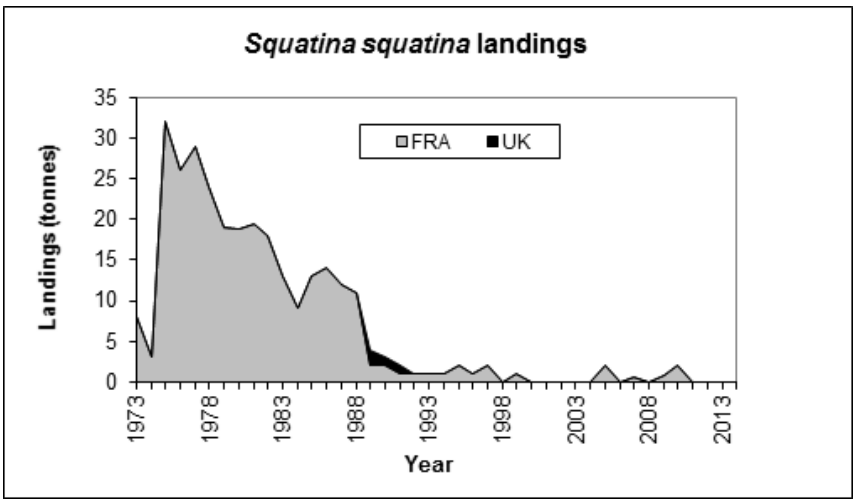

Figure 22.1. Angel shark in the Northeast Atlantic. Total reported landings of *Squatina squatina* (1973–2012). Angel shark has been listed as a non-retained/prohibited species on European fisheries regulations since 2009 and so this species is now reported very rarely in landing statistics.

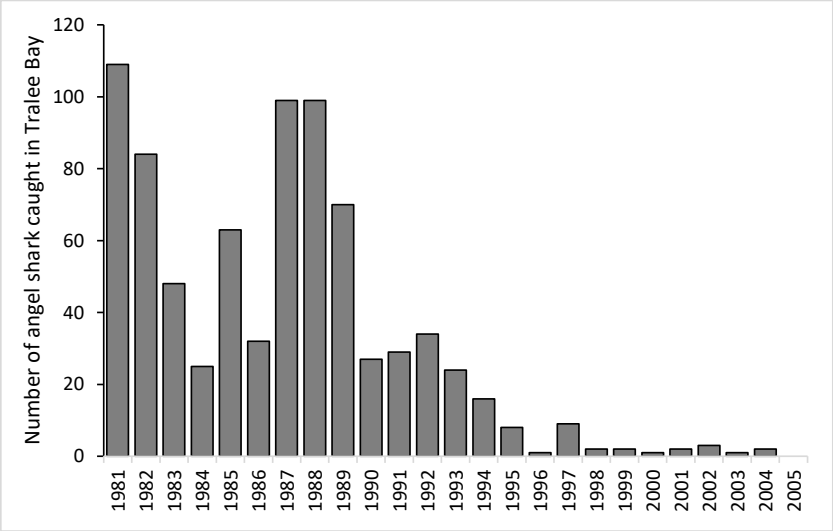

Figure 22.2. Angel shark in the Northeast Atlantic. Numbers of angel shark caught by two charter boats in Tralee Bay 1981–2005. Adapted from Irish Central Fisheries Board data presented in ICES (2008).

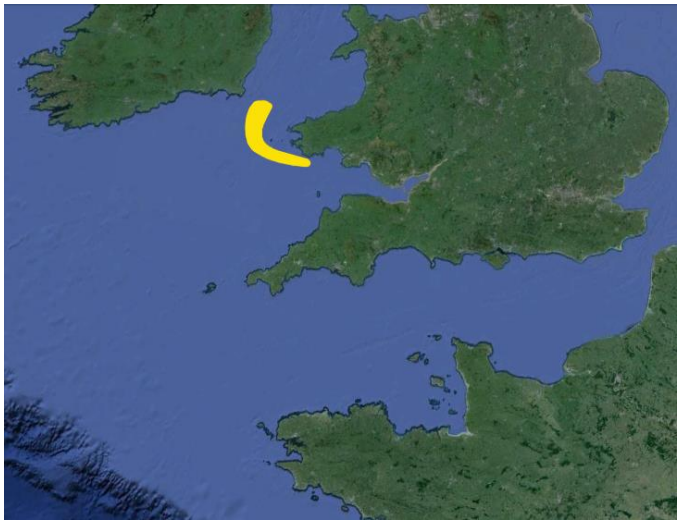

Figure 22.3. Angel shark in the Northeast Atlantic. The suspected over-wintering area off Pembrokeshire, where occasional individuals have been reported by French vessels.

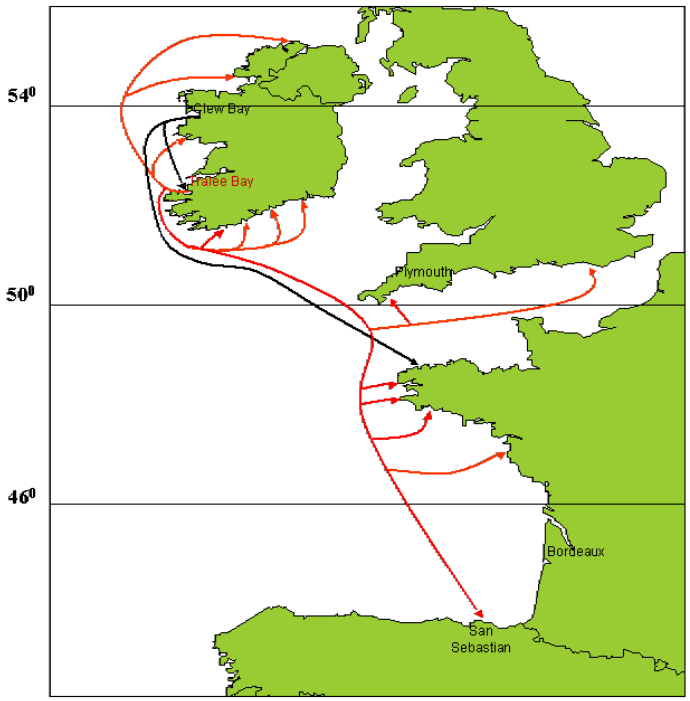

Figure 22.4. Angel shark in the Northeast Atlantic. Longer-distance movements of angel shark tagged off the west coast of Ireland, 1970–2006. Source: Irish Central Fisheries Board.

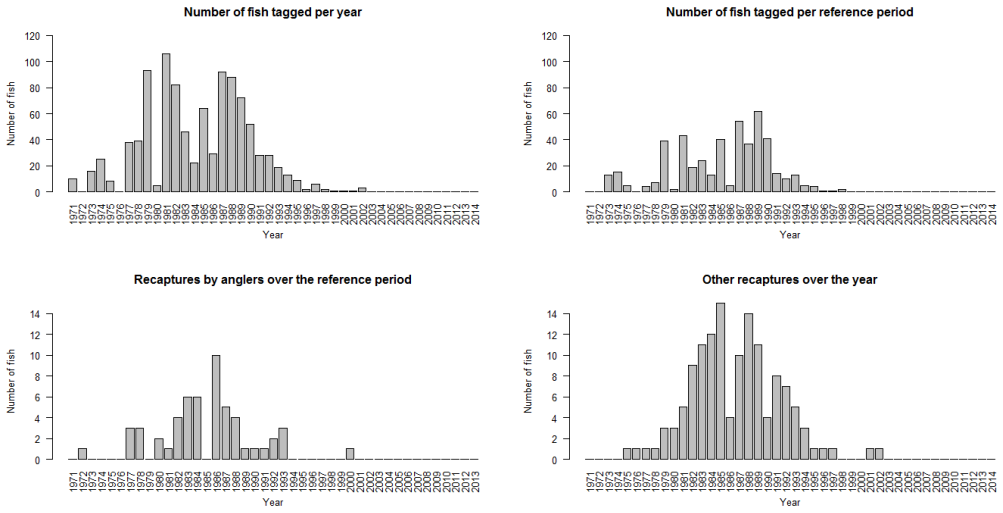

Figure 22.5. Angel shark in the Northeast Atlantic. Number of sharks captured, recaptured and newly captured per year in Tralee Bay, Ireland. Source: Bal *et al.* (2014 WD).

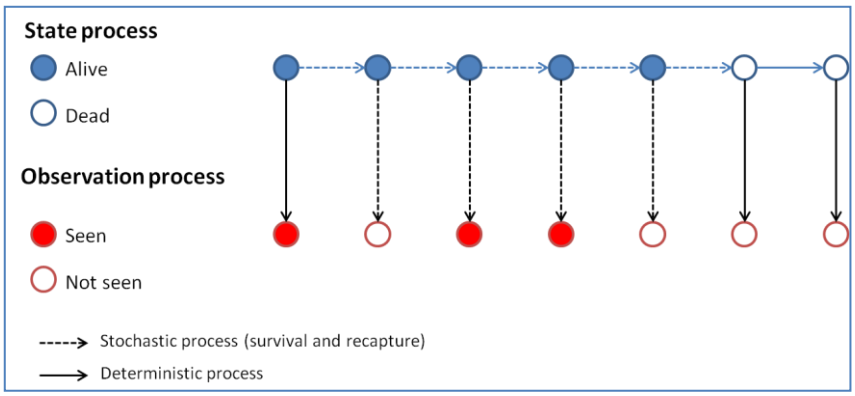

Figure 12.6. Angel shark in the Northeast Atlantic. Example of the state and observation process of a marked individual over time for the CJS model. The sequence of true states in this individual is A = [1, 1, 1, 1, 1, 0, 0] and the observed capture history is H = [1, 0, 1, 1, 0, 0, 0]. Source: Bal *et al.* (2015 WD).

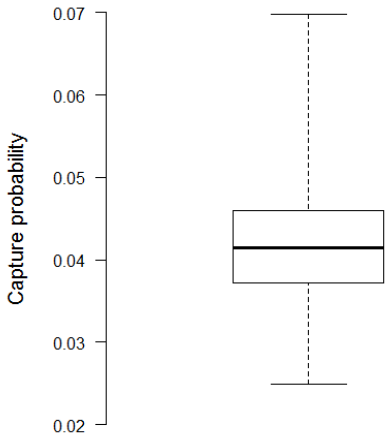

Figure 22.7. Angel shark in the Northeast Atlantic. Boxplot of the individual capture probability posterior. Source: Bal *et al.* (2015 WD).

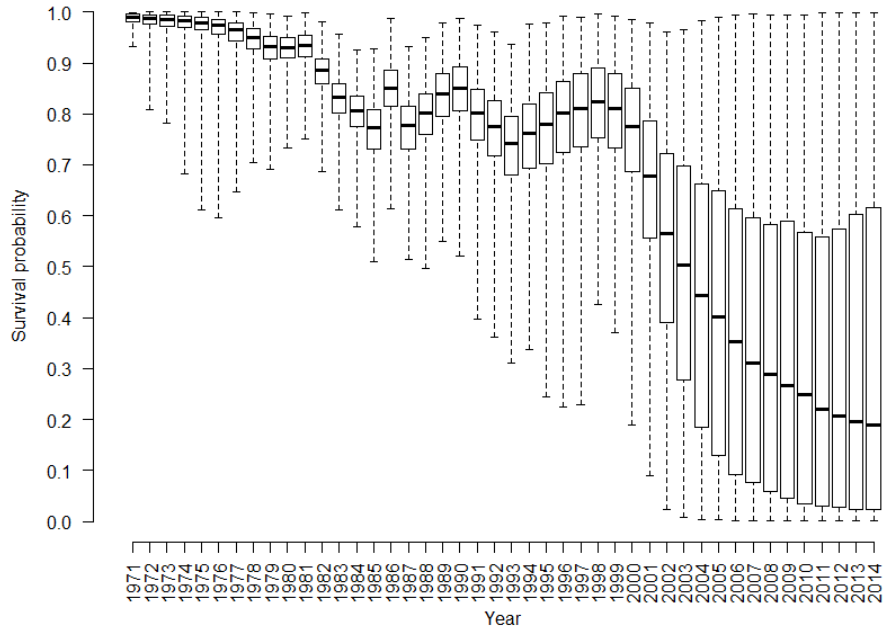

Figure 22.8. Angel shark in the Northeast Atlantic. Boxplot of annual survival probabilities posteriors. Source: Bal *et al.* (2015 WD).

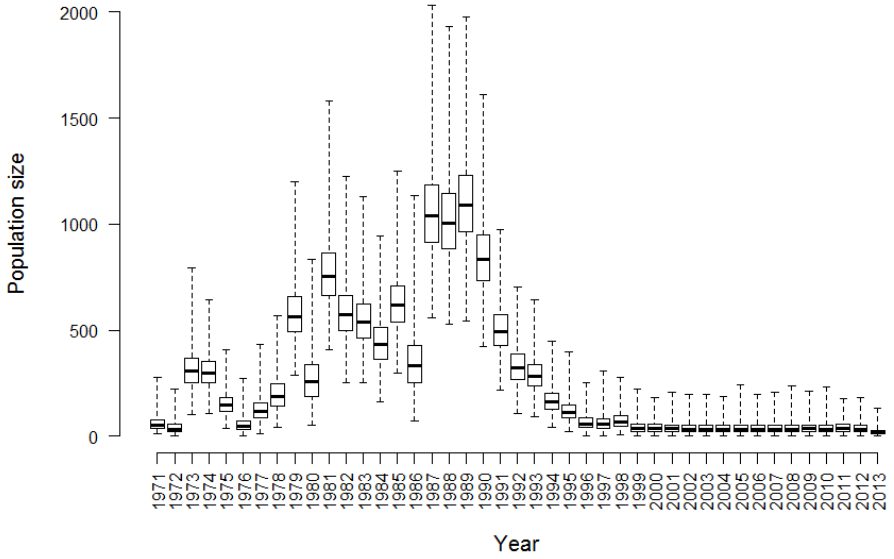

Figure 22.9. Angel shark in the Northeast Atlantic. Boxplot annual population sizes posteriors without population dynamics structure. Source: Bal *et al.* (2015 WD).

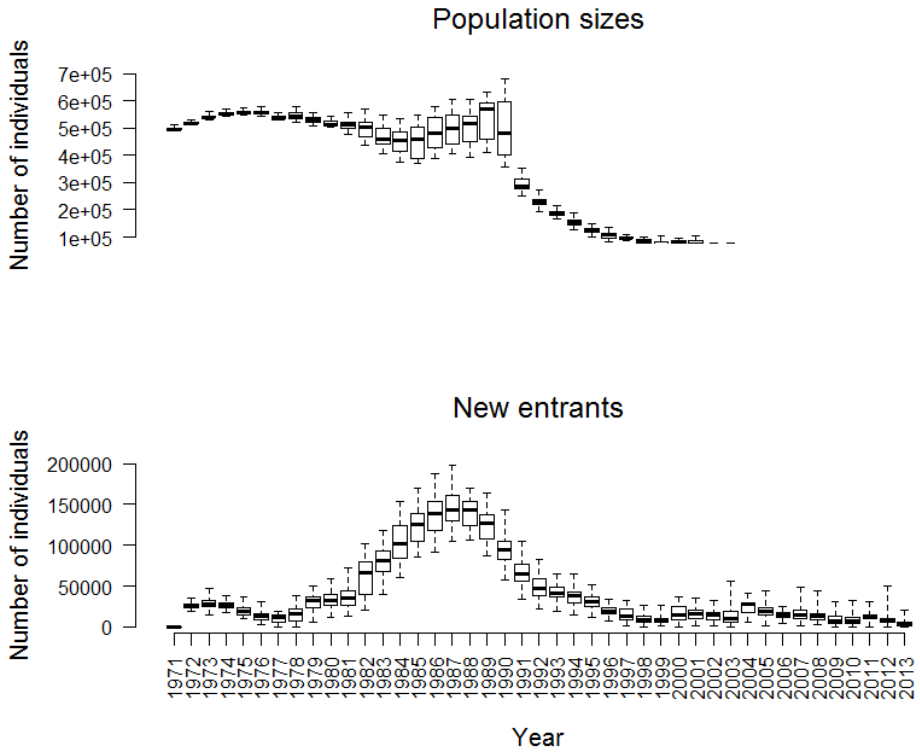

Figure 22.10. Angel shark in the Northeast Atlantic. Boxplot annual population sizes and number of entrants posteriors with population dynamics structure. Source: Bal *et al.* (2015 WD).