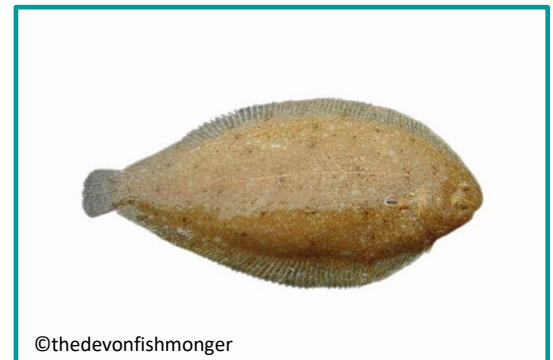


Sole

(*Solea solea*)

Summary

Size (total length)	60 cm (Wheeler, 1987)
Lifespan	-
Size of maturity (L₅₀) (North Sea pop.)	25 cm (Mollet et al., 2007)
Fecundity (eastern Channel)	>240,000 eggs (Witthames et al., 1995)
Reproductive frequency	Annual
Capture methods	Trawls, gill nets
Minimum Landing Size	24 cm
Fishing Season	Year round (peak Spring & Autumn)



Description

Sole (*Solea solea*) is a right-eyed flatfish commonly referred to as Dover sole or Common sole and can be found from Norway to the coast of Senegal, including the Mediterranean (FAO, 2020). There are several other species referred to as sole but in Europe the name is mainly used for *Solea solea*. Within the Southern IFC District additional species which may be referred to as sole include sand sole (*Pegusa lascaris*), lemon sole (*Microstomus kitt*) and solenette (*Buglossidium luteum*). The Dover sole is commonly found on sandy and muddy grounds from 10-100 m in depth while young juveniles can be found in water as little as 1 m deep in intertidal pools and on sandy shores (Wheeler, 1987).

Soles are nocturnal hunters and feed mainly on crustaceans, worms, and small molluscs (Teixeira and Cabral, 2010; Wheeler, 1987).

Reproductive Life history

The spawning season of sole is related to sea water temperature (Devauchelle et al., 1987). In the English Channel spawning starts when temperatures rise above 7°C and takes place from late February until the end of June in depths between 40-50 m (Pawson, 1995; Ramsay and Witthames, 1996; Wheeler, 1987). Several spawning sites have been identified along the south coast including between Beachy Head and the Isle of Wight, to the west of the Isle of Wight and further west of the Channel around Hurd Deep (Pawson, 1995). For stock located in the southern North Sea the main spawning site is located off the Thames estuary (Bromley, 2003). Peak spawning occurs in April and May. However, due to warming sea temperatures the spawning season is gradually shifting to earlier in the year for sole stocks around the UK, including in the Eastern Channel (Fincham et al., 2013). Older females begin to spawn

earlier in the season compared to younger fish and have a longer spawning season (Ramsay and Witthames, 1996). Older, larger females are also more fecund with average number of eggs estimated at 20,766 /per cm of fish (El-Aiatt et al., 2019) whilst Jones (1974) estimated an average of 728 eggs/ per gram of fish. In the English Channel Witthames et al, (1995) estimated females release between 239,635 – 324,368 eggs based on a 35 cm female.

Sole are broadcast spawners where reproduction takes place externally via females releasing unfertilised eggs and males releasing sperm simultaneously into the water column. To ensure fertilisation males and females display close synchronisation by swimming together whilst releasing gametes. Several spawnings can occur in one season with intervals of 3 to 10 days (Fonds, 1979). The eggs hatch approximately 8 days after fertilisation depending on water temperature (Pawson, 1995). In the North Sea temperature limits range between 7°C and 19°C with higher temperatures being detrimental to egg development (Fonds, 1979). Upon hatching, larvae measure approximately 3-3.5 mm in length and float at the surface (Fonds, 1979). They remain pelagic for 6 weeks and move with the currents towards inshore nurseries. At around 8-9 mm in length the larvae metamorphose into the flatfish form (Fonds, 1979). As small juveniles they inhabit estuaries, tidal inlets, and shallow, sandy shores (Pawson, 1995; Wheeler, 1987). Smaller individuals are found in deeper areas of estuaries whereas larger juveniles of 1 year move with the tides onto mudflats (Pawson, 1995). Juveniles remain in estuaries for approximately two years before moving to deeper water (Pawson, 1995). Adults undertake short migrations between offshore areas and shallower spawning grounds, returning to the spawning ground that they were born at each year (Pawson, 1995). Sole usually grow between 30-40 cm but can attain 60 cm in length (Wheeler, 1987; ICES, 2013).

Size of maturity (SOM)

Size of maturity (SOM) is often used to help establish an appropriate Minimum Conservation Reference Size (MCRS) to ensure individuals can reproduce at least once before capture. For finfish, SOM is commonly accepted as the total length (L) at which 50% of a population are mature and is referred to as the L_{50} . Maturity in finfish is determined by the classification of gonad development based on macroscopic (external appearance of the gonad) or microscopic methods (histology). Histological techniques (analysis of microscopic morphological features) provide the most accurate results, but it is a time consuming and expensive process. Maturity classification based on the external appearance of the gonad is quick, simple, and cheap however, it is not as accurate as histology and results may be subjective (Brown-Peterson et al., 2011).

Despite sole being one of the main species caught in England there are very few studies that have assessed its SOM in UK waters. Sole is often quoted as becoming sexually mature between 25-30 cm in length (Tous et al., 2015) however, no studies were found to confirm the higher end of this size range. In the North Sea female SOM has shifted over time (between 1960 and 2002) towards smaller fish from 28.6 cm to 24.6 cm due to an evolutionary response to fishing pressure (Mollet et al., 2007). In the Mediterranean male and female sole have been found to mature at 19.8 cm and

20.1 cm respectively whilst females in the Aegean Sea mature at a much smaller size of 15.4 cm (table 1). El-Aiatt et al, (2019) found all sole greater than 20 cm were mature in the Mediterranean.

Sole become sexually mature from three years of age but not all individuals spawn at this age. In the North Sea only 51% of sole spawn at three years (Bromley, 2003) and in the eastern English Channel approximately 70% of females spawn. By four years 100% of females are thought to spawn in the eastern English Channel (Ramsay, 1993 cited in Ramsay and Witthames, 1996).

Table 1. Size at maturity estimates (L_{50}) for sole (*Solea solea*) in studies undertaken across the species range. Male and female total length given in cm. Please refer to the Appendix for more information about each study.

Location	Male	Female	Reference
North Sea	-	24.6	Mollet et al., 2007
Mediterranean Sea	19.8	20.1	El-Aiatt et al., 2019
Aegean Sea	-	15.4	Cerim and Ateş, 2019

The MCRS for sole (*Solea spp.*) caught in the Southern IFC District is 24 cm. Based on the limited literature reviewed the current MCRS is in line with size at 50% maturity for populations in the North Sea. Allowing for a portion of the population to reproduce at least once before capture.

Southern IFCA Fishery

Fishing activity

In 2019, sole was the most caught species of fish within the Southern IFC District, closely followed by plaice (MMO, 2019). Sole is mainly targeted using gill nets and otter trawls in the District and can be caught throughout the year but peaks in activity occur in Autumn. Sole is a nocturnal predator and is more likely to be captured by fisheries at night, when it is active and swimming in the water column, than during the day (ICES, 2013). However, fishers in the District will catch sole during daylight hours.

Since January 2019 sole is subject to the European Union's Landings Obligation therefore all caught sole, irrespective of size, must be landed. Smaller specimens that cannot be sold at market are used as bait for other fisheries.

Recreational

Recreational anglers fish for sole from the shore and by vessel across the District. The species is also favoured by spear fishers due to its popularity as an eating fish. Shored based anglers are likely to catch smaller specimens than when fishing from a vessel in deeper water due to juveniles inhabiting estuaries and shallow water. Fishing for sole mainly takes place in the summer through to November with charter boats offering evening trips specifically for sole.

A recent review undertaken by the MMO to map recreational sea angling activity in England found flatfish to be the fifth most valued species for charter boats operating in the South Inshore marine planning area (Devon and Severn, Southern and Sussex IFCA districts) (MMO, 2020). Flatfish are more popular for vessel based recreational fishing than shore-based fishing with the greatest value for charter boats occurring in spring and summer (MMO, 2020).

Landings & Value of Fishery

Sole is the fifth most landed species of fish landed into English ports by UK vessels. However, it is by far the most valuable fish species landed with annual landings worth in excess of £10 million between 2015-2019. In 2019, 1,600 tonnes of sole was landed into England worth £18.4 million (MMO, 2019). By comparison, cod the most common fish landed in 2019 at 3,400 tonnes was worth £8.1 million and the second most landed species, monk/angler fish, was valued at £7.7 million (2,600 tonnes).

Southern IFCA do not hold effort or catch data for sole caught within the District, however landings data from the MMO can help indicate the scale of the fishery over time. In 2019 approximately 88 tonnes of sole worth £1.2 million was landed into ports across the Southern IFC District (fig.1*). Landings were fairly consistent between 2005 and 2014 with the majority of landings remaining between 90-110 tonnes. In 2015, landings reduced considerably from 106 tonnes in 2014 to 43 tonnes. Since 2015 landings gradually recovered to pre-2015 levels with 85 tonnes landed in 2018 and 88 tonnes in 2019. The average price per tonne of sole between 2005 and 2016 was £8,300 but within the last few years the average price has increased to around £11,600. In 2019, price per tonne of sole was approximately £13,400.

*these figures represent UK vessels that land into ports in the Southern IFC District, some of which would have fished outside the district and be >12 metres in length.

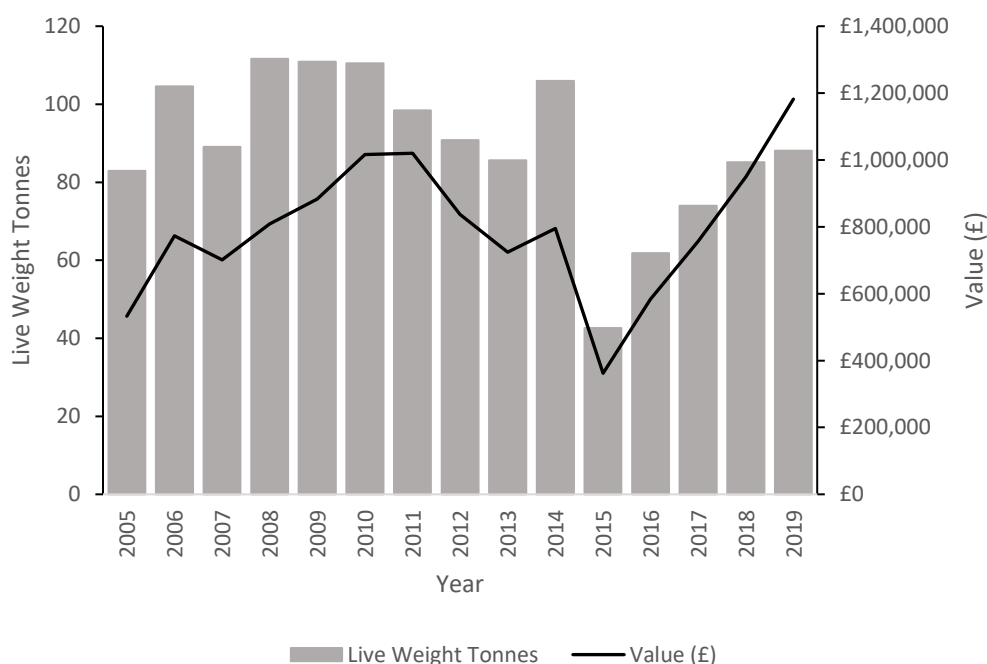


Figure 1. Landings of sole (*Solea spp.*) in the Southern IFC District from 2005 to 2019. Data sourced from the Marine Management Organisation (MMO)

Sole stocks in the English Channel (ICES Division 7.e and 7.d) are healthy with fishing pressure within sustainable levels and stocks being above maximum sustainable yield (ICES, 2020a, 2020b).

Associated management

Commercial landings of sole within the Southern IFC District are subject to a minimum landing size of 25 cm (total length) under European Legislation (Regulation (EU) 2019/1241). The Southern IFCA Minimum Conservation Reference Size Byelaw, which at time of writing is currently awaiting sign off by the Secretary of State, will apply the minimum size of 25 cm to all fishery participants in the district (including recreational). The minimum size for sole is consistent around the coast of England as all IFCAs enforce the EU's 25 cm minimum size.

In addition to a minimum size sole are managed through an EU multiannual management (Regulation (EU) 2019/472) which limits effort on sole stocks in the English Channel through quotas, cap on days at sea and gear restrictions. In recent years bycatch restrictions have been introduced to reduce discarding. All quota species are subject to Landing Obligations meaning all catch must be landed and counted against quota regardless of size unless exemptions apply. Since 2019 sole has been subject to the Landing Obligation.

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Appendix

Table A. Size at maturity estimates (L_{50}) for sole (*Solea solea*) from the literature. Measurements given in cm for total length (L_{50}).

Study location	Total No. surveyed	No. of individuals (n)		Length Data		Size at Maturity Data										Reference	
				Size range		Total No. of individuals	No. of individuals (n)		Size of smallest mature individual		Size at 50% maturity (L_{50})		Age at 50% maturity (years)		Size range of mature individuals		
		M	F	M	F		M	F	M	F	M	F	M	F	M		F
North Sea	12,808	-	-	-	-	-	-	-	-	-	-	24.6	-	3	-	-	Mollet et al., 2007
Mediterranean	1643	549	1094	-	-	-	-	-	-	-	19.8	20.1	-	-	-	-	El-Aiatt et al., 2019
Aegean Sea	607	-	607	-	19.7-30.4	-	-	-	-	-	-	15.4	-	-	-	-	Cerim and Ates, 2019