Presence of European sea bass (*Dicentrarchus labrax*) and other species in proposed bass nursery areas

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Executive summary

Juvenile sea bass occupy nursery grounds in estuaries and coastal areas for up to their first six years of life during which time they are subject to being bycatch in fisheries. Bass Nursery Areas (BNAs) were designated in England and Wales in the 1990s to reduce the impact of commercial and recreational fishing in areas where the majority of sea bass were likely to be below the minimum conservation reference size (MCRS – formerly, minimum landing size (MLS)) established in UK and EU legislation. In total, 37 estuaries and other coastal sites were designated as BNAs and additional restrictions on commercial and recreational fishing were imposed. These are thought to have played an important role in protecting the stock, possibly generating changes in size distribution, increased juvenile survival, and improvements in the productivity of the stock.

In 2015, Defra assessed the need for changes to existing BNAs and new designations. A questionnaire was sent to the nine mainland Inshore and Fisheries Conservation Authorities (IFCAs) and the Marine Management Organisation (MMO) requesting information to support the review of BNAs. Responses were received from eight IFCAs and the MMO, that included 48 proposed amendments to the existing BNA legislation (39 new site designations, five changes of extent, and four no longer required).

In this report, the evidence for each of the 48 proposed BNA amendments was compiled to assess their importance for juvenile sea bass and related fishing activity. The importance for juvenile sea bass was evaluated from the presence, abundance, and distribution of sea bass, and the extent of important sea bass habitat (e.g., salt marsh, intertidal areas). Juvenile was defined as fish being of length less than 36 cm. No comprehensive data sets were available, so it was necessary to collate a number of different sources. Data were compiled for abundance of sea bass from the Environment Agency (EA) sampling of estuaries and coastal waterbodies, Solent and Thames bass surveys, Thames Herring Survey, Cefas Young Fish Survey, power station screens, local IFCAs, and non-governmental organisations (NGO) surveys, and other sources (e.g., species records). Physical data on the temperature, salinity, and size, and habitat characteristics were sourced from the EA. Commercial fishing was assessed from landings in the adjacent International Council for the Exploration of the Sea (ICES) statistical rectangle and presence of commercially exploited fish within the BNA.

Different levels of evidence existed that were collected in varying ways for each area; hence, making direct comparison across areas impossible. Sufficient data were available to ascertain the presence of juvenile sea bass for 22 out of the 48 proposed amendments, but for another 22 limited or no evidence existed. Where data were available, they were not of sufficient resolution to generate spatial distributions of juvenile sea bass within each area or changes throughout the year. The remaining four proposed amendments related to the removal of BNAs no longer benefiting from warm water outflows due to decommissioned power stations. In those cases, the proposed amendment was reasonable as the feature had been removed, but broader protection could be considered

where there was evidence of the presence of juvenile sea bass in the estuaries within which the power stations were located (e.g., Bradwell in the Blackwater, Kingsnorth in the Medway).

Site designation amendments that extend the BNAs will provide additional protection, but this depends on how much of the total recruitment of sea bass to local populations is sourced from each area. This could not be assessed from the current data as the report uses a range of local surveys to indicate the presence and size of juvenile sea bass, not the total abundance of juveniles in the water body. Further work is recommended within nursery areas to understand the distribution of sea bass, the nature and extent of commercial fisheries, levels of discarding, and the relative contribution of individual nursery areas to the stock.

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1. Introduction

Bass Nursery Areas (BNAs) were set up in the 1990s to protect sea bass in areas where catches below the Minimum Conservation Reference Size (MCRS - previously termed Minimum Landing Size, MLS) predominate (Bass (Specified Areas) (Prohibition of Fishing) Order 1990: SI 1990 No. 1156 - Figure 1, Appendix 1). BNAs have been in existence for some time, and with declining overall sea bass stocks, Defra decided to undertake a collective review of current measures in BNAs and their effectiveness. This document provides a summary of the knowledge of biology and management of sea bass, the background to the establishment of the original BNAs, the proposed changes to the BNAs and evidence to support classification of BNAs, and the additional information and studies required to assess the impact of BNAs on the stock.

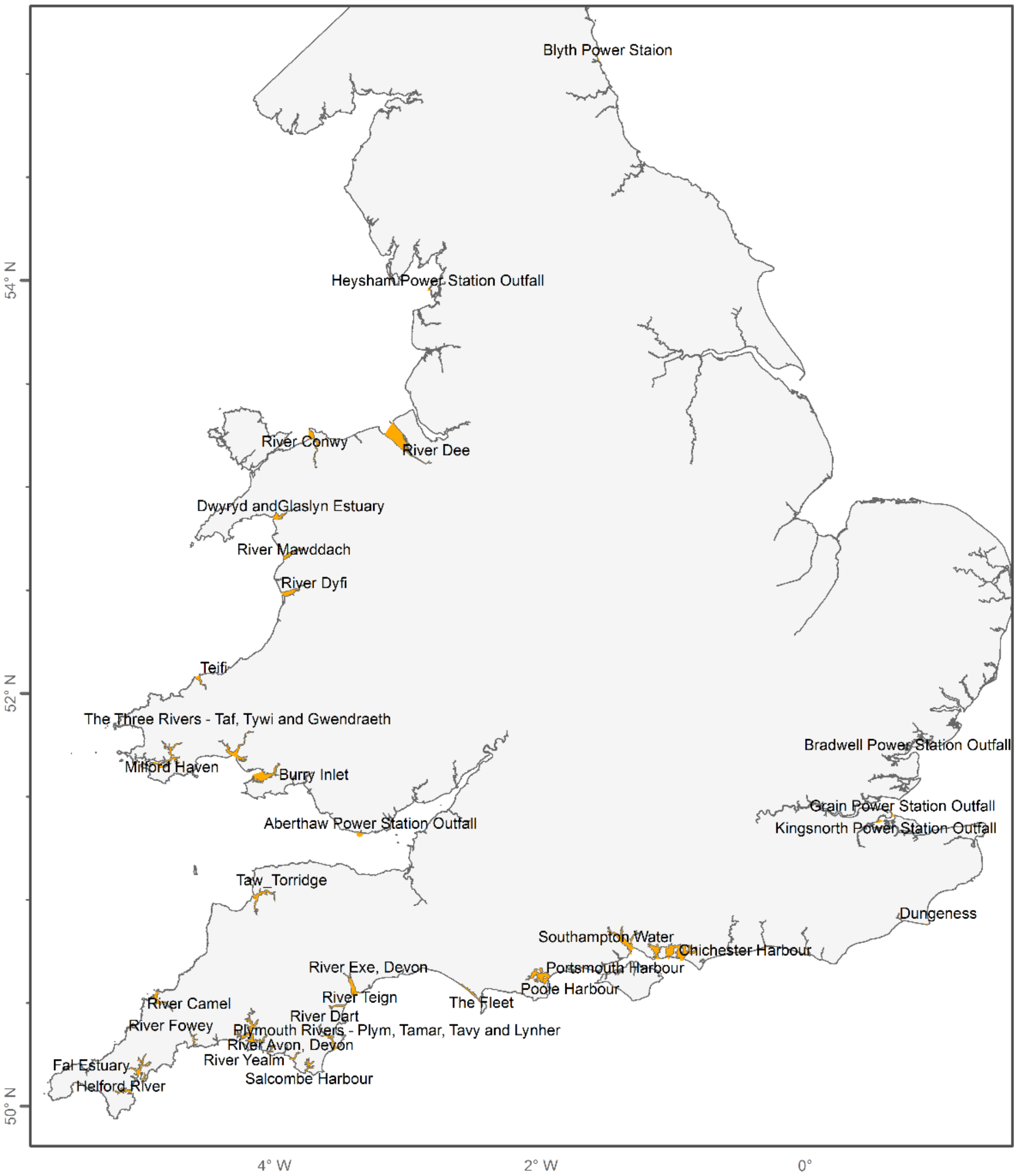


Figure 1. Existing bass nursery areas (BNAs) specified under the Statutory Instrument 1999 No 75 The Bass (Specified Areas) (Prohibition of Fishing) (Variation) Order 1999) (see Appendix 1).

1.1. Biology and management

The European sea bass, *Dicentrarchus Labrax (L.)*, is widely distributed across the northeast Atlantic, ranging from northwest Africa to southern Scandinavia and individuals are present in the Mediterranean and Black Seas (see Pickett and Pawson, 1994 for a general review). Sea bass in the northern stock (ICES 4b and c, 7a, d-h) are relatively slow growing fish that can reach up to 30 years of age and mature at around four to six years (Pawson and Pickett, 1996). Sea bass have a complex lifecycle with a pelagic larval phase, juveniles then occupying nursery grounds generally in inshore areas, before migrating out to join the adult population.

Mature sea bass aggregate to spawn between February and June from the Celtic Sea to the southern North Sea. The geographic extent of spawning is thought to be bounded approximately by a minimum temperature of 9 °C and can expand as the season progresses and in warmer years (Pickett and Pawson, 1994). The pelagic phase of sea bass lasts between 50 and 70 days (Jennings and Ellis, 2015) during which time dispersal brings a proportion of the larvae to the vicinity of nursery grounds in estuaries, saltmarshes, and other sheltered coastal sites (Beraud *et al.*, 2017).

Several nursery areas for sea bass were identified in the UK in the 1980s along the south, west, and east coasts (Pawson and Pickett, 1987). Similar nursery areas occur in other European countries, which were often poorly documented, although studies are underway to improve this. Inshore beam trawl surveys around the Netherlands showed that young sea bass have been relatively common in the Western Scheldt estuary since the late 1990s, although at lower abundance than in other estuaries and lagoons surveyed (ICES, 2014). The ecology and temporal trends of juvenile sea bass in the Wadden Sea, where fish at ages zero to five were present, were studied by Cardoso *et al.* (2015). Sea bass nursery areas are known to occur in estuaries in France, but this had not been fully documented. Seine net surveys along the south and southeast coasts of Ireland have shown the existence of estuarine nursery areas for sea bass although at relatively low density in most years compared with similar habitats in England (Fahy *et al.*, 2000). No information on sea bass nursery areas was available for Belgium although the short coastline has few potential habitats for young sea bass. The characteristics of an estuary is indicative of its potential as a BNA (Pickett and Pawson, 1994) with the distribution of sea bass in estuaries related to salinity and depth (Kelley, 1988) and habitats like saltmarsh are important for juvenile sea bass (Colclough *et al.*, 2005; Fonseca, 2009). There is evidence that there is strong site fidelity of 0-group sea bass to specific areas of saltmarshes in the upper end of estuaries, so protection of these areas is likely to be beneficial (Laffaille *et al.*, 2001; Colclough *et al.* 2005; Fonseca *et al.*, 2009; Green *et al.* 2012). Small sea bass move onto areas of saltmarsh during the flood tides and return to deeper areas during the ebb (Laffaille *et al.*, 2001). However, it is unclear exactly how larger juvenile sea bass use nursery areas despite stylised representations being available (Figure 2).

In the UK, estuaries that normally contain juvenile sea bass have been categorised as: lowland, downland, sandy, rias, and natural harbours (see Pickett and Pawson, 1994). Lowland estuaries are identified as those with wide river mouths, flats, saltings, long inland penetration of high salinity waters and which are shallow (e.g., Blackwater, Severn). Downland estuaries are narrow with fast freshwater runoff, short inland penetration of salt water, strongly tidal and turbid, but do not contain extensive feeding areas for sea bass (e.g., Arun, Itchen). Sandy estuaries are produced by river deposits, often have dunes or saltmarshes along the tidal reaches, and juvenile sea bass may dominate fish communities (e.g., Nevern, Burry Inlet). Rias are valleys that have been flooded by the sea, have rocky areas, little sediment, and larger areas of deep water that may contain juvenile and adult sea bass throughout the year (e.g., Fal, Yealm). Natural harbours are tidal non-estuarine arms of the sea that are usually shallow and have large intertidal areas that may contain sea bass (e.g., Poole and Chichester Harbours). Methods developed to predict fish assemblages in estuaries identified latitude, temperature, salinity, dissolved oxygen, habitat, and mud as important factors in explaining the occurrence of sea bass in estuaries in Portugal, but the predictive ability was limited as the models only explained around 30% of the deviance (França and Cabral, 2016). Classification schemes have been developed for estuaries for the Water Framework Directive (WFD) that include ecotype (Coates *et al.*, 2007; Lepage *et al.*, 2016) and have potential to be used to assess association with sea bass.

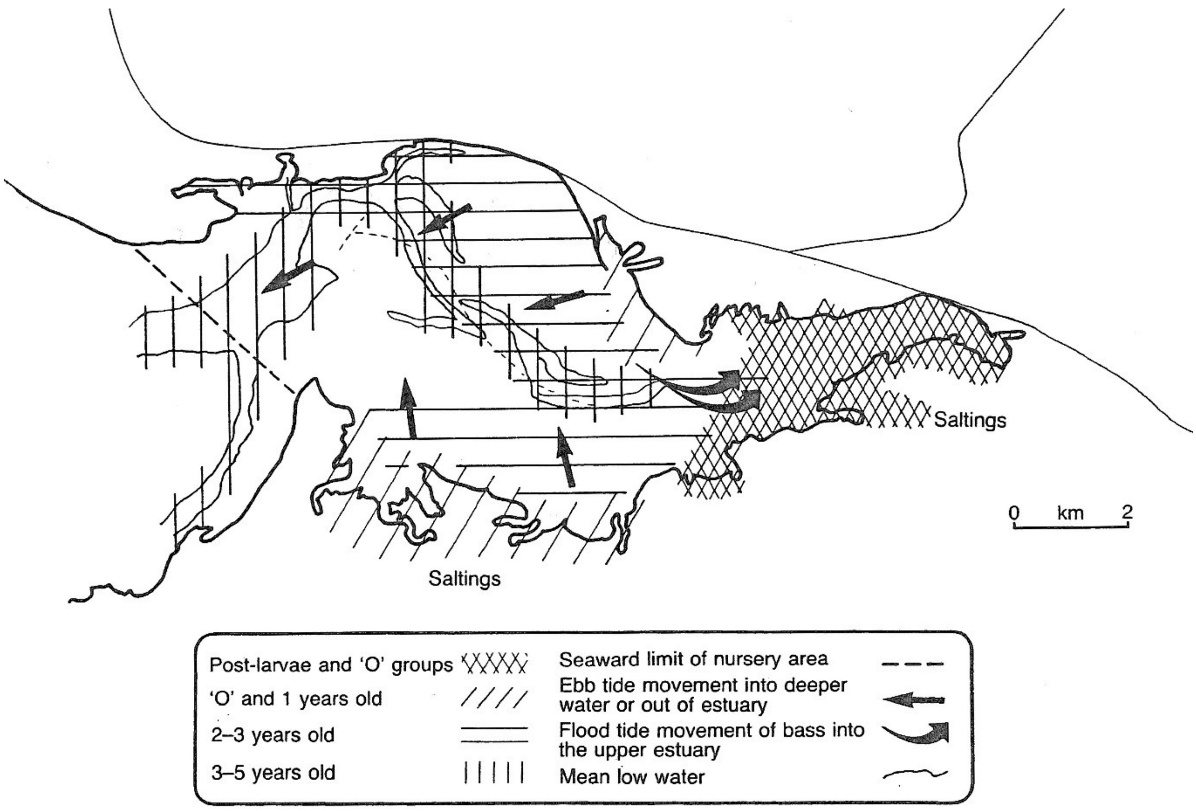


Figure 2. Stylised description of the distribution and behaviour of sea bass in a typical medium-sized sand-bar estuary nursery areas (reproduced from Pickett and Pawson (1994)).

Both adult and juvenile sea bass are present in estuaries, with sea bass of under 24 cm to over 60 cm captured in estuaries around England and Wales during tagging programmes

(Pawson *et al.*, 1987). There are differences in size at maturity between males and females, with males generally maturing at 31-35 cm aged four to six years and females at 40-45 cm aged five to eight years (Kennedy and Fitzmaurice, 1972; Pawson *et al.*, 1987; Armstrong and Walmesley, 2012). Examination of 700 sea bass from the English Channel and North Sea showed that fish below 32 cm mainly had immature gonads, very few fish between 32 and 42 cm had ripe or spent gonads, and most of fish over 42 cm had ripe or spent gonads (Pawson *et al.*, 1987; Pickett and Pawson, 1994). This led to the definition of fish as juvenile (32 cm or less), adolescent (32-42 cm) and adult (42 cm or larger) (Pawson *et al.*, 1987). Maturity ogives showed that females start to mature at around 35 cm, with 50% of male and females mature at 35 and 41cm, respectively (Armstrong and Walmsley, 2012). From around four years of age the juveniles become widely distributed in coastal waters before joining the adult population once mature (Pawson *et al.*, 2007). Tagging studies showed that 5% of juveniles, 20% of adolescents, and 50% of adults were recaptured more than 50 miles from original capture sites showing that migration starts between four to six years of age (Pawson and Pickett, 1987) and 93.5% of recaptured sea bass of under 36 cm that were tagged in BNAs were caught in local fisheries (Pickett *et al.*, 2004). Genetic studies show limited distinction between stocks (Fritsch *et al.*, 2007) and tagging studies have shown large migrations of sea bass (Pawson *et al.*, 2007) with some evidence of philopatry, where adults tend to return to the same coastal site each year after spawning (Pawson *et al.*, 2008; Doyle *et al.*, 2017).

Sea bass is a high value fish with significant exploitation by commercial fisheries (ICES, 2012), and is also an important species for recreational anglers with recreational removals constituting around a quarter of the total harvest of the northern stock in 2012 (Armstrong *et al.*, 2013; Hyder *et al.* 2017; 2018). Management of sea bass is done separately for four regions: i) Iberian Coast; ii) Bay of Biscay; iii) west of Scotland and south and west of Ireland; and iv) North Sea, English Channel, Celtic Sea, and Irish Sea (ICES, 2012). Scientific assessments of the northern stock (ICES 4a and b, 7a, d-h) have shown a rapid decline in the spawning stock biomass (SSB) since 2010 attributed to a succession of weak year classes from 2008-2012 and increased fishing mortality (ICES, 2016). The stock exhibits very large interannual variability in recruitment, driven by environmental factors (ICES, 2012). To conserve the stock, significant reductions in the harvest of sea bass have been implemented in the EU legislation through seasonal closures, increasing the MCRS (previously termed MLS) to 42 cm, monthly boat landings limits, and bag limits for recreational anglers (EU, 2015a-d; 2016; 2017).

1.2. History and original classification of BNAs

BNAs were introduced in 1990 as part of a new strategy for the long-term conservation and management of the sea bass fishery in English coastal waters (see Pickett and Pawson, 1994 for a general review). A full description of the process and underlying evidence can be found in other texts so is not described in detail here (Pawson and Pickett, 1987; Pickett and Pawson, 1994). The management strategy acknowledged that sea bass recruitment is heavily dependent on climatic conditions, and therefore focused primarily on improving long term yield and recruitment of fish to the spawning stock from each year class. Measures to achieve this centred around providing additional protection to juvenile sea bass that included: increasing the MCRS from 32 to 36 cm, restrictions on mesh size and use of gillnets, and prohibition of fishing in nursery areas for all or part of the year (Pickett and Pawson, 1994). The purpose of the BNAs was to prevent catches of sea bass in areas with a high proportion of fish below 36 cm (the MCRS implemented in 1990), including areas such as power station outfalls where such fish can aggregate and be particularly vulnerable to exploitation. Tagging studies had shown that sea bass below 32 cm (the MCRS between 1983 and 1990) tended to inhabit estuarine areas, while larger sea bass moved widely around the coast (Pawson *et al*., 1987).

Initially, 34 BNAs were defined (Pawson and Pickett, 1987) and legislated in the Bass (Specified Areas) (Prohibition of Fishing) Order 1990: SI1990 No. 1156, which specified that fishing for sea bass from a boat was prohibited. Shore angling was removed from the prohibition following lobbying by the recreational angling sector, but it was expected that shore anglers would respect the need for the prohibition and return any sea bass caught within the BNAs (MAFF, 1990). Changes to the BNA legislation were made in 1992 that altered the description of the Fawley Power Station BNA (Statutory Instrument 1992 No. 3027: The Bass (Specified Areas) (Prohibition of Fishing) (Variation) Order 1992), and in 1999 that added three additional BNAs and prohibited the use of sandeels for bait in all the nursery areas as it was considered very effective for targeting sea bass (Statutory Instrument 1999 No. 75: The Bass (Specified Areas) (Prohibition of Fishing) (Variation) Order 1999). In England and Wales, 37 river estuaries and other coastal sites are currently defined as BNAs, where additional restrictions on commercial and recreational fishing are imposed during all or part of the year (Statutory Instrument 1999 No 75: The Bass (Specified Areas) (Prohibition of Fishing) (Variation) Order 1999*)* (Figure 1, Appendix 1). The outflow areas of several power stations were included in the designation as the warm water from the discharge of cooling water was thought to attract and improve the survival of juvenile sea bass especially in cold winters (Pawson and Eaton, 1999). BNAs represent areas of 32,956 hectares in England (including the Dee estuary) and 46,764 hectares in total across England and Wales. These areas are thought to have played an important part in protecting stocks since their introduction in 1990 by moving the focus of fishing effort away from juvenile sea bass, the objective being to improve recruitment to the spawning stock and maintaining or increasing yields to the fishery (Pickett and Pawson, 1994).

Assessing the impact of the BNAs on the sea bass stock is complex. A yield-per-recruit analysis was done to look at the impact of different ages and sizes at which fish recruit to the fishery in each region (Pawson and Pickett, 1987), but this did not assess the impact of BNAs in isolation to the other measures (changes in MCRS and mesh size). Instead, an argument was made that it was possible to recognise distinct nursery areas for juvenile sea bass, where they were particularly vulnerable and could be protected against mortality other than due to natural causes (Pawson and Pickett, 1987). Pickett and Pawson (1994) provide the most comprehensive description stating that BNAs were assessed on: 1. the likely proportional contribution of recruits to the adult stock; and 2. the significance of protecting juvenile sea bass for the local fishery. They also indicated that it was possible to identify specific areas to close using the characteristic topography of the nursery area and information on local fishing areas. Pickett *et al.* (1995) did an appraisal of the UK sea bass fishery and its management, but specifically excluded an assessment of the impact of the BNAs. They stated that using BNAs to protect juvenile sea bass from unwanted fishing effort appeared to be supported by evidence of the size distributions inside and outside the areas. This appraisal was updated, but again the difficulty of assessing the impact of BNAs due to challenges in estimating exploitation rates was identified (Pawson *et al.*, 2005). However, evidence from tagging studies before and after the establishment of the BNAs, indicated that the increased survival of juvenile sea bass after 1,000 days (Pickett *et al.*, 2004) was likely to have driven some of the improvement in the yield-per-recruit (ICES, 2002; Pickett *et al.*, 2004).

Further expansion to the BNAs has been proposed in two separate studies. In 2009, 26 new areas were suggested as potential BNAs and the evidence for this categorisation compiled (Smith and Brown, 2009). The possible new BNAs identified were: Blackwater and Colne; Crouch and Roach; Thames; Medway and Swale; Walton Backwaters; Blyth; Deben; Alde and Ore; Stour and Orwell; North Norfolk Harbours; Breydon Water; Adur and Shoreham Power Station; Rother; Medina; Newton Harbour; Lymington; Keyhaven; Tees; Wyre; Lune; Kent; Duddon and Walney Channel; Ribble; Severn; Wye; and Usk (Smith and Brown, 2009). The Institute of Fisheries Management analysed the survey data collected by the Environment Agency for the WFD in 2015 and identified 18 potential new or changes to existing BNAs including: Adur; Alde; Blackwater; Bure (including Waveney and Yare); Crouch and Roach; Cuckmere; Dart; Dee; Exe; Great Ouse and Wash; Fal; Medway; Orwell; Poole Harbour; Severn; Suffolk Stour; Taw and Torridge; and Thames (Colclough, 2015).

1.3. Aims of current study

BNAs have been in existence for some time, and with declining overall sea bass stocks, Defra have decided to undertake a collective review of current measures in BNAs and their effectiveness. The overall aim of the current study was to collate and assess the evidence for changes proposed to BNAs by the IFCAs. To achieve this, it was necessary to compile existing data on the physical properties and abundance, size, and location of fish in estuaries across England, and assess the evidence in support of the proposed changes to BNAs. Further work to fill existing data and knowledge gaps was also identified.

2. Methods

2.1. Proposed changes to BNAs

In 2015, Defra sent a questionnaire to the nine mainland IFCAs and the MMO requesting information to support the review of BNAs. This included questions on the spatial and temporal extent, management measures, enforcement, activity by recreational and commercial fishers, and other benefits of existing BNAs, along with proposals for amendments to BNAs (see Appendix 2 for full list of questions). This provided information on the general evidence for BNAs and proposals for potential new, changes to existing, and no longer required BNAs. Specific evidence or detailed scientific data about presence of sea bass in estuaries was also requested.

For each proposed amendment to the existing BNA legislation, a map was created (shapefile), relevant data on the physical characteristics of the area and surrounding habitats were compiled, and data on the size, distribution, and abundance of sea bass and other fish species in estuaries were identified. It was not possible to compile all the grey literature for each proposed amendment due to the large numbers of areas and challenges of sourcing and compiling the individual reports. For each of the proposed amendments, an assessment of existing evidence was compiled on the physical characteristics, presence of sea bass, and presence of other species. These other species might provide an indication of commercial fishing opportunities and included: cod (*Gadus morhua*), grey mullet species of the family Muglidae (thick lipped grey mullet – *Chelon labrosus*, thin lipped grey mullet – *Liza ramada,* golden grey mullet – *Liza aurata*), plaice (*Pleuronectes platessa*); and sole (Dover Sole – *Solea solea*, Lemon Sole - *Microstomus kitt*, Sand Sole - *Pegusa lascaris*, Solenette - *Buglossidium luteum*). Summaries were prepared for each IFCA area, which comprised the physical characteristics, evidence compiled, and an assessment of the potential to support further consideration of each of the individual proposed amendments within that area.

2.2. Physical characteristics

It was difficult to compile data for the physical characteristics of estuaries as there is no single database containing all the information required, and there were often challenges in resolving different spatial resolutions. Total area of the BNA was derived from the shapefile for each existing and proposed change to the BNAs. Saltmarsh extent for individual BNAs was taken from data derived from aerial imagery by the Environment Agency (https://data.gov.uk/dataset/saltmarsh-extents1) (Hambidge and Phelan, 2014). Saltmarsh was defined as ‘any discrete marsh, grassland, or reed bed, subject to tidal inundation from saline waters’ (Environment Agency, 2011) The saltmarsh areas was based on historic data and existing aerial imagery, so may not accurately represent saltmarsh in managed realignments schemes (Hambidge and Phelan, 2014).

Additional physical characteristics were compiled from the following sources:

1. Environment Agency (EA) compilation of limited data on physical characteristics of 219 waterbodies throughout the UK including location, category of waterbody, WFD ecotype, hydrodynamic status, area, and length (hereafter titled “EA part”).
2. Environment Agency compilation of 152 variables for 27 reference systems (hereafter titled “EA full”) for WFD from several sources including WFD sampling, the Estuarine and Coastal Monitoring and Assessment Service, EUNIS, and Catchment Planning (Adam Waugh, pers. comm.). This database included biogeographic factors (e.g., latitude, longitude, waterbody size and distance to continental shelf), geomorphological factors (e.g., estuary depth, tidal type, and estuary salinity regime), habitat characteristics (e.g., intertidal area, saltmarsh, and subtidal habitat characteristics), and anthropogenic variables (e.g., hydrographical and physical regime, effects on the chemical water quality and biological dissolved oxygen).
3. Smith and Brown (2009) developed short physical descriptions of the waterbodies that they assessed for potential to be new BNAs along with a description of the relevant fishery.

The EA full dataset was considered the most comprehensive, followed by the EA part dataset, and finally Smith and Brown (2009), as the provenance was known and contained more variables (Table 4). For 14 of the 48 sites, the EA full data set was available, so characteristics of the estuary were plotted that are known to be important for sea bass, including the types of saltmarsh where available. Additional physical characteristics were not available for the open sea sites (the Manacles, The Runnel Stone, Sizewell Power Station, Shoreham Power Station).

2.3. Fish assemblages and landings

There were many surveys of small fish that have been done in estuaries, but were difficult to compile as the majority are either unpublished or published as grey literature rather than peer-reviewed articles. From discussions with the IFCAs, Defra, the Environment Agency (EA), and external experts, and examination of the literature, several key data sets were identified. These were:

1. EA sampling of 64 estuaries for WFD (Coates *et al.*, 2007).
2. Cefas Solent trawl survey for sea bass (Pickett *et al.*, 2002; Walmsley, 2005), the Cefas Thames Bass Survey (Walmsley, 2006), and the Cefas Thames Herring Survey (Walmsley, 2007).
3. Cefas young fish surveys using beam trawls in coastal waters of south east England (Rogers and Millner, 1996; Rogers *et al.*, 1998).
4. Power station screen sampling (e.g. Kelley, 1988; Pickett and Pawson, 1994; Pickett *et al.*, 1995).
5. Local surveys for specific uses done either by or in collaboration with the IFCA (e.g., Sussex IFCA (Nelson, 2014; 2017; Tebb *et al.*, 2015) and Eastern IFCA (Jessop *et al.*, 2013; Harwood and Perrow, 2016) small-fish surveys).

6. Species records of presence of sea bass from the National Biodiversity Network (https://data.nbn.org.uk/).
7. Anecdotal evidence from users of the estuaries (e.g., anglers).

National Biodiversity Network data was excluded as no information on fish length was provided. Anecdotal evidence from users of the marine environment was also excluded as no information on locations, size, or abundance was provided. The methodologies for each of the surveys used in the analyses are described in more detail below.

The Environment Agency and its predecessors have monitored 64 estuarine and coastal waterbodies across England since 1973. From 1973 to 2006, the monitoring was sporadic and inconsistent in most estuarine and coastal waterbodies. From 2007 onwards, nearly all monitoring consisted of one or more of four methods. Intertidal methods included using hand-hauled small gear including beach seine netting, beam trawling, and fyke netting (Table 1). Sub-tidally, where possible each waterbody was monitored using a larger vessel and an otter trawl (Table 1). For a full description of the methods, see Coates *et al.* (2007).

The Cefas Solent Bass Survey, which in recent years has been supported by the Southern and Sussex IFCAs and the Bass Anglers Sportfishing Society, started in 1981 with annual trawl samples of sea bass taken in the Solent, Southampton Water, Langstone Harbour, and Chichester Harbour (Pickett *et al.*, 2002). Since 1984, the main aim of the survey has been to determine the distribution and relative abundance of pre-recruit sea bass. Originally, surveys were done twice each year (May, September) (Pickett *et al.*, 2002), but in recent years a single survey has been done in September covering 35 locations (e.g., Brown, 2013). A high headline sea bass trawl with diagonal stretched 70 mm mesh and a 4 mm mesh cod-end was towed at 3 knots for between five and 20 minutes (Table 1) on the last ebb and through the flood of a spring tide (Pickett *et al.*, 2002). For each survey, the tow characteristics (time, location, depth weather) and biological information (species, numbers, size) were recorded (Pickett *et al.*, 2002). Commercial finfish species were all measured and total lengths to the nearest centimetre were recorded. Sea bass were collected with a hand net for measuring and removal of scale samples for age determination (Pickett *et al.*, 2002). This has been used to develop a recruitment index for sea bass, and time series of ages two to four are used in stock assessments (ICES, 2016). For a full description of the Solent Bass Survey, see Pickett *et al.* (2002) and Walmsley (2005).

Cefas carried out sea bass trawl surveys with support from the Environment Agency each year in the Thames estuary and Rivers Blackwater, Crouch, Roach, and Medway (Walmsley, 2006) between 1997 and 2009. The main aim of the surveys was to determine the distribution and relative abundance of pre-recruit sea bass, but all species captured were processed. The surveys were done in November, when juveniles move from the shallows at the edges of estuaries into deeper water because of falling temperatures and become vulnerable to the sampling gear. The surveys demonstrated the importance of these areas as nursery grounds for other species of fish, particularly sole. The same commercial fishing vessel (MFV Ina K) was used for the entire survey series. The survey used the same gear as described for the Solent survey, except that the vessel was a beam trawler, so two nets were fished simultaneously. The standard survey had a total of 34 tows (primary stations), each of which was fished for a duration of 20 minutes (Table 1). The catch was sorted in the same manner as the Solent survey, except that the port and starboard catches were recorded separately (Walmsley, 2006).

Table 1. Surveys in the fish assemblage data set including information on sampling methods and number of sea bass measured in each gear type.

Survey	Method	Height (m)	Width (m)	Mesh size - wings (mm)	Mesh size - centre / end (mm)	Number of sea bass measurements	Notes
EA WFD	Beam trawl (1.5 m)	0.45	1.5	20	5	461	200 m distance @ 3 knots
	Beam trawl (2.0 m)	0.5	2	20	10	66	variable distance @ 3 knots
	Beam trawl (2.4 m)	0.5	2.4	20	10	39	variable distance @ 3 knots
	Fyke	0.9	0.8	12	3	1,313	Soak for tidal cycle and dry weight of 20 kg
	Gill	2	91	10	10	0	One-hour soak
	Kick sampling	0.3	0.25	1	1	3	1 minute against current (only upper Thames)
	Otter trawl (single)	3	8	80	10	1,239	Variable time and dry weight of 95 kg
	Otter trawl (twin)	3	8	70	4		20-minute tow and dry weight of 180 kg
	Power station screen					7,259	Intake screen for power stations at variable frequency
	Seine	4	43	14	6.5	24,041	Two replicates and dry weight of 40 kg
	Trammel	2	182	20	8	47	One-hour soak (Severn only)
Solent Bass Survey	High headline trawl		12	70	4	185,718	Towed at 3 knots for 10 minutes
Thames Bass Survey	High headline trawl		12	70	4		Towed at 3 knots for 20 minutes
Thames Herring Survey	Larson sprat trawl		7.31		16	5,693	Towed at 3 knots for 1 hour
Young Fish Survey	Beam trawl (2 m)		2		4	Included EA WFD 2 m beam trawl	Towed at 1 knot and distance covered recorded
	Push net (1.5 m)		1.5		4	53	Pushed at 1 knot and distance covered recorded
Sussex IFCA	Beam trawl (2 m)		2	14	4	Included EA WFD 2 m beam trawl	Towed at 1- 3 knots for 10 minutes
	Seine	4	43	14	4	Included EA WFD seine net	Two replicates and dry weight of 50 kg
	Seine	2	22	27	5	25	Pagham Harbour in 2015-16
	Seine	2	22	27	5	100	Two hauls in Tide Mill Creek
	Fyke	0.5		10	6.5	50	One haul in Tide Mill Creek
	Seine		15		Fine	26	Pagham Harbour in 1998
EA	Seine		18	1.5	5	1,679	Pagham Harbour in 2007
	Fyke		3	4		44	Pagham Harbour in 2007
Eastern IFCA	Seine	4	43	14	4	Included EA WFD seine net	Survey of the Deben
	Fyke					23	Waldringfield Marshes fish survey
ECON and NT	Seine	5.00	60.00		5.00	114	Blakeney Estuary
	Seine	2	15		3	7	Burnham Estuary

A survey of herring in the Thames was done each year between 1989 and 2009 that was also used to sample sea bass (Walmsley, 2007). A total of 36 tows were done in the Thames estuary, Rivers Blackwater, Crouch, Roach, and Medway to provide biological data for herring stock assessments. A Larson sprat trawl was fished for 1 hour at a speed of 3 knots with a gape of 7.32 m and a cod end mesh size of 16 mm (Table 1). Herring and sea bass were sorted from the catch and measured, and all other species identified and counted (Walmsley, 2007).

The entrainment of fish on the cooling water intake screens of coastal power stations is well known (Turnpenny, 1988) and sea bass have been recorded (Pickett and Pawson, 1994). The entrainment of fish on the screens of some power stations has been monitored by various organisations since around 1970. Some data from screens at Shoreham Power Station were included in the Cefas Fishing Surveys System (FSS), but additional data was collated for Sizewell. The sampling frequency and years varied between power stations and did not occur after decommissioning, so was not relevant for decommissioned stations. At Sizewell, impingement sampling was done between 2009 and 2012 over 24 hours on between 28 and 40 occasions each year from March to February. On each day, three hourly samples were taken between 12:30 and 15:30, a single 18-hour bulk sample was then taken between 15:30 and 09:30 the following morning, and then a further three hourly samples were taken between 09:30 and 12:30. The (sub)sample was sorted for fish and the number and the weight of species or debris in the sorted portion were then multiplied up to provide numbers in the entire sample. Fish numbers were scaled to represent running at full capacity of four screens. Fish were measured and the length recorded in 5mm size classes. Other power stations data sets, such as West Thurrock Power Station, have shown importance of estuaries as sea bass nurseries (Thomas, 1998). Unfortunately, it was not possible to source all power station screen data.

The young fish survey was conducted by Cefas, starting in 1981 at 15 sectors from Portland to Flamborough Head. Fixed fishing stations were sampled in September each year within four depth bands (Rogers and Millner, 1996; Rogers *et al.*, 1998). Two main fishing gears were used: the 2 m beam trawl and 1.5 m push net both with a fine mesh net and cod end liner of 4 mm. Both gears passed over the ground at approximately 1 knot and the distance covered was recorded (Table 1). All fish sampled were identified and measured to the nearest 0.5 cm (Rogers and Millner, 1996; Rogers *et al.*, 1998).

The Sussex small fish surveys have been done since 2010 at Chichester, Cuckmere, Medmerry, Pagham Harbour, and Rye (Nelson, 2014). The objective of monitoring small fish communities was to develop a time series of biodiversity and relative abundance in near shore habitats. Samples were taken twice each year in June and September using a 2 m beam trawl and / or a 43 m seine net (Table 1). All fish were identified, and the total number and size (up to 50 measured to the nearest millimetre) recorded for each species (Nelson, 2014). Sussex IFCA also conducted a small fish survey in September 2015 in Tide Mill Creek (two hauls with seine net and one with fyke net) (Nelson, 2017) and Pagham Harbour (five seine net hauls at three sites) (Tebb *et al.*, 2015) (Table 1). In addition, Sussex IFCA provided data for Pagham Harbour from surveys done from 1992-

98 using a 15 m seine net and 2007 survey using seine and fyke nets carried out by the Environment Agency and University of Plymouth (Kathryn Nelson, pers. comm.). The data from the small fish survey for the Deben using seine nets was provided by the Eastern IFCA (Table 1) done in 2013 and 2014 (Jessop *et al.*, 2013). Small fish surveys were also sourced for two North Norfolk Estuaries, Blakeney and Burnham. Burnham small fish survey used 15 m long seine nets on 30th September 2015 (Table 1) (Stephen Thompson, unpublished data). The Blakeney small fish survey was led by ECON Ecological Consultancy Ltd in partnership with the National Trust and conducted in 2015 and 2016 using a 60 m long seine net (Table 1) (Harwood and Perrow, 2016). Additional data were provided from fyke net surveys of Waldringfield Marshes (Steve Colclough, pers. comm.).

2.4. Assessment of the evidence for BNAs

Shapefiles defining the boundaries of existing BNAs were sourced, and new shapefiles were created for the proposed new BNAs and changes to existing BNAs. Fish length and abundance data from the EA WFD sampling were provided by the Environment Agency (Adam Waugh, January 2015), and Thames and Solent Bass Survey (Pickett *et al.*, 2002; Walmsley 2005; 2006), Young Fish Survey (Rogers *et al.*, 1998) extracted from the Cefas Fishing Surveys System (FSS - https://www.cefas.co.uk/cefas-data-hub/dois/cefas-fishing-survey-system/). Additional data sets were provided by Sussex IFCA for Cuckmere and Medmerry (Nelson, 2014), Pagham Harbour (Tebb *et al.*, 2015), and Tide Mill Creek (Nelson, 2017); Eastern IFCAs for the Deben (Jessop *et al.*, 2013) and North Norfolk rivers (Stephen Thompson, unpublished data; Harwood and Perrrow, 2016); and Steve Colclough for Waldringfield Marshes.

These were combined into a single data set and joined spatially to the locations of estuaries and other waterbodies around England and Wales using ArcGIS 10.1 (© 2012 ESRI - http://www.esri.com/software/arcgis). A tolerance of 300 m was used to account for difference in locations of boundaries between estuary and land. A series of scripts and functions were written using Python (https://www.python.org/) to extract data and summaries created using R (https://www.r-project.org/). It was important to include only data that represent the current regime, so data from 1998 to present were included in the analysis. This represented the current regime as studies have showed a regime shift in the North Sea around 1993 (Kenny *et al.*, 2009), abrupt changes in fish populations between 1995 and 1998 (Auber *et al.*, 2015), and weak evidence for a regime shift in North and Wadden Seas in 1998 (Weijerman *et al.*, 2005).

For each BNA, the data on fish numbers and size were extracted from the database. The location of samples within the waterbody were plotted along with the extent of the proposed water body. The numbers of samples by gear type and time were extracted and the length frequency distribution of all sea bass caught by all surveys in the water body was plotted. The mean, maximum, and minimum lengths of sea bass in the samples were plotted by month, together with the same data for all samples aggregated over months for sea bass, cod, plaice, grey mullet, and sole.

Assessment of the presence of sea bass focussed on the probability of finding a sea bass in a haul and the numbers of hauls containing sea bass. These were classified as good, moderate, limited, or no evidence of the presence of sea bass (Figure 3A). Sea bass were taken by a wide variety of sampling gears used in the different surveys. These gears differed in their efficiency for catching sea bass across the size range present in the water body, due to the gear design as well as the location of tow positions. The results were treated as indicative of the presence of young sea bass, and not as a fully representative sample of all sea bass in the water body.

The purpose of the BNAs is to protect young sea bass that live in estuaries, so an upper size limit for the protection of sea bass in nursery areas was set at 36 cm. This reflects the length at which individuals migrate from the nursery grounds (four to six years) with a five-year-old fish being approximately 36 cm and in need of protection (Pickett and Pawson, 1994). In addition, females start to mature at 36cm (Armstrong and Walmsley, 2012). In the current review, the presence of sea bass of under 36 cm was used to define the potential of the area to support juvenile sea bass and combined with evaluation of the quality of the data (numbers of samples and gear types) to provide an overall assessment of the evidence for designation and if specific parts of each area could be closed to fishing.

The assessment of the potential as a BNA focussed on the evidence of the presence (probability of finding a sea bass and the numbers of hauls with sea bass), size composition (juvenile sea bass found), and the temporal component of the catch (number of months where sea bass were not caught) (Figure 3A). Proposed BNA were supported if the evidence of presence was good (≥ 20 hauls and probability of sea bass > 0.4) or moderate (≥ 4 hauls and probability of sea bass > 0.1), juvenile sea bass of less than 36 cm were present, sea bass were found in all but three months surveyed, and the original feature that was being protected still exists (Figure 3A). Proposed BNAs were not supported where the was poor evidence of presence (< 4 hauls with sea bass or probability of sea bass ≤ 0.1) or no sea bass present, adults of greater than 36 cm only present, more than three months with surveys where no sea bass were found, or the feature that the BNA was designed to protect (e.g., warm water outflow) had been removed (Figure 3A).

The proposed new BNAs or extensions to existing ones were considered to have a potential to interact with commercial fishing activities if the survey samples contained sea bass, cod, plaice or sole above the MCRS of 42 cm, 35 cm, 22 cm, and 24 cm, respectively, or if there were catches of individual grey mullet (which has no MCRS set) that may be large enough for sale (Figure 3B). Additional information on the potential interaction between BNAs and the commercial sector was obtained from official reported 2015 landings in the ICES statistical rectangles immediately adjacent to or including the BNAs. These were mainly landings for under 10 m fishing boats that typically deploy lines or gillnets in coastal waters, and tonnage of sea bass landed and the proportion of total landings that were sea bass was reported.

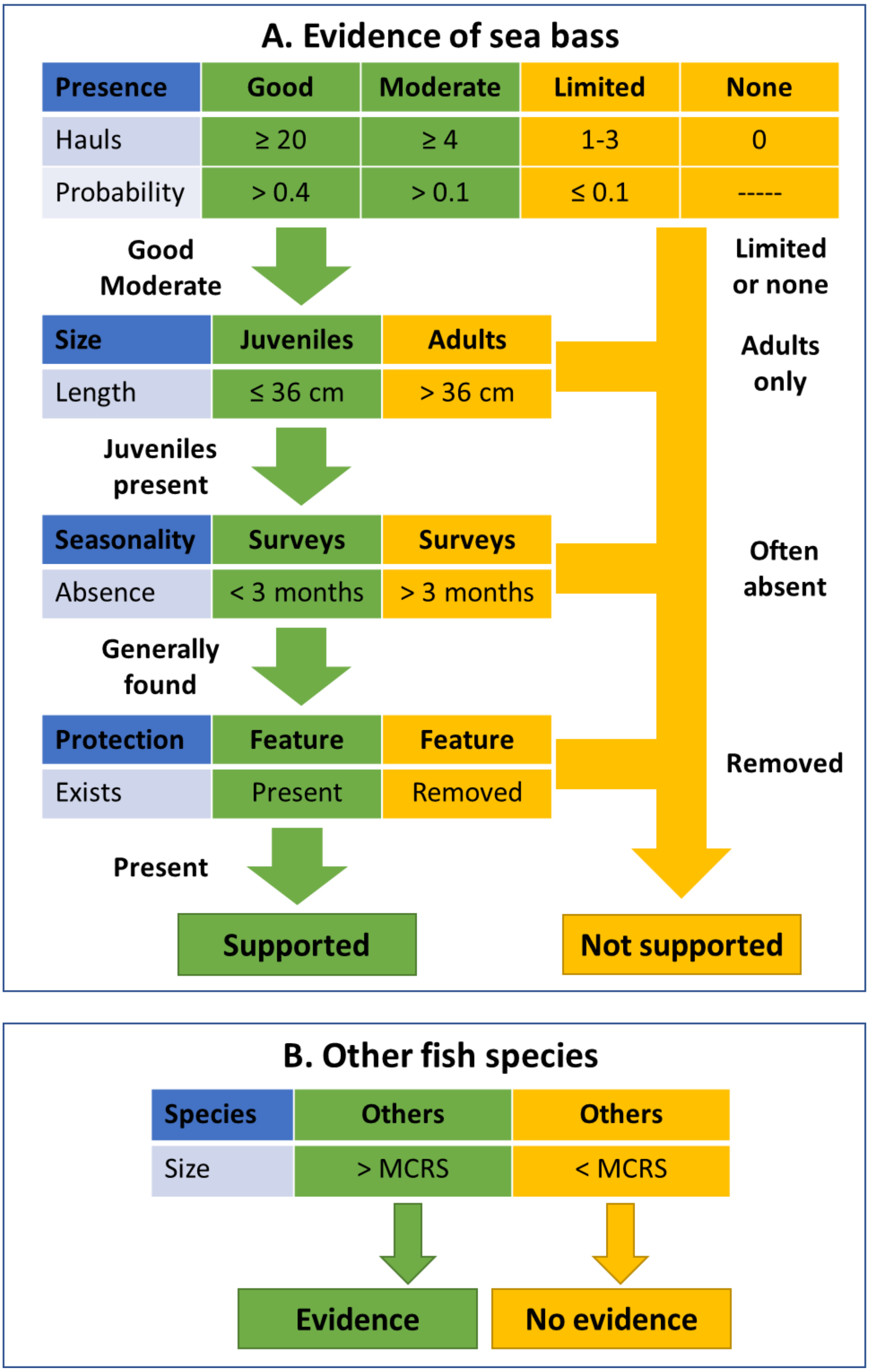


Figure 3. Decision tree used for the classification of the evidence for new BNAs (A) and the evidence for other fish species (B). These were used to generate the classification of evidence for BNAs and to assess if the further consideration of proposed BNA could be supported.

3. Results

Responses were received from nine mainland IFCAs and the MMO, with a list of 48 potential amendments to the existing legislation proposed (39 new, five changes, and four no longer required - Table 2). A summary of the feedback from the IFCAs including the evidence held and recreational and commercial fishing activities was created for each IFCA. The area of all the sites and associated saltmarsh was obtained from shapefiles and spatial layers, and additional habitat characteristics were available for 35 sites (Table 2). The total area of proposed amendments was 85,378 ha and represented around a 3-fold addition to the current area of BNAs in England of 32,956 ha including the River Dee (Table 3). However, 57,575 ha of the area was due to the proposed addition of two very large BNAs in the Thames and Humber (Table 4). Fish assemblage data was available for 27 out of the 48 potential amendments to the BNAs (Table 4). Supporting evidence was judged to be adequate for a total of 26 out of the 48 tabled amendments representing 47,880 ha and, if adopted, would mean that a total of 80,836 ha would be designated as BNAs (Table 3). The evidence underpinning each proposed amendment is summarised in the sections below.

Summary information for all the proposed amendments to BNAs was grouped by IFCA and each individual amendment discussed in detail in the sections below. However, to interpret these outputs and the case for supporting nursery areas, it was important to first look at the size selectivity of the gears used in the individual surveys. Most sea bass caught from 1998 to present were caught in the Thames and Solent Bass Surveys (high headline trawl), EA WFD (seine nets, otter trawl, fyke nets) and Thames Herring Survey (Larson Sprat Trawls) (Table 1). Length-frequency histograms for all sea bass caught showed that beam trawls, fyke nets, Larson trawls, otter trawls, power stations screen, seine nets, Solent and Thames survey trawls (Figure 4B-F, H, and I) caught a wide range of sizes, whereas push nets selected small sea bass (Figure 4G). Only trammel nets selected large sea bass catching both adults (>36 cm) and juveniles (defined as <36 cm in this report) (Figure 4J). However, the length frequency of catches by all gear covered both juvenile and adult sea bass, with fish of between 1 and 78 cm captured (Figure 4A). In general, Larson sprat trawls, otter trawls, and fyke net were generally not effective for sampling 0-group (i.e., individuals less than around 10 cm) sea bass, but 0-group fish were found in all these gears (Figure 4).

Table 2. Existing BNAs excluding those in Wales, and proposed amendments to BNAs including new locations, changes to existing boundaries, and those no longer required.

IFCA	Existing (28)	New (39)	Change (5)	No longer required (4)
Cornwall	Camel Fal Fowey Helford Percuil Plymouth Rivers	Gillan Creek The Manacles The Runnel Stone	Fal Fowey Plymouth Rivers	-----
Devon and Severn	Avon Dart Exe Salcombe Taw Teign Torridge Yealm	Parrett Severn (middle and upper)	Taw and Torridge	-----
Eastern		Alde and Ore Blakeney Brancaster Breydon Water Burnham Deben Orwell Sizewell Stour Thornham Titchwell Wells	-----	-----
Kent and Essex	Bradwell Power Station Grain Power Station Kingsnorth Power Station Dungeness Power Station	Crouch and Roach Hamford Water Thames (lower, middle, and upper)		Bradwell Power Station Kingsnorth Power Station
North Eastern		Humber (lower, middle, and upper)	-----	-----
North Western	Dee Heysham Power Station	-----	-----	-----
Northumberland	Blyth Power Station	-----	-----	Blyth Power Station
Southern	Chichester Harbour Fawley Power Station Langstone Harbour Poole Harbour Portsmouth Harbour Southampton Water The Fleet	Beaulieu Christchurch Harbour Keyhaven Lymington Medina Portland Harbour Wootton Creek Yar	The Fleet	Fawley Power Station
Sussex	Chichester Harbour	Adur Cuckmere Medmerry Ouse and Tide Mill Creek Pagham Harbour Shoreham Power Station	----	----

Table 3. Total area of existing BNAs and percentage increase in area protected for all the proposed amendments in relation to the existing area of BNAs in England.

Source	Area (ha)
Existing English BNAs (includes the Dee estuary)	32,956
Proposed additional area (all amendments)	85,378
Total area (all amendments)	118,334
Proposed additional area (supported by evidence)	47,880
Total area (supported by evidence)	80,836

Table 4. Summary of proposed amendments to existing BNA legislation, source of information, and physical characteristics. Source of shapefile is given as SI (statutory instrument 1999), IFCA (IFCA proposal), EA (Environment Agency estuary shapefiles), and Cefas. Physical characteristics comes from Environment Agency limited data (EA Part), Environment Agency full data (EA Full), or Smith and Brown (2009) (S and B). Area is derived from the shapefiles, some of which were digitised using OS Raster Colour 50k maps, showing the full extent of waterbodies until they reach the coast. Type and description indicates ecotype as defined in the WFD; modification can be heavily modified (HM) or not heavily modified (NHM).

IFCA	Area proposed	Type	Description	Shapefile	Physical characteristics	Fish assemblage	Waterbody category	Type	Description	Modification	Area (ha)	Saltmarsh (ha)
Cornwall	Fal	Change	There are various areas in and around the Fal which have near identical conditions to the existing BNAs. As well as extending protection to areas where it is possible juvenile sea bass congregate, it would also improve the communication and understanding of the legislation, particularly for visiting fishermen not familiar with the Fal.	SI	EA part	Present	Coastal	5	Moderately exposed, Mesotidal	HM	2,436	12
Cornwall	Fowey	Change	Pont Pill creek has very similar conditions to the wider Fowey and an extension to the mouth of the river from St Catherine's point to the Polruan cross rocks would be consistent with BNAs.	SI	EA part	Absent	Transitional	2	Partly mixed, meso	NHM	297	2
Cornwall	Gillan Creek	New	This small creek near the Helford is adjacent to the existing Helford BNA and provides a very similar environment where smaller sea bass have been known to aggregate.	SI	Shape	Absent	----	----	----	----	72	----
Cornwall	Plymouth Rivers (Sound)	Change	The mouth of the Plymouth rivers has broadly similar features to those found further upriver. The Plymouth breakwater forms an easily identifiable boundary for the Plymouth rivers. A line drawn west to Picklecombe Point and east to Staddon Point would complete a useful boundary to enclose Plymouth Sound.	SI	EA part	Absent	Transitional	4	Mixed, meso, extensive intertidal	HM	3,401	44
Cornwall	The Manacles	New	An area bounded on the East by a line drawn 125 degrees True from Porthkerris Point (50°03'.94N, 005°03'.98W), to the point where it intersects a line drawn 070 degrees True from Lowland Point (50°02'.19N, 005°04'.09W), and on the South along that line to Lowland Point.	IFCA	Shape	Absent	----	----	----	----	501	----

IFCA	Area proposed	Type	Description	Shapefile	Physical characteristics	Fish assemblage	Waterbody category	Type	Description	Modification	Area (ha)	Saltmarsh (ha)
Cornwall	The Runnel Stone	New	An area bounded on the East by a line drawn 180 degrees True from St Levan Church (50°02'.55N, 005°39'.60W), to a point where it intersects a line drawn 238 degrees True from Tater-du (50°03'.14N, 005°34'.67W), and on the South by a line drawn 270 degrees True from this point to the point where it intersects a line drawn 180 degrees True from Gwennap Head (50°02'.09N, 005°40'.77W), and on the West by a line drawn thence to Gwennap Head.	IFCA	Shape	Absent	----	----	----	----	360	----
Devon and Severn	Parrett	New	Anecdotal information from Elver fishers suggests that some years they catch large amounts of juvenile sea bass in their Elver nets. Adult sea bass are regularly caught by anglers at Burnham-on-Sea. The confluence of Parrett Estuary and Severn Estuary and presence of large amounts of saltmarsh suggest the area would be suitable habitat for juvenile sea bass. The closure of Parrett Estuary suggested is between Steart Point (51.2184, 3.0196) and Beacon (51.2177, 3.0107). The closing line of the Brue as part of the Parrett Estuary is between 51.2184,-3. 0015 and 51.2269, -3.0015	EA	EA part	Present	Transitional	1	Partly mixed, macro	HM	548	21
Devon and Severn	Severn – upper and middle	New	Proposed area is upstream of the M4 bridge. Data from Oldbury Power Station suggests this area is important for juvenile sea bass and this area contains saltmarsh that is an important habitat for juvenile sea bass.	EA	EA full	Present	Transitional	3	Mixed, macro, extensive intertidal	HM	7,053	119
Devon and Severn	Taw and Torridge	Change	The Taw and Torridge rivers have a joint estuary with single connection to the sea. These areas have near identical conditions to the existing BNAs. This would extend protection to areas where it is possible juvenile sea bass congregate.	Cefas	EA full	Present	Transitional	1	Partly mixed, macro	HM	3,129	93

IFCA	Area proposed	Type	Description	Shapefile	Physical characteristics	Fish assemblage	Waterbody category	Type	Description	Modification	Area (ha)	Saltmarsh (ha)
Eastern	Alde and Ore	New	The Alde and Ore, Breydon Water, Deben Estuary and Stour and Orwell estuary complex have all been identified as important areas for juvenile sea bass from sampling of young fish for the Water Framework Directive.	EA	EA full	Present	Transitional	4	Mixed, meso, extensive intertidal	HM	1,088	56
Eastern	Blakeney	New	Extensive areas of saltmarsh are present that are important habitat for juvenile sea bass, so is likely to be a nursery area.	ST	EA part	Present	Coastal	10	Lagoon-	NHM	879	444
Eastern	Brancaster	New	Extensive areas of saltmarsh are present that are important habitat for juvenile sea bass, so is likely to be a nursery area.	ST	Shape	Absent	----	----	----	----	375	133
Eastern	Breydon Water	New	See Alde and Ore.	EA	EA part	Present	Transitional	2	Partly mixed, meso	HM	888	5
Eastern	Burnham	New	Extensive areas of saltmarsh are present that are important habitat for juvenile sea bass, so is likely to be a nursery area.	ST	Shape	Present	----	----	----	----	311	191
Eastern	Deben	New	See Alde and Ore.	EA	EA part	Present	Transitional	4	Mixed, meso, extensive intertidal	HM	782	74
Eastern	Orwell	New	See Alde and Ore.	EA	EA full	Present	Transitional	4	Mixed, meso, extensive intertidal	HM	1,249	17
Eastern	Sizewell	New	Evidence from monitoring of fish entrained in the seawater intake at Sizewell nuclear power station indicates clearly that this is an important area for sea bass, including for juvenile sea bass.	EA	Shape	Present	----	----	----	----	217	----
Eastern	Stour	New	See Alde and Ore.	EA	EA full	Present	Transitional	4	Mixed, meso, extensive intertidal	HM	2,553	45
Eastern	Thornham	New	Extensive areas of saltmarsh are present that are important habitat for juvenile sea bass, so is likely to be a nursery area.	ST	Shape	Absent	----	----	----	----	71	46
Eastern	Titchwell	New	Extensive areas of saltmarsh are present that are important habitat for juvenile sea bass, so is likely to be a nursery area.	ST	Shape	Absent	----	----	----	----	20	13
Eastern	Wells	New	Extensive areas of saltmarsh are present that are important habitat for juvenile sea bass, so is likely to be a nursery area.	ST	Shape	Absent	----	----	----	----	426	302

IFCA	Area proposed	Type	Description	Shapefile	Physical characteristics	Fish assemblage	Waterbody category	Type	Description	Modification	Area (ha)	Saltmarsh (ha)
Kent and Essex	Bradwell Power Station (Blackwater)	No longer required	The power station is now decommissioned, and warm water is no longer emitted from the power station, so the feature that attracted sea bass no longer exists.	SI	EA part	Absent	Transitional	4	Mixed, meso, extensive intertidal	HM	9	----
Kent and Essex	Crouch and Roach	New	Requested by MMO.	EA	EA part	Present	Transitional	4	Mixed, meso, extensive intertidal	NHM	2,375	219
Kent and Essex	Hamford Water	New	Requested by the MMO. Hamford Water is home to large populations of juvenile sea bass and fish over the MCRS.	Cefas	Shape	Present	----	----	----	----	233	0.4
Kent and Essex	Kingsnorth Power Station (Medway)	No longer required	The power station is now decommissioned, and warm water is no longer emitted from the power station, so the feature that attracted sea bass no longer exists.	SI	EA full	Absent	Transitional	3	Mixed, macro, extensive intertidal	HM	381	30.8
Kent and Essex	Thames - lower	New	The Thames Estuary and its tributaries in their entirety provide significant nursery functions for a wide range of species and is one of the primary fish production areas for the southern North Sea. As sea bass is now a year-round resident, it makes use of the parts of the estuary which are, nursery areas. i.e., saltmarsh and the smaller estuaries that feed into the Thames.	EA	EA full	Present	Transitional	3	Mixed, macro, extensive intertidal	HM	20,104	93
Kent and Essex	Thames - middle	New	See Thames – lower.	EA	EA full	Present	Transitional	3	Mixed, macro, extensive intertidal	HM	4,421	39
Kent and Essex	Thames - upper	New	See Thames – lower.	EA	EA full	Present	Transitional	3	Mixed, macro, extensive intertidal	HM	317	----
North Eastern	Humber - lower	New	Regular and increasing reports of sea bass captured within the Humber Estuary, where a targeted recreational fishery is developing. Recommend aligning BNA with current EMS seaward boundaries, to a landward boundary of the Humber Bridge.	EA	EA full	Present	Transitional	3	Mixed, macro, extensive intertidal	HM	24,786	490

IFCA	Area proposed	Type	Description	Shapefile	Physical characteristics	Fish assemblage	Waterbody category	Type	Description	Modification	Area (ha)	Saltmarsh (ha)
North Eastern	Humber - middle	New	See Humber – lower.	EA	EA full	Present	Transitional	3	Mixed, macro, extensive intertidal	HM	6,714	372
North Eastern	Humber - upper	New	See Humber – lower.	EA	EA full	Present	Transitional	3	Mixed, macro, extensive intertidal	HM	1,233	60
Northumberland	Blyth Power Station	No longer required	Blyth Power Station ceased production in 2001 and a few years later the warm water outfall pipe was demolished. Since then, no commercial or recreational fishers have been seen in the area.	SI	EA part	Absent	Transitional	2	Partly mixed, meso	HM	80	----
Southern	Beaulieu	New	The Keyhaven, Beaulieu and Lymington estuaries contain large areas of saltmarsh and are areas where sea bass are observed to concentrate.	EA	EA part	Absent	Transitional	4	Mixed, meso, extensive intertidal	HM	307	45
Southern	Christchurch Harbour	New	Christchurch Harbour is an important area for sea bass and fishing, by nets is already restricted by IFCA byelaw and through private fishery rights.	EA	EA part	Absent	Transitional	4	Mixed, meso, extensive intertidal	HM	276	13
Southern	Fawley Power Station (Southampton Water)	No longer required	The power station has been decommissioned, so the BNA should be removed.	SI	EA full	Present	Transitional	4	Mixed, meso, extensive intertidal	HM	97	----
Southern	Keyhaven (Avon Water)	New	The protection measures should be extended beyond the Ferry Bridge to include the entire Ferry Bridge Channel.	EA	S and B	Absent	----	----	----	----	18	0.1
Southern	Lymington	New	See Beaulieu.	EA	EA part	Absent	Transitional	4	Mixed, meso, extensive intertidal	HM	245	72
Southern	Medina	New	The Isle of Wight has several important estuaries that will function as BNA, but there is little quantitative evidence. Anecdotal evidence confirms the presence of juvenile sea bass in these areas. There are harbours and creeks on the Isle of Wight that currently do not receive BNA protection; these include the River Yar (Bembridge), River Medina, and Wootton Creek.	EA	EA part	Absent	Transitional	4	Mixed, meso, extensive intertidal	HM	163	1.2
Southern	Portland Harbour	New	Requested by MMO.	Cefas	Shape	Absent	----	----	----	----	1,085	----

IFCA	Area proposed	Type	Description	Shapefile	Physical characteristics	Fish assemblage	Waterbody category	Type	Description	Modification	Area (ha)	Saltmarsh (ha)
Southern	The Fleet	Change	The protection measures could be extended beyond the Ferry Bridge to include the entire Ferry Bridge Channel.	EA	EA part	Absent	Transitional	6	Transitional lagoon	HM	495	2
Southern	Wootton Creek	New	See Medina.	EA	EA part	Absent	Transitional	4	Mixed, meso, extensive intertidal	HM	23	0.2
Southern	Yar (Bembridge Harbour Lagoon)	New	See Medina.	EA	EA part	Absent	Transitional	6	Transitional lagoon	Artificial	9	1
Sussex	Adur	New	Any rivers that offer intertidal habitats in the lower tidal reaches potentially offer significant ecosystem function for juvenile sea bass, and therefore could have value as a BNA. Examples in Sussex include the Adur and Ouse.	EA	EA full	Present	Transitional	1	Partly mixed, macro	HM	137	12
Sussex	Cuckmere	New	IFCA small fish surveys show that juvenile sea bass are significant and sizeable in Cuckmere.	IFCA	EA part	Present	Transitional	1	Partly mixed, macro	HM	36	3
Sussex	Medmerry	New	IFCA small fish surveys show that juvenile sea bass are significant and sizeable in Medmerry. The managed realignment scheme has created a significant new estuary south east of Bracklesham Bay.	EA	Shape	Present	----	----	----	----	491	----
Sussex	Ouse	New	Sussex IFCA small fish survey shows presence of sea bass in Tide Mill Creek which feeds into Ouse.	EA	EA part	Present	Transitional	1	Partly mixed, macro	HM	137	1
Sussex	Pagham Harbour	New	Pagham Harbour is believed to be an important site, as can be inferred by habitat similarity to Chichester Harbour. Sussex IFCA small fish survey shows presence of juvenile sea bass. There is also a considerable amount of saltmarsh in the area which is favourable to sea bass.	EA	EA part	Present	Coastal	7	Sheltered, Macrotidal	Artificial	257	103
Sussex	Shoreham Power Station	New	Shoreham Power Station hot water discharge (hot pipe South of Shoreham Port) is a site where we know that juvenile sea bass aggregate in large numbers.	EA	Shape	Present	----	----	----	----	172	----

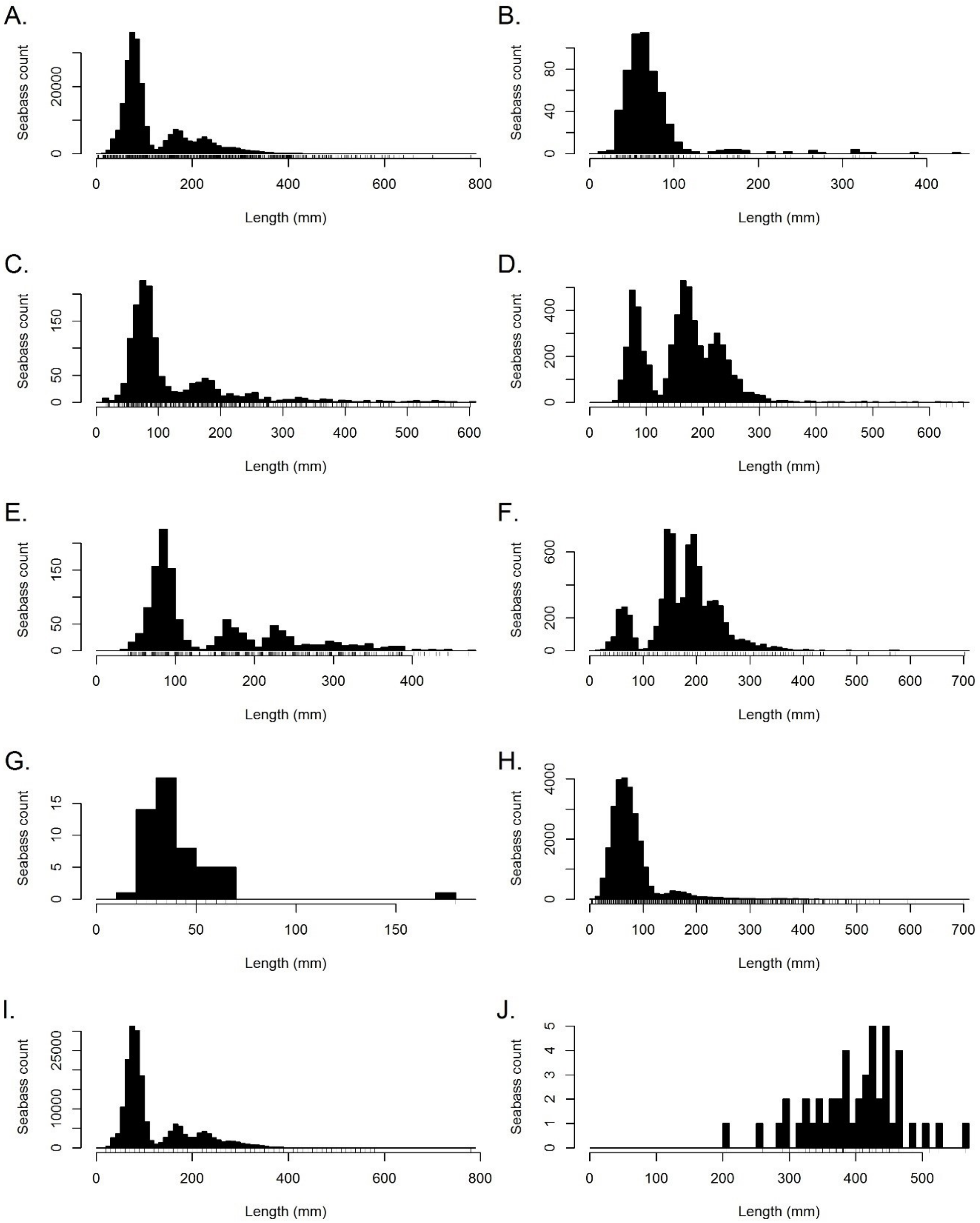


Figure 4. Size-frequency selectivity of different gears used to sample sea bass in the WFD and Thames and Solent Bass Survey for all gears (A), beam trawls (B), fyke nets (C), Larson trawls (D), otter trawls (E), power stations screen (F), push nets (G), seine nets (H), Solent and Thames survey trawls (I), and trammel nets (J).

3.1. Cornwall

Cornwall IFCA currently has six existing BNAs covering the Camel, Fal, Fowey, Helford, Percuil, and Plymouth Rivers (Table 2). The proposed amendments represent new BNAs at Gillan Creek, the Manacles, the Runnel Stone, and changes to the boundaries of the Fal estuary, River Fowey, and Plymouth Rivers (Table 2, Figure 5A). A summary of the Cornwall IFCA response to the Defra questionnaire and the evidence supporting proposed amendments are outlined in this section.

3.1.1. Summary of IFCA response

Cornwall IFCA holds no data on the aggregation of sea bass by size, but suggested inclusion of areas where pre-recruit sea bass school in summer. Schooling makes these sea bass susceptible to bycatch in large numbers and is related to the habitat and topography (Pawson *et al.*, 2008). Areas with similar biotopes to current BNAs could be protected, particularly if they are contiguous to an existing BNA, making a change to the boundary appropriate. This could include extensions to existing BNAs for: Plymouth Rivers to the breakwater (Picklecombe Point to Staddon Point); River Fowey to include the mouth of the river from St Catherine’s Point to the Polruan rocks; Gillan Creek on the Helford River; and various creeks in the River Fal. Expansion of the BNA network could include all rivers and creeks in Cornwall as this would be easier to enforce, improve understanding, and reduce bycatch. The prohibition of fishing for sea bass in a BNA during the closed period may afford some protection, but angling and some small-scale commercial netting are still allowed that could reduce the protection.

Fishing for sea bass is an important commercial activity in Cornwall with most of the commercial sea bass boats belonging to the under 10 m fleet, but relatively few operate in the rivers systems and there is good compliance with legislation. A byelaw that prohibits the use of any net less than 250mm mesh size is designed to conserve bass that aggregate around two rocky reef areas at The Manacles and the Runnelstone. Another byelaw prohibits the use of almost all fixed nets and drift nets for fishing for any sea fish within any rivers and estuaries, significantly benefitting any bass within such waterways. In these places, only specially permitted seine nets and ebb nets may be authorised by Cornwall IFCA and these are unlikely to capture significant quantities of sea bass, if any, and would likely only be as an unintended bycatch that could be released alive. Minimum net mesh sizes introduced in BNAs may reduce bycatch, but can still catch undersized sea bass (Revill *et al.*, 2009). Recreational angling is also an important activity with many tourists and locals participating. Recreational and commercial angling using sandeel as bait from boats is prohibited in BNAs, but there is angling for sea bass from the shore and other species from boats. There may also be an impact on recreational angling due to increasing travel distances for vessels moored at the head of BNAs including the Camel and the Fal. There was doubt about the value of banning sandeels as bait as other methods were felt to be equally effective. Protection of other species was dependent on the management measure, but could affect fisheries for seabream, grey mullet, and sandeel.

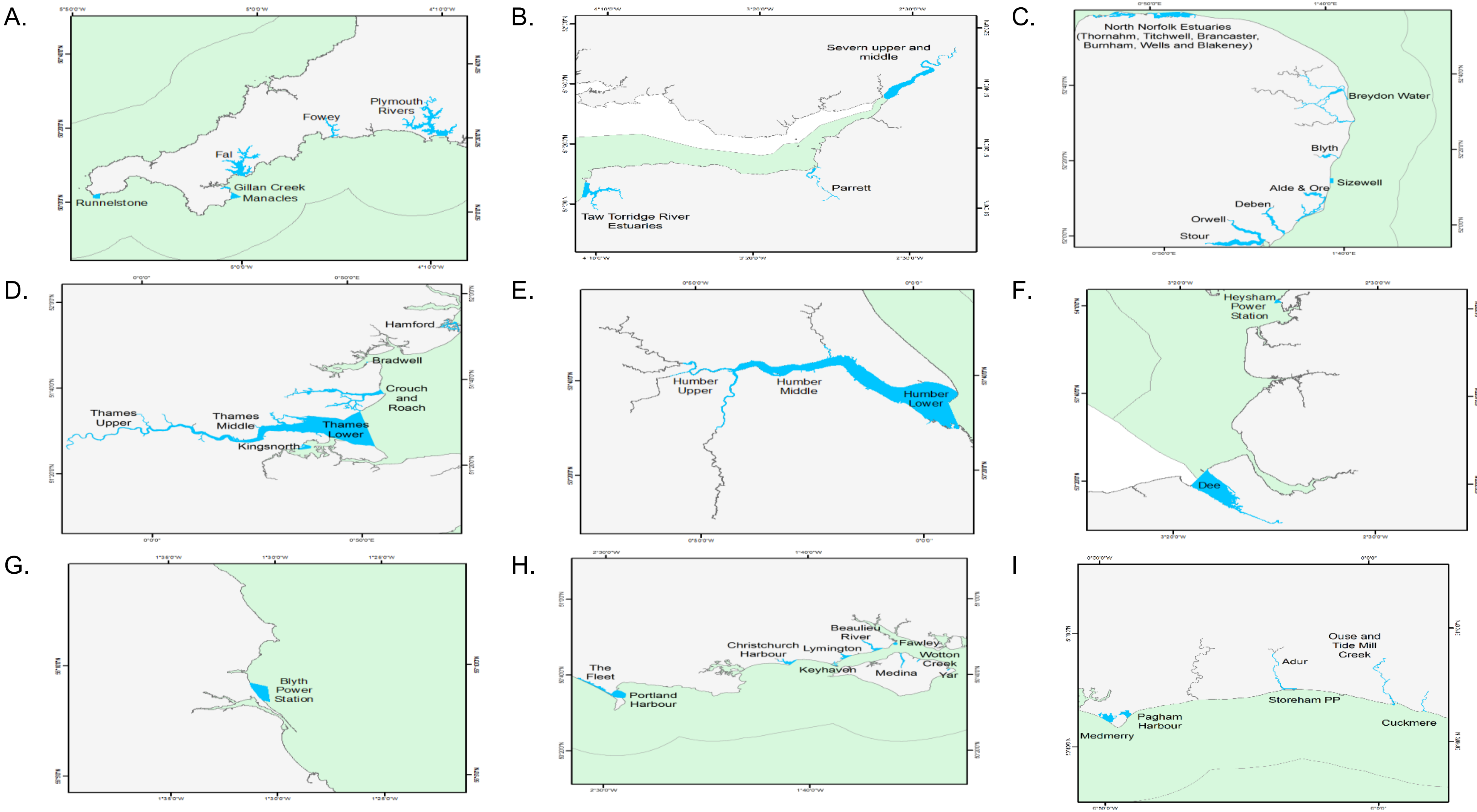


Figure 5. Proposed amendments to the BNAs for Cornwall (A), Devon and Severn (B), Eastern (C), Kent and Essex (D), North Eastern (E), North Western (F), Northumberland (G), Southern (H) and Sussex (I) IFCAs. Green indicates IFCA jurisdiction and blue indicates the proposed BNA.

Cornwall IFCA have no data on the seasonal fluctuations of sea bass in BNAs, but external consultation provided anecdotal evidence that sea bass are caught all year round. External consultation generally favoured the retention, extension, and addition of BNAs, and simplification of the regulations. If BNAs improve the public understanding of environmental resources in Cornwall and improve sea bass stocks, this could lead to socio-economic benefits for the recreational sector, tourist industry and the commercial sector.

3.1.2. Fal (change)

The Fal Estuary is a large area that includes saltmarsh and mudflats. The estuary is a ria, and it has been suggested that these types of estuaries contain juvenile sea bass all year even in the deeper water (Pickett and Pawson, 1994). There were a small number of under 10 m vessels that operate out of Falmouth that use nets, pots, and handlines to target several species including sea bass (Walmsley and Pawson, 2007).

The extension of the existing Fal estuary BNA is to cover other creeks with similar conditions to the existing BNA and represents an extension of the current boundary to the end of the estuary (Figure 6A). Limited physical data was provided for the whole Fal estuary, so no information on the habitat types in the proposed additional area was available (Table 4), but some information on area of the estuary and saltmarsh extent (Figure 7A and B). Sea bass have been caught and measured at two locations in nine hauls conducted using otter trawls and seine nets from 2002-13 (Figure 6A-C). The mean number of sea bass in the catch was low at three fish per haul (Figure 6B), including both adults and juveniles (Figure 6D), with a 12% chance of catching a sea bass in a haul (Table 5). Sea bass were found between September and November, but were not found in April and May (Figure 6E). Cod, grey mullet, plaice, and sole were also caught in the surveys, but were generally below the MCRS (Figure 6F). In 2015, landings by under 10 m vessels from the adjacent ICES rectangle indicated that 66 t of sea bass were retained representing 0.8% of the catch of all species (Figure 8).

Conclusion: There is moderate evidence of juvenile sea bass from a small number of hauls and a low probability of catching sea bass in a haul, but juveniles were found in samples together with limited numbers of fish above MCRS (Table 5). Hence, there is evidence to support further consideration of the proposed extension to Fal BNA (Table 5).

3.1.3. Fowey (change)

The proposed change to the River Fowey BNAs was to cover Pont Pill and extension to the south of the river (Figure 9A). Limited physical data was provided for the whole Fowey estuary, so no information on the habitat types in the proposed additional area was available (Table 4), but information was available on the area and saltmarsh (Figure 7A and B). The estuary is a ria, and it has been suggested that these types of estuaries contain juvenile sea bass all year even in the deeper water (Pickett and Pawson, 1994). In

2015, landings by under 10 m vessels from the adjacent ICES rectangle indicated that 38 t of sea bass were retained representing 0.9% of the catch of all species (Figure 8).

Conclusion: There were no data on the fish assemblage compiled in this study for the extension to the River Fowey BNA, so there is insufficient evidence at present to support the proposed BNA (Table 5). More data are required before a BNA designation could be considered.

3.1.4. Gillan Creek (new)

The proposed new BNA at Gillan Creek was based on its similarity and proximity to the existing River Helford BNAs (Figure 9B). No physical data were available (Table 4), but information was available on the area and saltmarsh (Figure 7A and B). The estuary is similar in environment to the Helford River indicating that it will contain juvenile sea bass. In 2015, landings by under 10 m vessels from the adjacent ICES rectangle indicated that 28 t of sea bass were retained representing 0.8% of the catch of all species (Figure 8).

Conclusion: There were no survey data on the fish assemblage compiled in this study for Gillan Creek, so there is insufficient evidence at present to support the proposed BNA (Table 5). More data are required before a BNA designation could be considered.

3.1.5. Plymouth Rivers (change)

The proposed change to the Plymouth Rivers BNAs was an extension to the breakwater as an easily identifiable boundary (Figure 9C). Limited physical data was provided for the whole Plymouth sound, so no information on the habitat types in the proposed additional area was available (Table 4), but information was available on the area and saltmarsh (Figure 7A and B). In 2015, landings by under 10 m vessels from the adjacent ICES rectangle indicated that 39 t of sea bass were retained representing 0.9% of the catch of all species (Figure 8).

Conclusion: There were no survey data on the fish assemblage compiled in this study for the extension to the Plymouth Rivers BNA, so there is insufficient evidence at present to support the proposed BNA (Table 5). More data are required before a BNA designation could be considered.

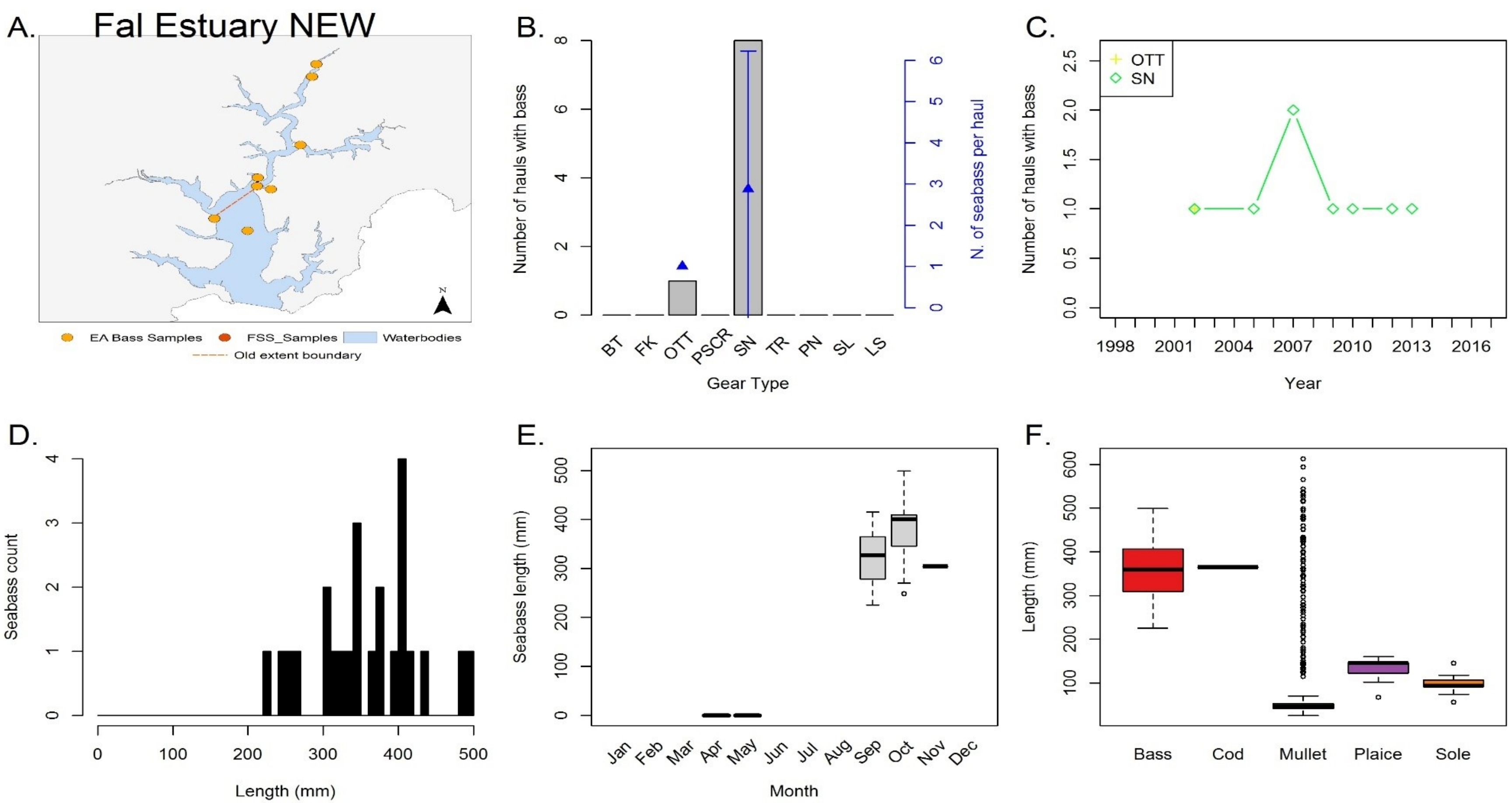
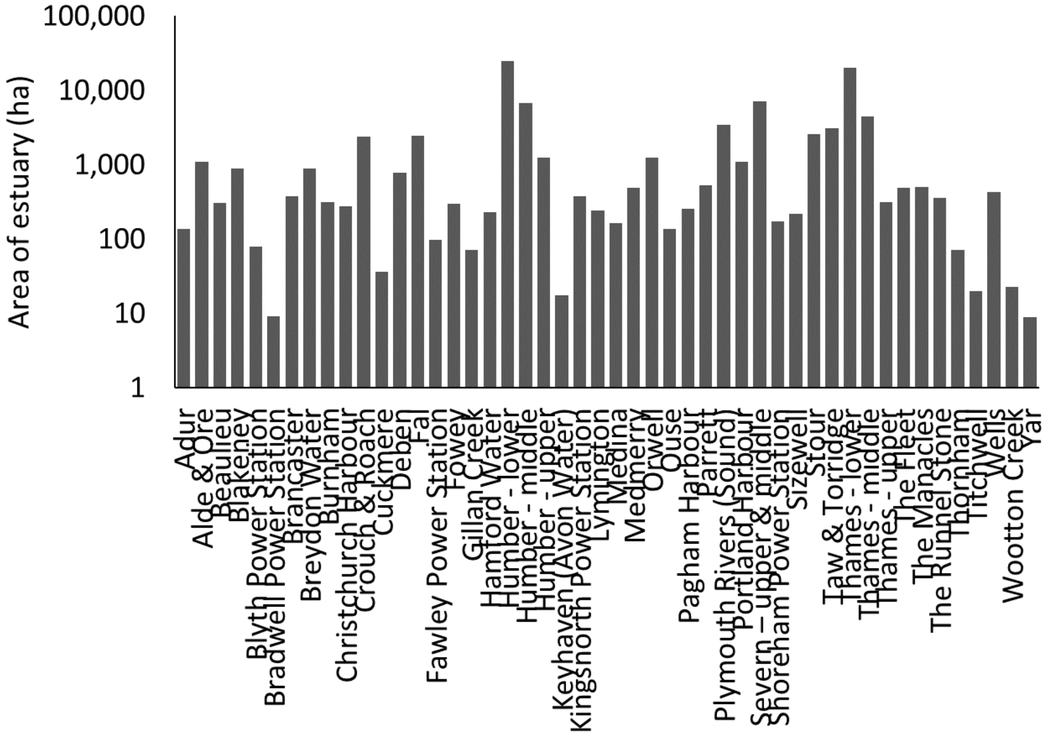


Figure 6. Assessment of the presence of sea bass and other fish in the River Fal including: the area proposed and stations sampled (A); number of samples of sea bass and number of sea bass per sample (B - BT = beam trawl, FK = fyke, LS = Larson Sprat, OTT = otter; PN = push, PSCR = power station screen, SL = Solent survey, SN = seine, TR = trammel net); number of samples by gear over time (C – codes as B); length-frequency of sea bass (D); mean length of sea bass by month (E); and length of sea bass, cod, grey mullet, plaice, and sole (F).

A.



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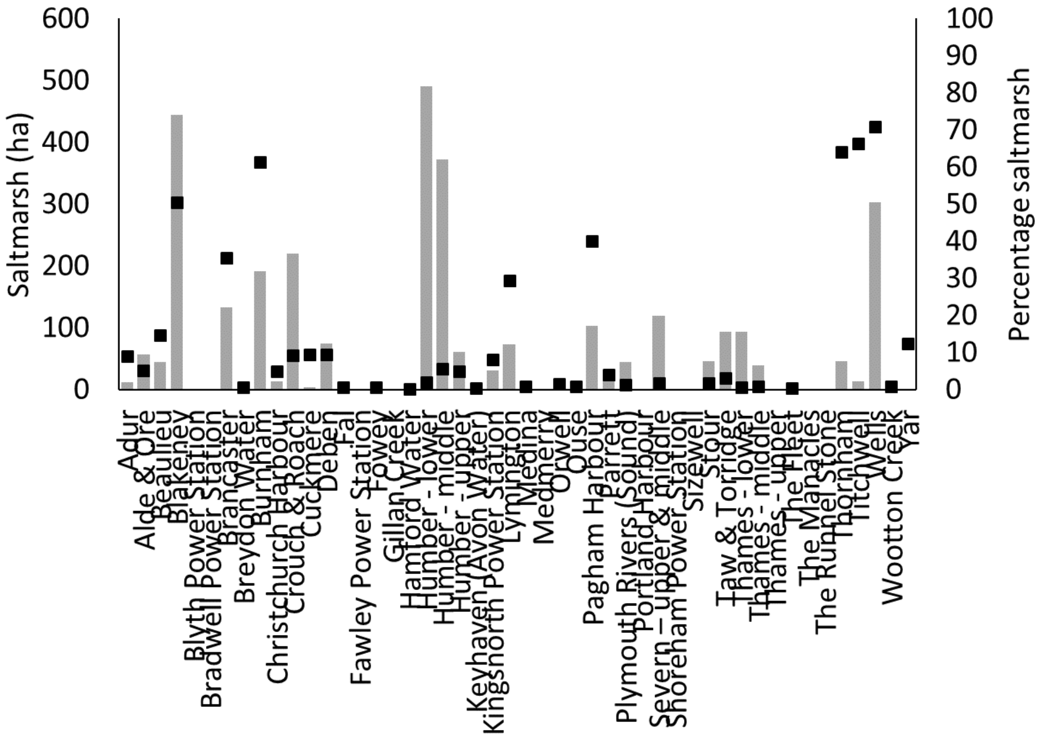

Figure 7. Physical properties of individual estuaries compiled from various databases by the Environment Agency including: area in hectares (A), and saltmarsh area and percentage (B).

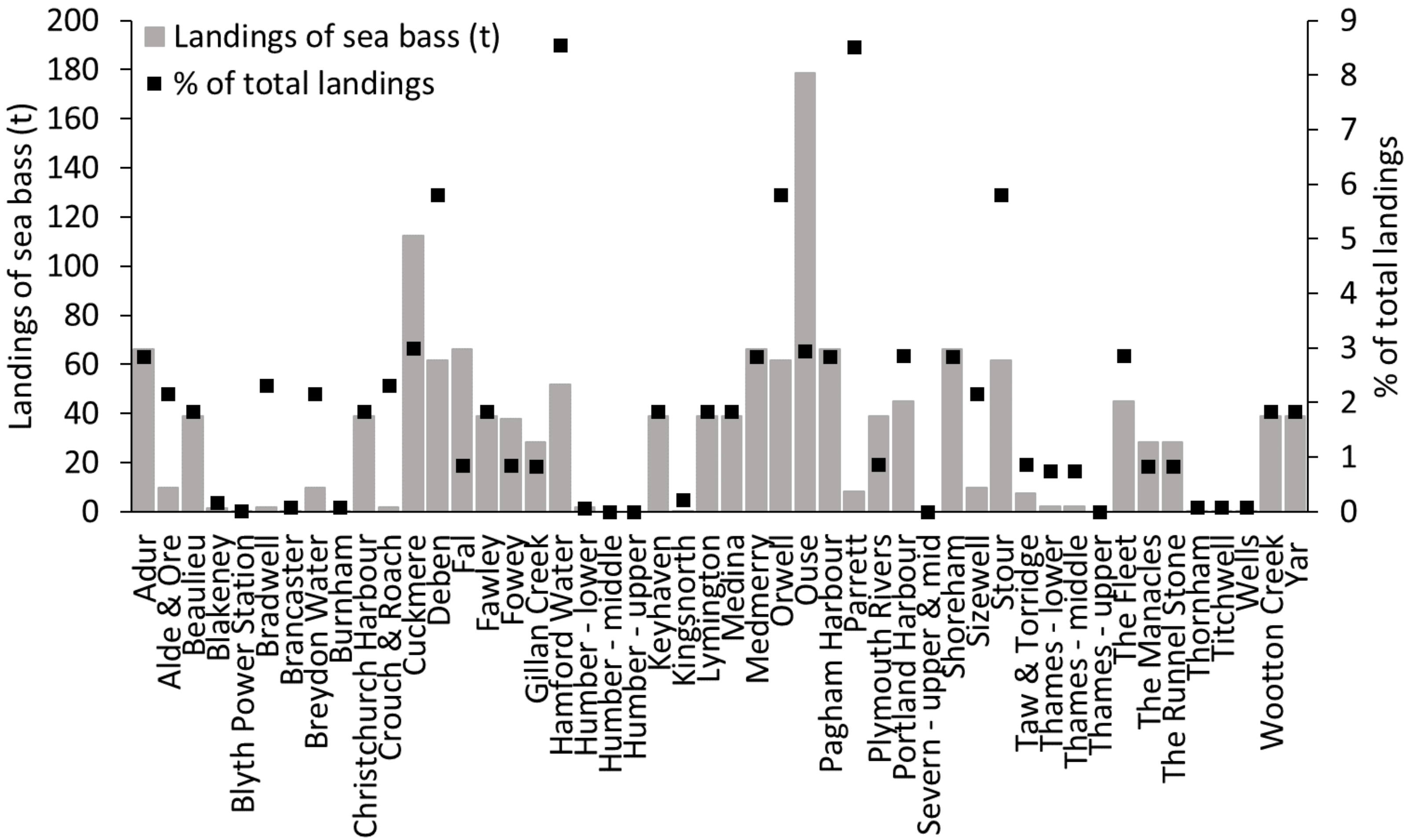

Figure 8. Landing in tonnes by under 10 m boats of sea bass and percentage of the total landings that are sea bass.

Table 5. Summary information for each proposed amendment to the existing BNA legislation including numbers of stations and hauls with sea bass, probability of finding a sea bass in a haul, strength of evidence supporting BNA, size and timings of sea bass found, finding cod, plaice or sole above MCRS, and decision to support further consideration of the amendment.

IFCA	Area proposed	Type	Stations	Hauls with sea bass	Probability of sea bass	Evidence of sea bass	Timing of sea bass	Size of sea bass	Found	Other species	Support	Spatial	Temporal
Cornwall	Fal	Change	2	9	0.12	Moderate	Sep - Nov	Both	Not Apr and May	Below MCRS	Yes	Estuary	All year
Cornwall	Fowey	Change	0	0	----	None	----	----	----	----	No	----	----
Cornwall	Gillan Creek	New	0	0	----	None	----	----	----	----	No	----	----
Cornwall	Plymouth Rivers (Sound)	Change	0	0	----	None	----	----	----	----	No	----	----
Cornwall	The Manacles	New	0	0	----	None	----	----	----	----	No	----	----
Cornwall	The Runnel Stone	New	0	0	----	None	----	----	----	----	No	----	----
Devon and Severn	Parrett	New	1	4	1.00	Moderate	May - Sep	Juvenile	Always	Above MCRS	Yes	Estuary	All year
Devon and Severn	Severn– upper and middle	New	14	51	0.38	Good	Jan - Nov	Both	Not Dec	Above MCRS	Yes	Estuary	All year
Devon and Severn	Taw and Torridge	Change	8	30	0.94	Good	May - Oct	Both	Always	Above MCRS	Yes	Estuary	All year
Eastern	Alde and Ore	New	5	48	0.50	Good	May - Oct	Both	Always	Above MCRS	Yes	Estuary	All year
Eastern	Blakeney	New	2	21	0.31	Moderate	May - Jul	Juvenile	Always	Below MCRS	Yes	Estuary	All year
Eastern	Brancaster	New	0	0	----	None	----	----	----	----	No	----	----
Eastern	Breydon Water	New	3	23	0.77	Good	May - Nov	Both	Always	Above MCRS	Yes	Estuary	All year
Eastern	Burnham	New	2	3	0.60	Limited	Sep	Juvenile	Always	Below MCRS	No	----	----
Eastern	Deben	New	5	6	0.60	Moderate	Jul - Oct	Juvenile	Always	Below MCRS	Yes	Estuary	All year
Eastern	Orwell	New	5	155	0.61	Good	May - Oct	Both	Not Nov	Below MCRS	Yes	Estuary	All year
Eastern	Sizewell	New	1	78	0.80	Good	Jan - Dec	Both	Always	Above MCRS	Yes	Area	All year
Eastern	Stour	New	6	109	0.49	Good	May - Nov	Both	Always	Above MCRS	Yes	Estuary	All year
Eastern	Thornham Estuary	New	0	0	----	None	----	----	----	----	No	----	----
Eastern	Titchwell	New	0	0	----	None	----	----	----	----	No	----	----
Eastern	Wells	New	0	0	----	None	----	----	----	----	No	----	----
Kent and Essex	Bradwell Power Station (Blackwater)	No longer required	0	0	----	None	May - Dec	Both	Always	Below MCRS	Yes	----	----
Kent and Essex	Crouch and Roach	New	56	72	0.95	Good	May - Dec	Both	Always	Below MCRS	Yes	Estuary	All year
Kent and Essex	Hamford Water	New	1	8	0.80	Moderate	Sep - Oct	Both	Not Nov	Above MCRS	Yes	Estuary	All year
Kent and Essex	Kingsnorth Power Station (Medway)	No longer required	0	0	----	None	May - Dec	Both	Always	Above MCRS	Yes	----	----
Kent and Essex	Thames – lower	New	130	165	0.87	Good	May - Dec	Both	Always	Above MCRS	Yes	Estuary	All year
Kent and Essex	Thames – middle	New	39	190	0.57	Good	May - Dec	Both	Always	Above MCRS	Yes	Estuary	All year
Kent and Essex	Thames - upper	New	5	90	0.27	Good	Jun - Sep	Juvenile	Always	Below MCRS	Yes	Estuary	All year
North Eastern	Humber - lower	New	4	17	0.06	Limited	May - Oct	Both	Not Jul, Aug, Nov	Above MCRS	No	----	----

IFCA	Area proposed	Type	Stations	Hauls with sea bass	Probability of sea bass	Evidence of sea bass	Timing of sea bass	Size of sea bass	Found	Other species	Support	Spatial	Temporal
North Eastern	Humber - middle	New	3	10	0.07	Limited	May - Oct	Juvenile	Not Jun, Jul, and Nov	Below MCRS	No	----	----
North Eastern	Humber - upper	New	2	7	0.08	Limited	Sep	Juvenile	Always	Above MCRS	No	----	----
Northumberland	Blyth Power Station	No longer required	0	0	----	None	----	----	----	----	Yes	----	----
Southern	Beaulieu	New	0	0	----	None	----	----	----	----	No	----	----
Southern	Christchurch Harbour	New	0	0	----	None	----	----	----		No	----	----
Southern	Fawley Power Station (Southampton Water)	No longer required	13	3	1.00	Limited	Sep	Both	Always	Below MCRS	Yes	----	----
Southern	Keyhaven (Avon Water)	New	0	0	----	None	----	----	----	----	No	----	----
Southern	Lymington	New	0	0	----	None	----	----	----	----	No	----	----
Southern	Medina	New	0	0	----	None	----	----	----	----	No	----	----
Southern	Portland Harbour	New	0	0	----	None	----	----	----	----	No	----	----
Southern	The Fleet	Change	0	0	----	None	----	----	----	----	No	----	----
Southern	Wootton Creek	New	0	0	----	None	----	----	----	----	No	----	----
Southern	Yar (Bembridge Harbour Lagoon)	New	0	0	----	None	----	----	----	----	No	----	----
Sussex	Adur	New	7	88	0.61	Good	May - Nov	Both	Always	Below MCRS	Yes	Estuary	All year
Sussex	Cuckmere	New	7	35	0.80	Good	May - Oct	Juvenile	Always	Below MCRS	Yes	Estuary	All year
Sussex	Medmerry	New	13	33	0.77	Good	Jun - Oct	Juvenile	Always	Below MCRS	Yes	Estuary	All year
Sussex	Ouse and Tide Mill Creek	New	3	4	1.00	Moderate	Sep - Oct	Juvenile	Always	None	Yes	Estuary	All year
Sussex	Pagham Harbour	New	6	99	0.86	Good	Jun-Sep	Juvenile	Always	None	Yes	Estuary	All year
Sussex	Shoreham Power Station	New	1	32	0.68	Good	Jan-Apr, Dec	Juvenile	Not Jun and Jul	Below MCRS	Yes	Area	All year

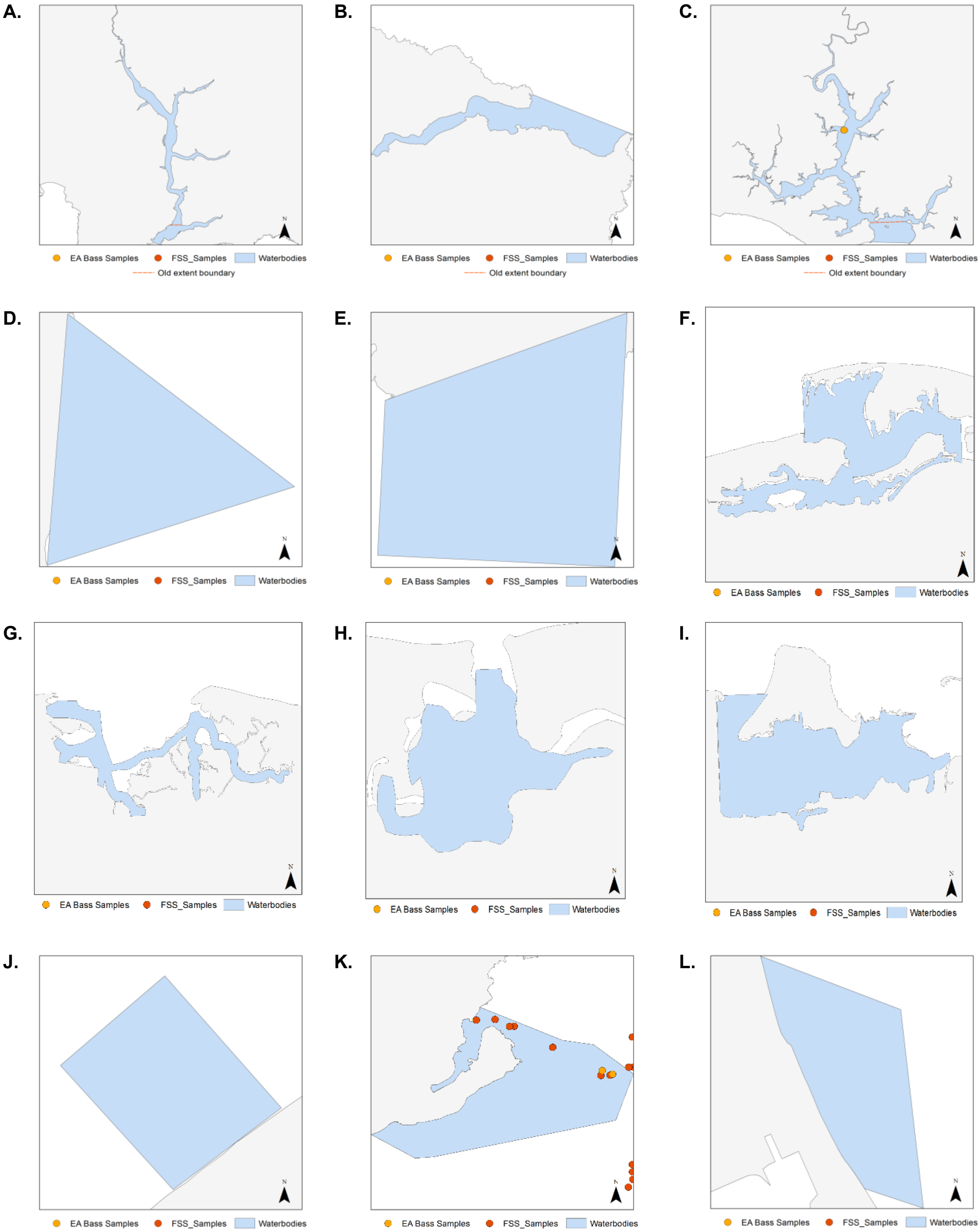

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Figure 9. Proposed amendments to BNAs where no data exist in the current data sources. A. Fowey; B. Gillan Creek; C. Plymouth Rivers; D. The Manacles; E. The Runnel Stone; F. Brancaster Estuary; G. Thornham Estuary; H. Titchwell Estuary; I. Well's Estuary; J. Bradwell Power Station; K. Kingsnorth Power Station; L. Blyth Power Station; M. Beaulieu; N. Christchurch Harbour; O. Keyhaven; P. Lymington; Q. Medina; R. Portland Harbour; S. The Fleet; and T. Wootton Creek; and U. Yar (Bembridge).

3.1.6. The Manacles (new)

The proposed new BNA at the Manacles was based on the evidence from fishers of aggregations of sea bass around this feature (Figure 9D). No physical data were available (Table 4), but information was available on the area (Figure 7A). Fishers indicated that sea bass including juveniles congregate in this area that is important to the handline fisheries, and local bylaws control netting. In 2015, landings by under 10 m vessels from the adjacent ICES rectangle indicated that 28 t of sea bass were retained representing 0.8% of the catch of all species (Figure 8).

Conclusion: There were no survey data on the fish assemblage compiled in this study for the Manacles, so there is insufficient evidence at present to support the proposed BNA (Table 5). More data are required before a BNA designation could be considered.

3.1.7. The Runnel Stone (new)

The proposed new BNA at the Runnel Stone was based on the evidence from fishers of aggregations of sea bass around this feature (Figure 9E). No physical data were available (Table 4), but information was available on the area (Figure 7A). Fishers indicated that sea bass including juveniles congregate in this area that is important to the handline fisheries, and local bylaws control netting. In 2015, landings by under 10 m vessels from the adjacent ICES rectangle indicated that 28 t of sea bass were retained representing 0.8% of the catch of all species (Figure 8).

Conclusion: There were no survey data on the fish assemblage compiled in this study for the Runnel Stone, so there is insufficient evidence at present to support the proposed BNA (Table 5). More data are required before a BNA designation could be considered.

3.2. Devon and Severn

Devon and Severn IFCA currently has eight existing BNAs covering the Avon estuary, Dart estuary, Exe estuary, Salcombe ria, River Taw, River Torridge, Teign estuary, and Yealm estuary (Table 2). The proposed amendments represent new BNAs covering the River Parrett estuary and upper and middle Severn estuary, and an extension to the existing Taw and Torridge BNA (Table 2, Figure 5B). A summary of the Devon and Severn IFCA response to the Defra questionnaire and the evidence supporting proposed amendments are outlined in this section.

3.2.1. Summary of IFCA response

Recreational and commercial fishing are important activities in the Devon and Severn IFCA district. Sea bass and other species (including grey mullet and seabream) are all highly prized by anglers. Considerable economic benefit is derived from anglers targeting these species in the estuaries and rivers. There is a significant amount of shore angling in BNAs, with local bylaw restrictions that currently reduce the potential for shore based netting activities. Recreational angling and some limited netting from boats also takes place within BNAs. There are two European Marine Sites (EMS) in the district related to salmon with limited netting, managed by the EA.

Whilst the effect of existing BNAs is unknown, it is likely that juvenile sea bass have benefited to some degree due to the reduction in fishing effort, and work alongside fixed net restrictions originally introduced to protect migratory salmonids. Many of the estuaries are fished all year, and anecdotal evidence suggests that sea bass are present, so full year protection should be considered. Restricting all netting in BNAs should be considered as bycatch of sea bass and salmonids is likely. Restrictions on the use of sandeel should be retained. New BNAs should be considered in the River Parrett and upper and middle Severn estuaries, but may impact on commercial fishing, so needs appropriate consultation.

BNAs are regularly monitored by the IFCA with recreational anglers less aware of the restrictions than commercial fishers. The enforcement activities have included prosecution for fishing in a BNA, seizures of illegal nets, and several warnings have been issued. Management measures were generally appropriate including restrictions of the use of live sandeels, but the restriction of all drift netting in BNAs would reduce the bycatch of sea bass. BNAs were thought to provide protection for salmonids, grey mullet, and seabream.

The impact of any additional BNAs is likely to affect very small vessels (under 7 m) as they would find it difficult to fish in other areas in poor weather, and it would increase fuel costs. Recent analysis of the MMO landings data indicated that 0.6% of fish landed in all Devon ports were sea bass (83 t) with a total value of £849,322. There is a significant amount of shore angling in BNAs, with local netting bylaws restricting any recreational netting from shore. The removal of netting from these areas would lead to a recreational fishery and is unlikely to impact on commercial fishers as income from grey mullet and seabream is small. However, an evaluation of the costs and benefits would be needed to assess this effectively. Significant effort has been put into the development of sea bass management by the IFCA with research being commissioned to increase understanding of the local situation.

3.2.2. Parrett (new)

The Parrett is a lowland estuary opening into the Bristol Channel that is partially mixed and highly modified (Figure 10A) with limited physical data for the whole Parrett estuary, so no information on the habitat types in the proposed additional area was available apart from comprising of 4% saltmarsh by area (Table 4, Figure 7A and B). It is a lowland estuary, and these types of estuaries have been suggested to contain juvenile sea bass all year (Pickett and Pawson, 1994). There was anecdotal evidence from elver fishers that juvenile sea bass are found in the estuary and sea bass have been caught in four hauls at one location conducted using fyke nets between 2012-13 (Figure 10A-C). The mean number of sea bass in the catch was low at seven fish per haul (Figure 10B), catches contained juveniles (Figure 10D), and sea bass were caught in all hauls (Table 5). Sea bass were found between May and September and were caught in all months surveyed (Figure 10E). Cod, grey mullet, plaice, and sole were also caught in the surveys, but were generally below the MCRS (Figure 10F). In 2015, landings by under 10 m vessels from the adjacent ICES rectangle indicated that 8 t of sea bass were retained representing around 9% of the catch of all species (Figure 8).

Conclusion: There is moderate evidence of juvenile sea bass from a small number of hauls and a high probability of catching sea bass in a haul, with juveniles found in samples and limited fish above MCRS (Table 5). Hence, there is evidence to support further consideration of the proposed Parrett BNA (Table 5).

3.2.3. Severn estuary – middle and upper (new)

The Severn estuary is a large wide-mouthed estuary with a large tidal range. There are extensive mudflats, sandbanks as well as areas of rocky outcrops in the estuary and along the shoreline. Approximate water-filled area at low water is 23 km^2 with a shoreline of 224 km and tidal channel length in the region of 58 km (Smith and Brown, 2009). Detailed physical data including habitat types were available for the whole Severn that indicated large areas of saltmarsh that juvenile sea bass may exploit (Table 4, Figure 7A and B). There was good evidence for the presence of juvenile sea bass in the estuary, with a recent review indicating the importance of the estuary as a nursery area for fish (Bastreri *et al.*, 2014). Juvenile sea bass were caught in 51 hauls at 14 locations in surveys conducted in the upper and middle Severn using fyke, trammel, and seine nets, beam trawls, and power station screens from 1998-2014 (Figure 11A-C). The mean number of sea bass in the catch was between one and seven fish per haul (Figure 11B), catches contained both juveniles and adults (Figure 11D), and there was a 38% chance of catching a sea bass in a haul (Table 4). Sea bass were found between January and November, but no sea bass were caught in surveys during December (Figure 11E). Cod, grey mullet, plaice, and sole were also caught in the surveys, including individuals above the MCRS (Figure 11F). There was no ICES rectangle adjacent to the upper and middle Severn, so landings by under 10 m vessels were assumed to be negligible.

Conclusion: There is good evidence of juvenile sea bass in the middle and upper Severn from many hauls and a moderate probability of catching sea bass in a haul, with both juveniles and adults found and limited presence of other fish above MCRS (Table 5). Hence, there is evidence to support further consideration of the proposed middle and upper Severn BNA (Table 5).

3.2.4. Taw and Torridge Rivers (change)

The Rivers Taw and Torridge have a common estuary that empties into the Bristol Channel at Apppledore. There were around 10 boats operating from Bideford and Appledore, including both potters and netters, that fish mainly in the Bristol Channel for demersal species, but sea bass was an important fishery in spring and autumn (Walmsley and Pawson, 2007). The estuary is partially mixed and highly modified, with physical data available and saltmarsh represent around 3% of the area (Table 4, Figure 7A and B). The two individual rivers are already classified as BNAs, so the extension proposed covers the joint estuary to the seaward boundary (Figure 12A). As the habitat is similar to the existing BNAs, it is likely that juvenile sea bass will be found in the proposed extension. Juvenile sea bass were found in the estuary and sea bass were caught in 30 hauls at eight locations conducted using mainly seine nets with one beam trawl haul between 2007-14 (Figure 12A-C). The mean number of sea bass in the catch was 78 fish per haul in seine nets (Figure 12B), catches contained juveniles (Figure 12D), and there was 94% chance of catching a sea bass in a haul (Table 5). Sea bass were found between May and October and were caught in all months surveyed (Figure 12E). Cod, grey mullet, plaice, and sole were also caught in the surveys, with some above the MCRS (Figure 12F). In 2015, landings by under 10 m vessels from the adjacent ICES rectangle indicated that 8 t of sea bass were retained representing around 1% of the catch of all species (Figure 8).

Conclusion: There is good evidence of juvenile sea bass from a small number of hauls and a high probability of catching sea bass in a haul, with juveniles found in samples and limited fish above MCRS (Table 5). Hence, there is evidence to support further consideration of the proposed extension to the existing Taw and Torridge BNAs (Table 5).

3.3. Eastern

Eastern IFCA currently has no existing BNAs, but has proposed amendments representing new BNAs covering the Alde and Ore, Blakeney, Brancaster, Breydon Water, Burnham, Deben, Orwell, Sizewell Power Station, Stour, Thornham, Titchwell and Wells (Table 2, Figure 5C). A summary of the Eastern IFCA response to the Defra questionnaire and the evidence supporting proposed amendments are outlined in this section.

3.3.1.Summary of IFCA response

There are currently no BNAs designated within the Eastern IFCA district, but previous analysis of the EA sampling in support of WFD alongside other local sources of data indicated the importance of the district as nursery grounds for juvenile fish including sea bass (Colclough, 2015). Increasing sea temperatures may also enhance the potential for BNAs in the eastern part of the country. There are important recreational and commercial fisheries in this district. Management measure are likely to impact on both the recreational and commercial fishing communities, but should take account of the effort from shore as well as boats. Commercial fishing activities include netting for shrimp, grey mullet, and salmonids, and drift netting for herring, with restrictions on locations likely to limit fishing opportunities in poor weather. The importance of the southern areas of this district for sea bass is shown in port sampling of commercial catch data. This is also an important area for recreational angling with fishing from the shore and boats common, with a number of charter boats operating in the region. These activities provide employment and direct financial benefit to the local economy, as well as the additional spend locally by resident and visiting anglers. As a result, it is important for designation of any new BNAs to be flexible and considered all year, but must be based on an impact assessment that considers local factors.

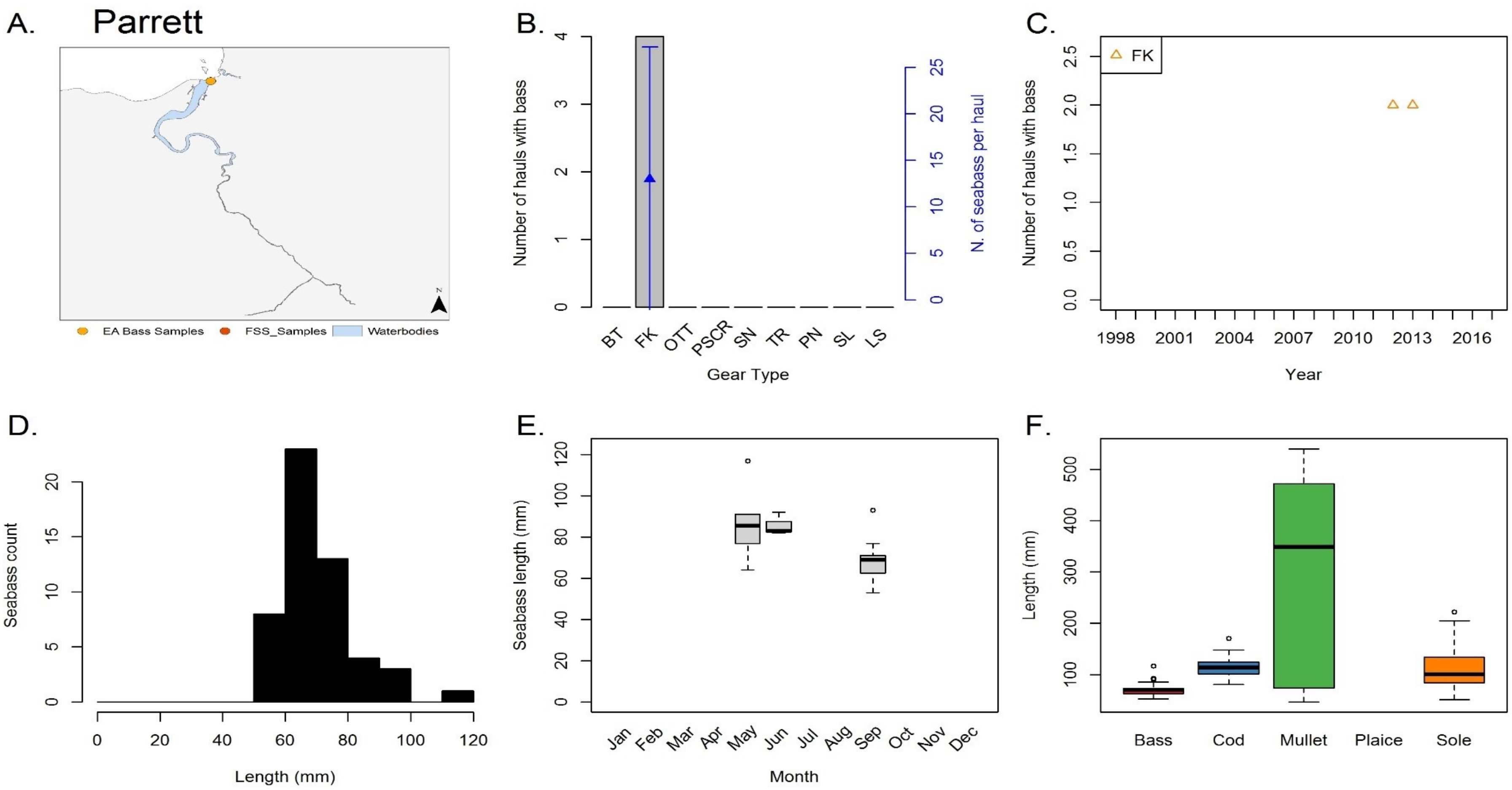

Figure 10. Assessment of the presence of sea bass and other fish in the River Parrett including: the area proposed and stations sampled (A); number of samples of sea bass and number of sea bass per sample (B - BT = beam trawl, FK = fyke, LS = Larson Sprat, OTT = otter; PN = push, PSCR = power station screen, SL = Solent survey, SN = seine, TR = trammel net); number of samples by gear over time (C – codes as B); length-frequency of sea bass (D); mean length of sea bass by month (E); and length of sea bass, cod, grey mullet, plaice, and sole (F).

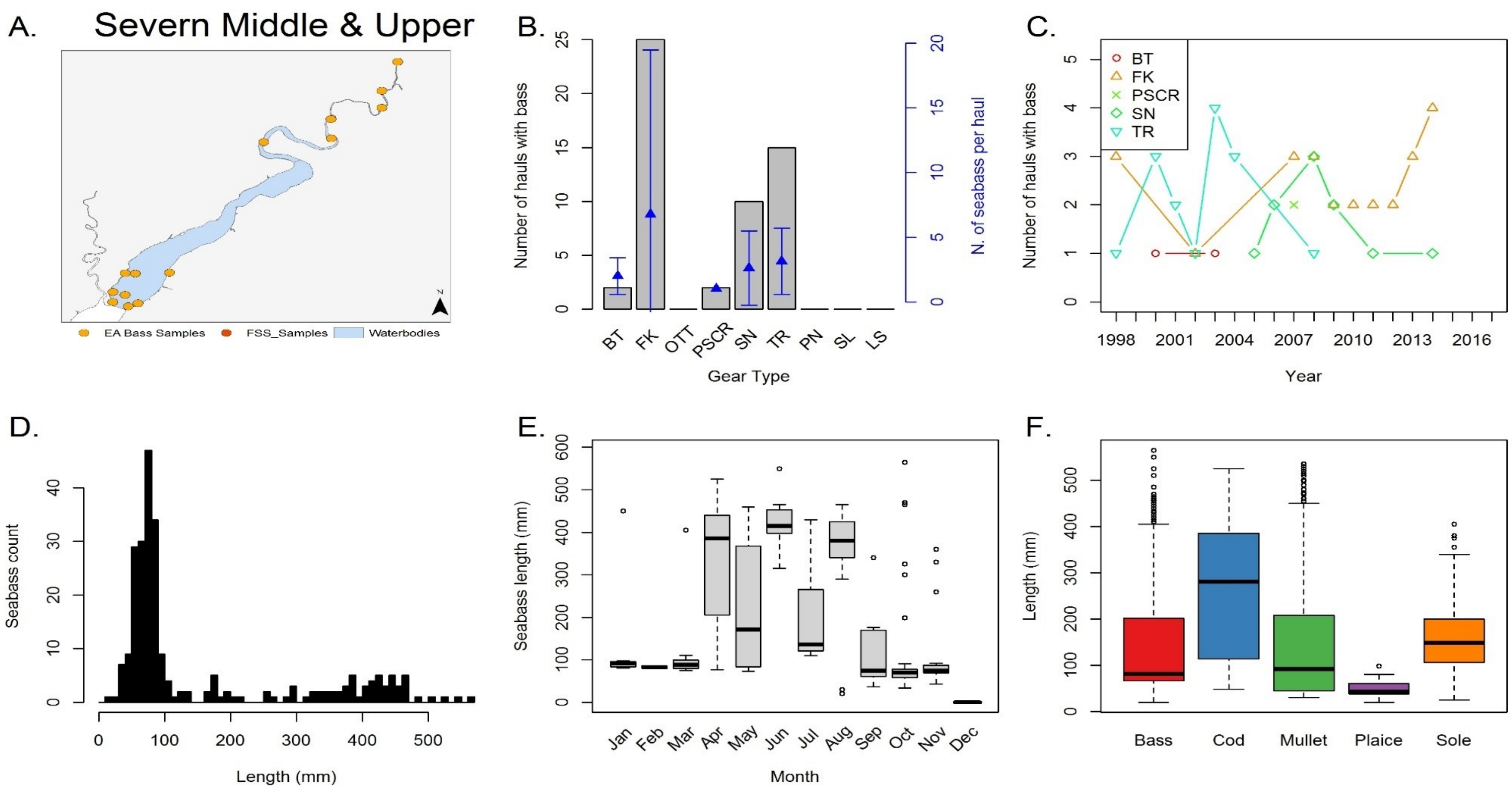

Figure 11. Assessment of the presence of sea bass and other fish in the upper and middle Severn including: the area proposed and stations sampled (A); number of samples of sea bass and number of sea bass per sample (B - BT = beam trawl, FK = fyke, LS = Larson Sprat, OTT = otter; PN = push, PSCR = power station screen, SL = Solent survey, SN = seine, TR = trammel net); number of samples by gear over time (C – codes as B); length-frequency of sea bass (D); mean length of sea bass by month (E); and length of sea bass, cod, grey mullet, plaice, and sole (F).

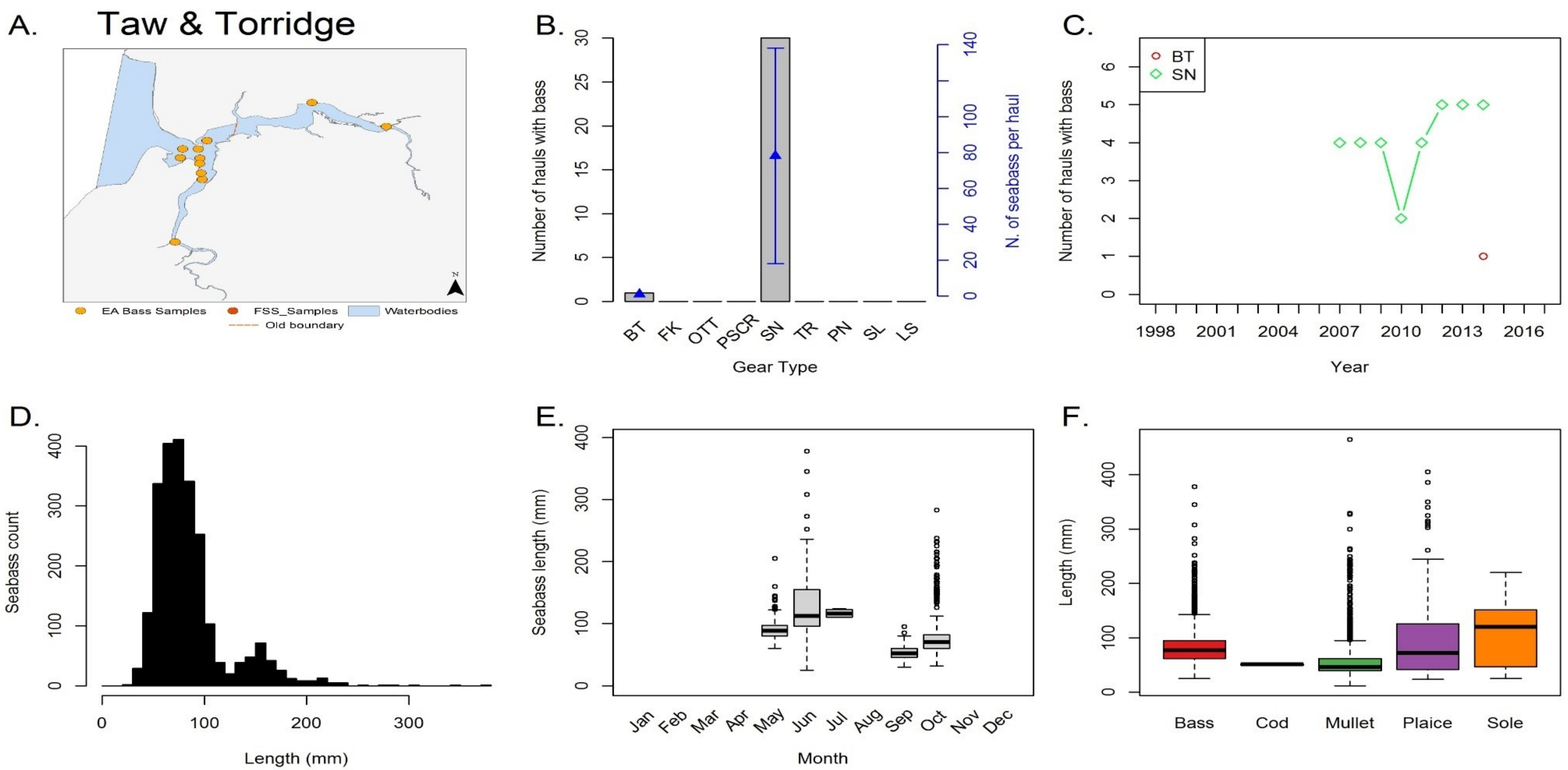

Figure 12. Assessment of the presence of sea bass and other fish in the Taw and Torridge including: the area proposed and stations sampled (A); number of samples of sea bass and number of sea bass per sample (B - BT = beam trawl, FK = fyke, LS = Larson Sprat, OTT = otter; PN = push, PSCR = power station screen, SL = Solent survey, SN = seine, TR = trammel net); number of samples by gear over time (C – codes as B); length-frequency of sea bass (D); mean length of sea bass by month (E); and length of sea bass, cod, grey mullet, plaice, and sole (F).

New BNAs are proposed within the district at a number of locations based on evidence compiled by the IFCA including: Sizewell Power Station, the Stour and Orwell estuary complex, Breydon Water, The Alde and Ore estuary complex, and Deben estuary (Table 2, Figure 5C). It is likely that extensive areas of estuarine saltmarsh on the North Norfolk and Lincolnshire Wash coasts are sea bass nursery areas, so the estuaries at Blakeney, Brancaster, Burnham, Thornham, Titchwell and Well are proposed (Table 2, Figure 5C). Other MPAs exist including the EMS in The Wash, Stour and Orwell, Alde and Ore, Deben, and Breydon Water, and proposed Marine Conservation Zones at Cromer Shoal chalk beds and the Lincolnshire Belt. BNAs are likely to afford protection for other small fish including dab, flounder, sole, smelt, and grey mullet species.

3.3.2. Alde and Ore (new)

The Alde and Ore is a narrow lowland estuary, with a shallow and narrow mouth, some mudflats and adjoining tidal creeks, draining through marshland and with a strong tidal exchange. Approximate water-filled area at low water is 5.4 km^2 with a shoreline of 82 km and tidal channel length in the region of 28 km (Smith and Brown, 2009). No information on angling was available although some charter activity was reported from Orford, three longshore boats operated from this beach (separated from the estuary by a long shingle spit) and fyke nets were set in the Rivers Alde and Ore (Smith and Brown, 2009). Some full-time vessels worked from Orford and small single-handed vessels fished part-time. Pots may be set for lobsters and crabs in season. Sole, sea bass, grey mullet, crab, and lobster were also caught in the river (Smith and Brown, 2009). During the summer, one or two boats used rod and lines, commercially or for angling charter, on wrecks and banks up to 30 miles offshore for cod, sea bass, pollack, and ling (Walmsley and Pawson, 2007).

Detailed physical data including habitat types were available for the whole Alde and Ore that showed large areas of saltmarsh that juvenile sea bass may exploit (Table 4, Figure 7A and B). Juvenile sea bass were caught in 48 hauls at five locations in surveys conducted using beam trawls, fyke nets, and seine nets from 2003-2014 (Figure 13A-C). The mean number of sea bass in the catch was between one and 10 fish per haul (Figure 13B), catches contained juveniles and adults (Figure 13D), and there was a 50% chance of catching a sea bass in a haul (Table 5). Sea bass were found between May and October and were always caught during a month with surveys (Figure 13E). Cod, grey mullet, plaice, and sole were also caught in the surveys, including some above the MCRS (Figure 13F). In 2015, landings by under 10 m vessels from the adjacent ICES rectangle indicated that 10 t of sea bass were retained representing 2% of the catch of all species (Figure 8).

Conclusion: There is good evidence of juvenile sea bass from a large number of hauls and a moderate probability of catching sea bass in a haul, with both juveniles and adults found and limited other fish above MCRS (Table 5). Hence, there is evidence to support further consideration of the proposed Alde and Ore BNA (Table 5).

3.3.3. Blakeney (new)

There are a number of tidal creeks on the north coast of Norfolk, comprised of small lowland rivers and large areas of draining saltmarsh and mudflats that are often bordered by sand spits (Smith and Brown, 2009). At Morston and Blakeney, eight vessels target crabs and lobsters using pots, with two vessels targeting grey mullet and sea bass alongside two individuals using fixed set nets, and many individuals are involved in bait digging (Walmsley and Pawson, 2007). The extensive areas of mudflats and saltmarsh are ideal habitat for juvenile sea bass, so the coastal lagoon of 879 ha that includes 444 ha of saltmarsh has been proposed as a BNA (Table 4, Figure 7A and B). Partial physical data exist, and the waterbody has not been heavily modified (Table 4). Juvenile sea bass were caught in 21 hauls at two locations in surveys conducted using seine nets during 2015-2016 (Figure 14A-C). The mean number of sea bass in the catch was around 16 fish per haul (Figure 14B), catches contained juveniles (Figure 14D), and there was a 31% chance of catching sea bass in a haul (Table 5). Sea bass were found between May and July and were always caught during a month with surveys (Figure 14E). Plaice and sole were caught in the surveys, with plaice above the MCRS (Figure 14F). In 2015, landings by under 10 m vessels from the adjacent ICES rectangle indicated that 1.5 t of sea bass were retained representing 0.2% of the catch of all species (Figure 8).

Conclusion: There is moderate evidence of juvenile sea bass from a moderate number of hauls and a high probability of catching sea bass in a haul, with juveniles found (Table 5). Hence, there is evidence to support further consideration of the proposed Blakeney BNA (Table 5).

3.3.4. Brancaster (new)

There are a number of tidal creeks on the north coast of Norfolk, comprised of small lowland rivers and large areas of draining saltmarsh and mudflats that are often bordered by sand spits (Smith and Brown, 2009). At Brancaster and Burnham, oysters are cultivated and harvested all year, eight vessels harvest mussels, six target crabs and lobsters using pots, and two dredge for mussels and cockles (Walmsley and Pawson, 2007). The extensive areas of mudflats and saltmarsh are ideal habitat for juvenile sea bass, with 375 ha that includes 133 ha of saltmarsh has been proposed as a BNA (Table 4, Figure 7A and B, Figure 9F). No additional physical data were available, nor were surveys of fish assemblages (Table 4). In 2015, landings by under 10 m vessels from the adjacent ICES rectangle indicated that 0.4 t of sea bass were retained representing 0.1% of the catch of all species (Figure 8).

Conclusion: There were no data on the fish assemblage compiled in this study, so there is insufficient evidence at present to support the proposed BNA (Table 5). More data are required before a BNA designation could be considered.

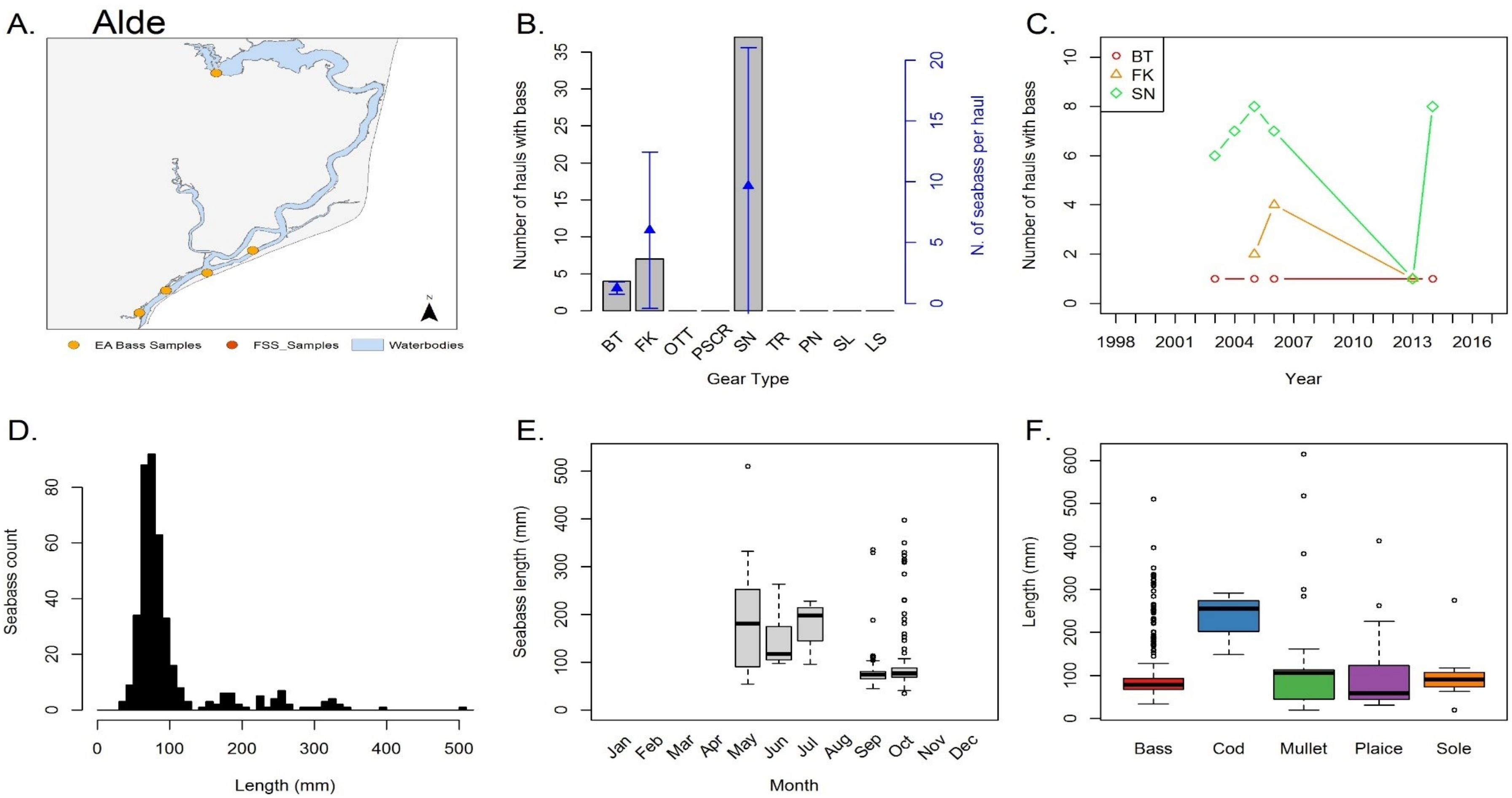

Figure 13. Assessment of the presence of sea bass and other fish in the Rivers Alde and Ore including: the area proposed and stations sampled (A); number of samples of sea bass and number of sea bass per sample (B - BT = beam trawl, FK = fyke, LS = Larson Sprat, OTT = otter; PN = push, PSCR = power station screen, SL = Solent survey, SN = seine, TR = trammel net); number of samples by gear over time (C – codes as B); length-frequency of sea bass (D); mean length of sea bass by month (E); and length of sea bass, cod, grey mullet, plaice, and sole (F).

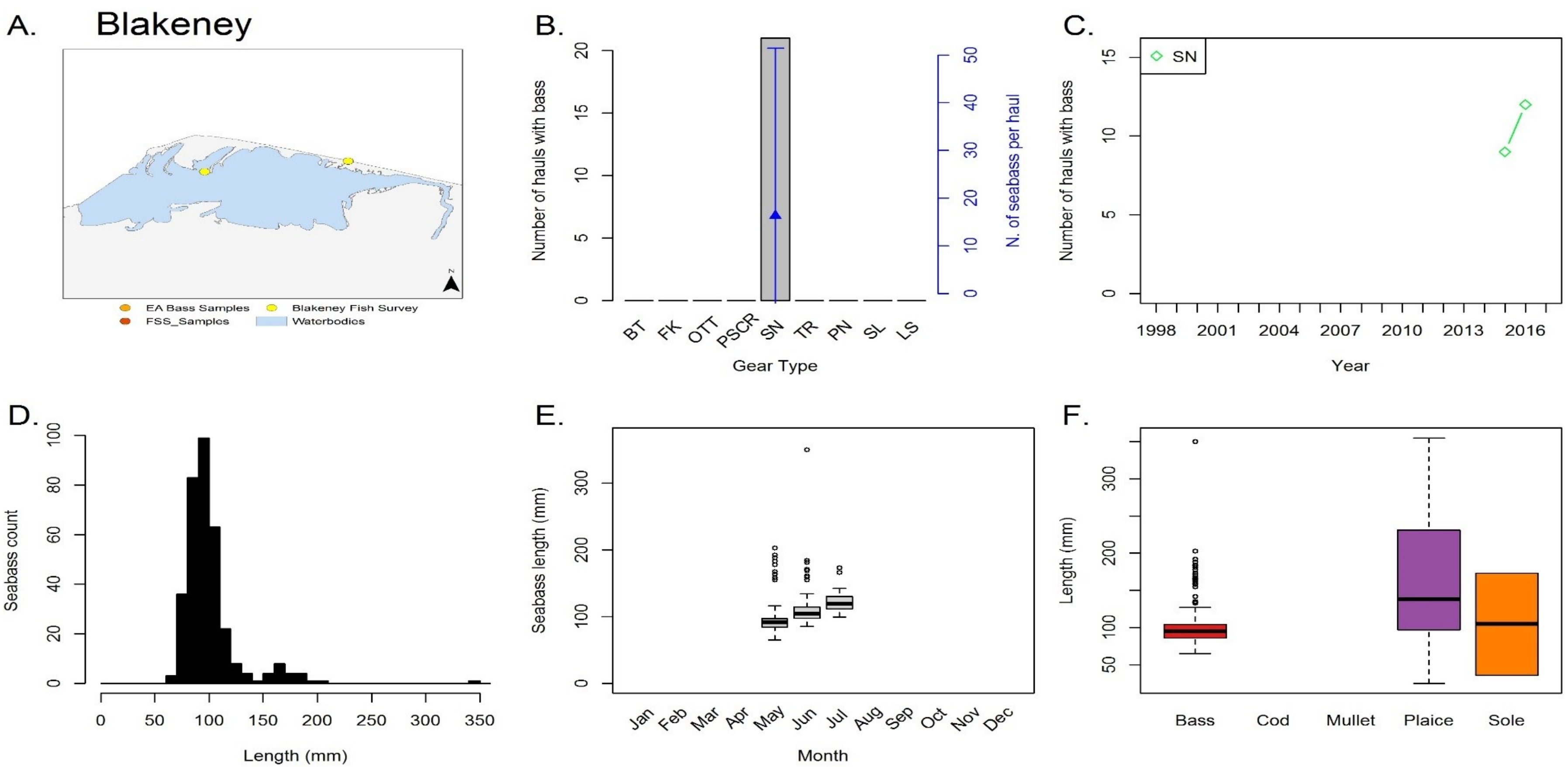

Figure 14. Assessment of the presence of sea bass and other fish in the Blakeney including: the area proposed and stations sampled (A); number of samples of sea bass and number of sea bass per sample (B - BT = beam trawl, FK = fyke, LS = Larson Sprat, OTT = otter; PN = push, PSCR = power station screen, SL = Solent survey, SN = seine, TR = trammel net); number of samples by gear over time (C – codes as B); length-frequency of sea bass (D); mean length of sea bass by month (E); and length of sea bass, cod, grey mullet, plaice, and sole (F).

3.3.5. Breydon Water (new)

Breydon Water is a lowland estuary with mudflats and adjoining tidal creeks draining marshland and a strong tidal exchange through a narrow and urbanised mouth. Approximate water-filled area at low water is 1.1 km^2, with a shoreline of 26 km and tidal channels length in the region of 10 km (Smith and Brown, 2009). Four charter vessels operate, and an offshore longline fleet and inshore fleet are based in Great Yarmouth harbour (Smith and Brown, 2009). Between Great Yarmouth and Lowestoft, five to seven longshore boats operate from Hopton and Corton (Walmsley and Pawson, 2007). All these boats can target sea bass.

There was limited physical data for Breydon Water, so no information on the habitat types in the proposed additional area was available apart from saltmarsh (Table 4, Figure 7A and B). Juvenile sea bass were caught in 23 hauls at three locations in surveys conducted using beam trawls, otter trawls and seine nets during 2007-2012 (Figure 15A-C). The mean number of sea bass in the survey catches was between one and 24 fish per haul (Figure 15B), catches contained juveniles and adults (Figure 15D), and there was a 77% chance of catching a sea bass in a haul (Table 5). Sea bass were found between May and November and were always caught in months with surveys (Figure 15E). Cod, grey mullet, plaice, and sole were also caught in the surveys, including some above the MCRS (Figure 15F). In 2015, landings by under 10 m vessels from the adjacent ICES rectangle indicated that 10 t of sea bass were retained representing 2% of the catch of all species (Figure 8).

Conclusion: There is good evidence of juvenile sea bass from a large number of hauls and a high probability of catching sea bass in a haul with both juveniles and adults found, but there are fish of other species above MCRS present (Table 5). Hence, there is evidence to support further consideration of the proposed Breydon Water BNA.

3.3.6. Burnham (new)

There are a number of tidal creeks on the north coast of Norfolk, comprised of small lowland rivers and large areas of draining saltmarsh and mudflats that are often bordered by sand spits (Smith and Brown, 2009). At Brancaster and Burnham, oysters are cultivated and harvested all year, eight vessels harvest mussels, six target crabs and lobsters using pots, and two dredge for mussels and cockles (Walmsley and Pawson, 2007). The extensive areas of mudflats and saltmarsh are ideal habitat for juvenile sea bass, with the 311 ha proposed BNA including almost 191 ha of saltmarsh (Table 4, Figure 7A and B). No additional physical data exist (Table 4). Juvenile sea bass were caught in three hauls at one location in surveys conducted using seine nets during 2015 (Figure 16A-C). The mean number of sea bass in the catch was two fish per haul (Figure 16B), catches contained juveniles (Figure 16D), and 60% chance of catching sea bass in each haul (Table 5). Sea bass were found between September and were always caught during a month with surveys (Figure 16E). Only grey mullet were caught in addition to sea bass in the survey (Figure 16F). In 2015, landings by under 10 m vessels from the adjacent ICES rectangle indicated that 0.4 t of sea bass were retained representing 0.1% of the catch of all species (Figure 8).

Conclusion: There is limited evidence of juvenile sea bass from a low number of hauls and a high probability of catching sea bass in a haul, with juveniles found (Table 5). More data are required before a BNA designation could be considered.

3.3.7. Deben (new)

The River Deben is a narrow lowland estuary with a strong tidal exchange through a shallow and narrow mouth, some mudflats and adjoining tidal creeks that drain through marshland. Approximate water-filled area at low water is 2.9 km^2 with a shoreline of 40 km and tidal channels length in the region of 14.9 km (Smith and Brown, 2009). No information on angling was available and seven vessels were based in Felixstowe ferry at the mouth of the Deben (Walmsley and Pawson, 2007). All these boats can target sea bass.

There was limited physical data for the Deben, so no information on the habitat types in the proposed additional area was available apart from 74 ha of saltmarsh (Table 4, Figure 7A and B). Juvenile sea bass were caught in six hauls at five locations sampled using seine and fyke nets between 2013 and 2016 (Figure 17A-C). The mean number of sea bass in the catch was six fish per haul (Figure 17B), catches contained juveniles (Figure 17D), and there was around a 60% chance of catching a sea bass in a haul (Table 5). Sea bass were found in July and October were found in all months surveyed (Figure 17E). Grey mullet were also caught in the surveys, but were below the MCRS (Figure 17F). In 2015, landings by under 10 m vessels from the adjacent ICES rectangle indicated that 62 t of sea bass were retained representing 6% of the catch of all species (Figure 8).

Conclusion: There is moderate evidence of juvenile sea bass from a small number of hauls and a medium probability of catching sea bass in a haul with juveniles, and there were no other fish above MCRS (Table 5). Hence, there is evidence to support further consideration of the proposed Deben BNA (Table 5).

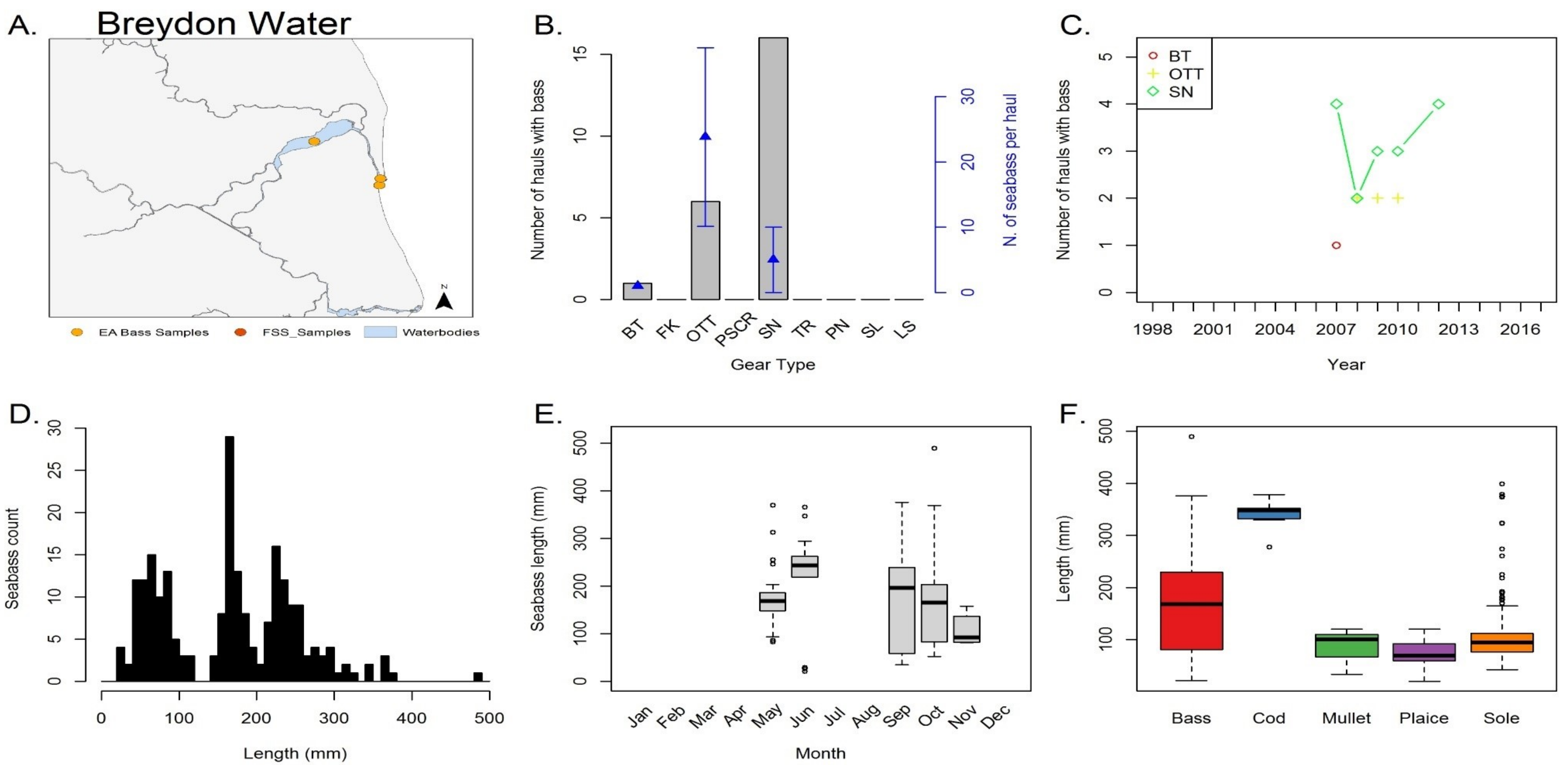

Figure 15. Assessment of the presence of sea bass and other fish in Breydon Water including: the area proposed and stations sampled (A); number of samples of sea bass and number of sea bass per sample (B - BT = beam trawl, FK = fyke, LS = Larson Sprat, OTT = otter; PN = push, PSCR = power station screen, SL = Solent survey, SN = seine, TR = trammel net); number of samples by gear over time (C – codes as B); length-frequency of sea bass (D); mean length of sea bass by month (E); and length of sea bass, cod, grey mullet, plaice, and sole (F).

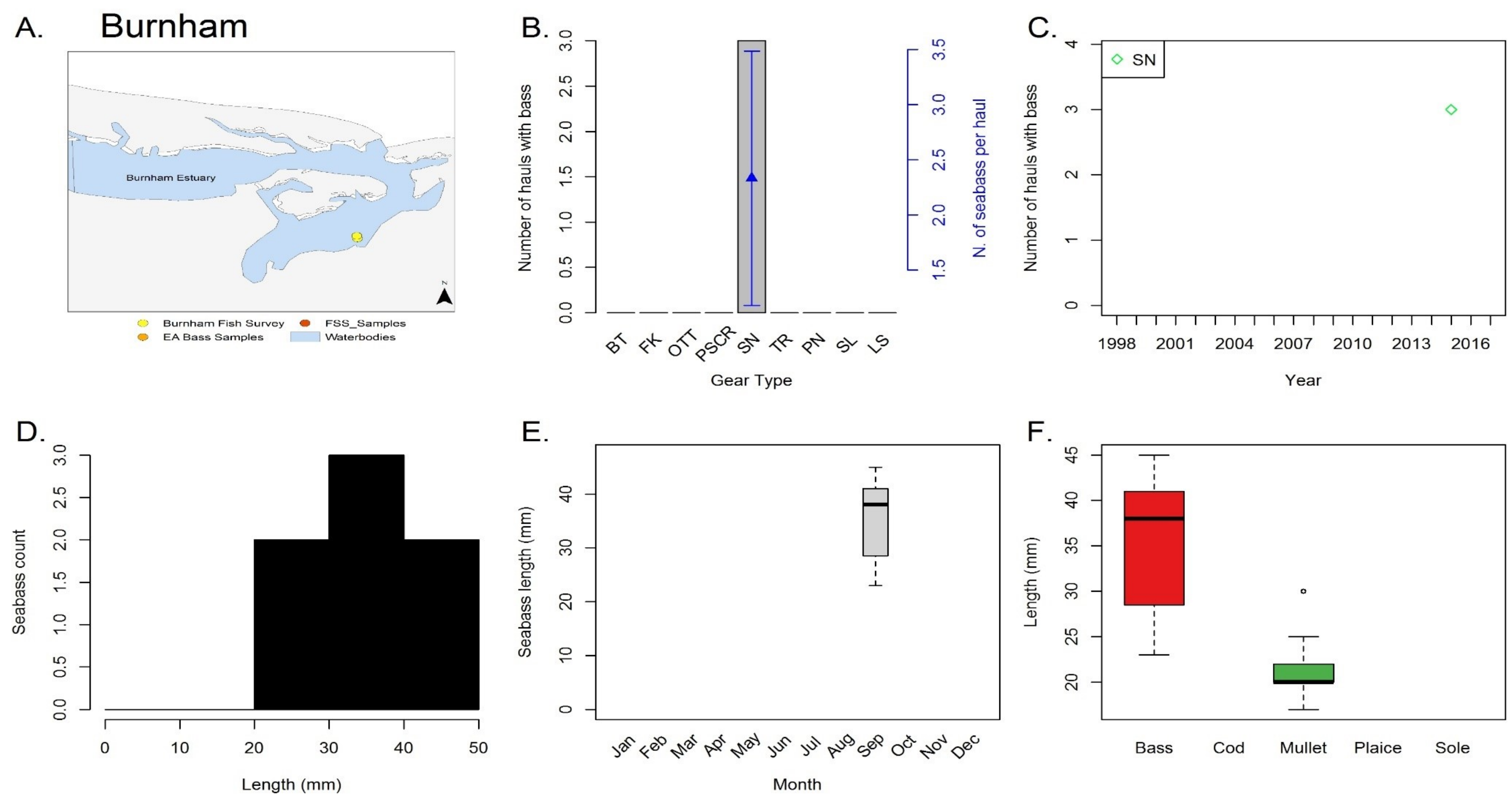

Figure 16. Assessment of the presence of sea bass and other fish in the Burnham including: the area proposed and stations sampled (A); number of samples of sea bass and number of sea bass per sample (B - BT = beam trawl, FK = fyke, LS = Larson Sprat, OTT = otter; PN = push, PSCR = power station screen, SL = Solent survey, SN = seine, TR = trammel net); number of samples by gear over time (C – codes as B); length-frequency of sea bass (D); mean length of sea bass by month (E); and length of sea bass, cod, grey mullet, plaice, and sole (F).

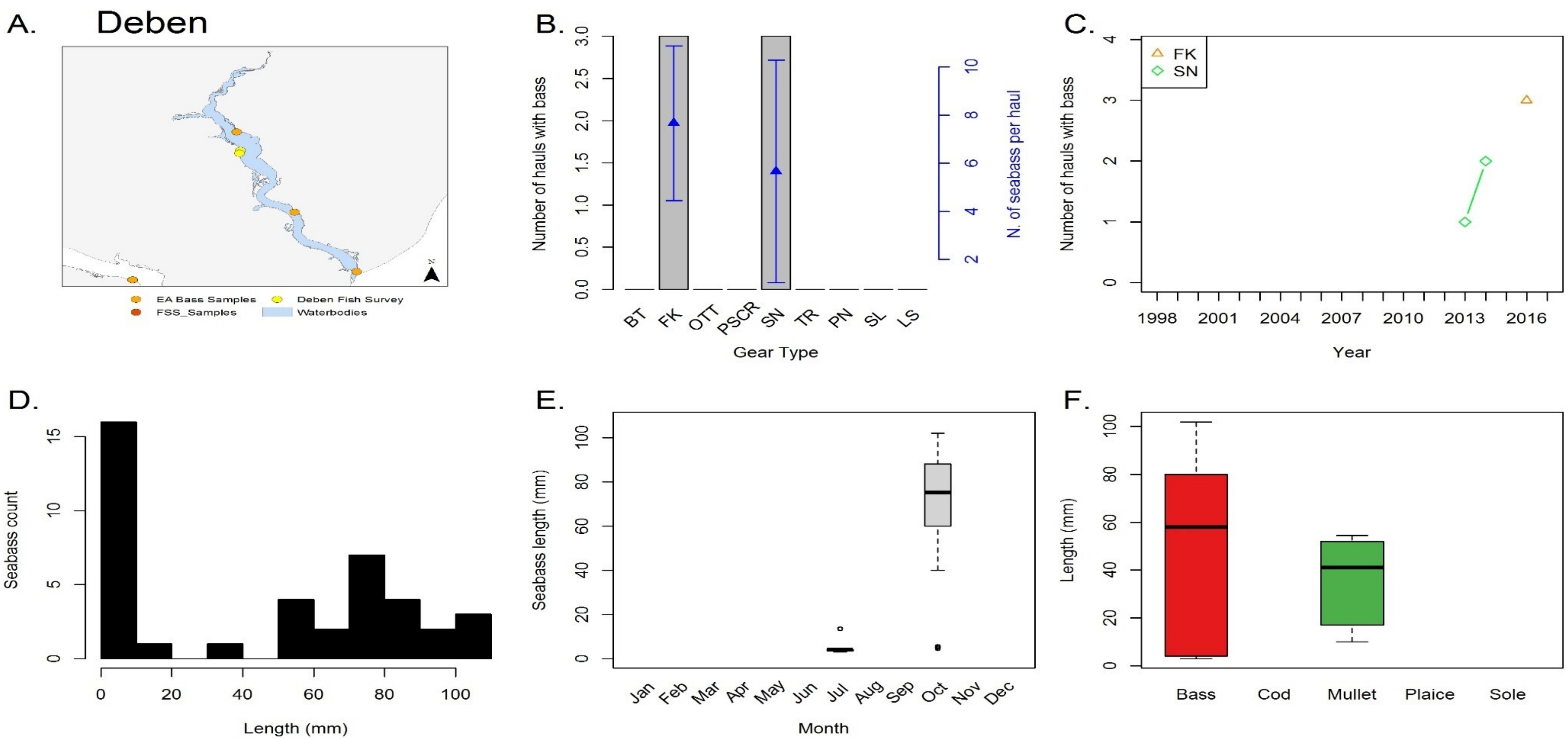

Figure 17. Assessment of the presence of sea bass and other fish in the River Deben including: the area proposed and stations sampled (A); number of samples of sea bass and number of sea bass per sample (B - BT = beam trawl, FK = fyke, LS = Larson Sprat, OTT = otter; PN = push, PSCR = power station screen, SL = Solent survey, SN = seine, TR = trammel net); number of samples by gear over time (C – codes as B); length-frequency of sea bass (D); mean length of sea bass by month (E); and length of sea bass, cod, grey mullet, plaice, and sole (F).

3.3.8. Orwell (new)

The Stour and Orwell are wide-mouthed lowland estuaries without major sand banks, but with mudflats and adjoining tidal creeks draining marshland. There are major ports and a dredged deep-water channel at estuary mouth. Approximate water-filled area at low water is 19.3 km^2 with a shoreline of 122 km and tidal channel length in the region of 20 km (Smith and Brown, 2009). The sea bass fishery, good marina facilities, and sheltered estuarine waters attracted many recreational angling boats that fish in the estuaries and surrounding areas (Smith and Brown, 2009). At Shotley, there were four full-time under 10 m commercial boats and a few part-time boats fish the Stour, eel fyke netting, shrimp trawling, lobster potting, and the setting of stake nets along the shore for flounder, sole, sea bass and grey mullet. Around six under 10 m boats worked part-time in the Orwell (Walmsley and Pawson, 2007). All these boats can target sea bass. Detailed physical data including habitat types were available for the Orwell that indicated areas of saltmarsh areas that juvenile sea bass exploit (Table 4,Figure 7A and B).

For the Orwell, analysis showed that juvenile sea bass were caught in 155 hauls at five locations in surveys conducted using beam trawls, fyke nets and seine nets in 2004-14 (Figure 18A-C). The mean number of sea bass in the catch was between two and 22 fish per haul (Figure 18B), catches contained juveniles and adults (Figure 18D), and there was a 61% chance of catching a sea bass in a haul (Table 5). Sea bass were found between May and November and were found in all months where there was a survey apart from November (Figure 18E). Cod, grey mullet, plaice, and sole were also caught in the surveys, but were generally below the MCRS (Figure 18F). In 2015, landings by under 10 m vessels from the adjacent ICES rectangle indicated that 62 t of sea bass were retained representing around 6% of the catch of all species (Figure 8).

Conclusion: There is good evidence of juvenile sea bass from a large number of hauls and a high probability of catching sea bass in a haul with juveniles found, although there were other fish above MCRS (Table 5). Hence, there is evidence to support further consideration of the proposed Orwell BNA (Table 5).

3.3.9. Sizewell (new)

The area around power station outflows is known to attract small sea bass and a number were included in the original BNA designation. Sizewell Power Station has four intakes with screens that young fish are impinged on. At Sizewell, impingement sampling was done between 2009 and 2012 over 24 hours on 97 occasions (Figure 19A-C). There was no physical data for Sizewell, but the feature is the warm water outflow and area proposed was derived from the shapefile (Table 4, Figure 7A). Analysis of the power station screen samples showed that juvenile sea bass were found in 78 (80%) of samples (Table 5) collected during 2009-2012 (Figure 19A-C). The mean number of sea bass in the catch was 1,304 fish per sample (Figure 19B), and samples contained juveniles and adults (Figure 19D). Sea bass were found all year round (Figure 19E) and cod, grey mullet, plaice and sole above the MCRS were also present in the samples (Figure 19F). In 2015, landings by under 10 m vessels from the adjacent ICES rectangle indicated that 10 t of sea bass were retained representing 2% of the catch of all species (Figure 8).

Conclusion: There is good evidence that the area in the immediate vicinity of the power station has sufficient aggregation of juvenile sea bass to give a high probability of them being impinged by the cooling water intakes, although individuals of other species above MCRS are present (Table 5). Hence, there is evidence to support further consideration of the proposed Sizewell BNA (Table 5).

3.3.10. Stour (new)

A detailed description of the Stour and Orwell complex is provided in the section on the Orwell. Detailed physical data including habitat types were available for the Stour that indicated areas of saltmarsh areas that juvenile sea bass exploit (Table 4, Figure 7A and B).

For the Stour, analysis showed that juvenile sea bass were caught in 109 hauls at six locations in surveys conducted using beam trawls, fyke nets, otter trawls, and seine nets from 2007-14 (Figure 20A-C). The mean number of sea bass in the catch was between one and 14 fish per haul (Figure 20B), catches contained juveniles and adults (Figure 10D), and there was a 49% chance of catching a sea bass in a haul (Table 5). Sea bass were found between May and November and were found during all months with surveys (Figure 20E). Cod, grey mullet, plaice, and sole were also caught in the surveys, including some above the MCRS (Figure 20F). In 2015, landings by under 10 m vessels from the adjacent ICES rectangle indicated that 62 t of sea bass were retained representing around 6% of the catch of all species (Figure 8).

Conclusion: There is good evidence of juvenile sea bass from a large number of hauls and a high probability of catching sea bass in a haul with juveniles found, although there were other fish above MCRS (Table 5). Hence, there is evidence to support further consideration of the proposed Stour BNA (Table 5).

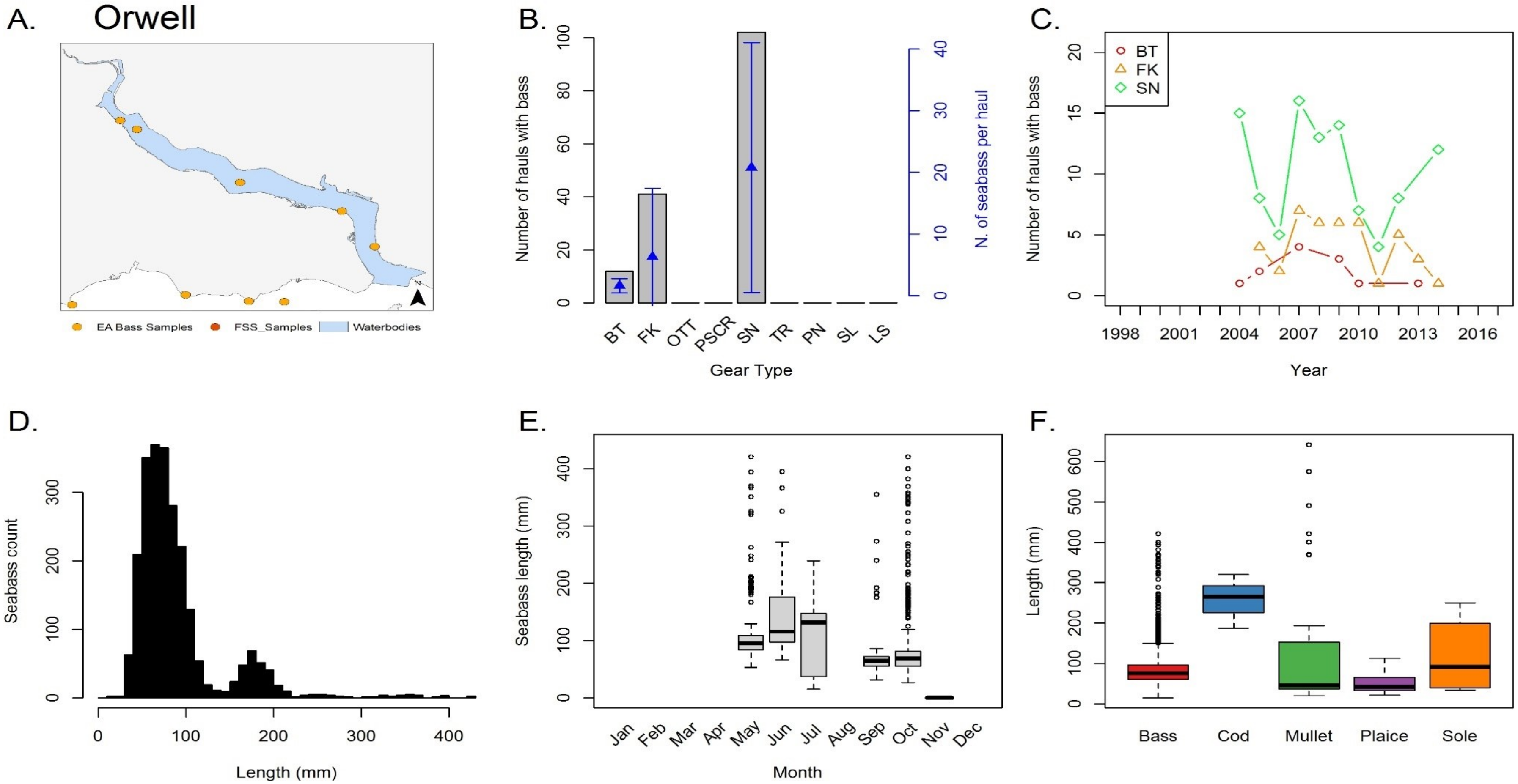

Figure 18. Assessment of the presence of sea bass and other fish in the River Orwell including: the area proposed and stations sampled (A); number of samples of sea bass and number of sea bass per sample (B - BT = beam trawl, FK = fyke, LS = Larson Sprat, OTT = otter; PN = push, PSCR = power station screen, SL = Solent survey, SN = seine, TR = trammel net); number of samples by gear over time (C – codes as B); length-frequency of sea bass (D); mean length of sea bass by month (E); and length of sea bass, cod, grey mullet, plaice, and sole (F).

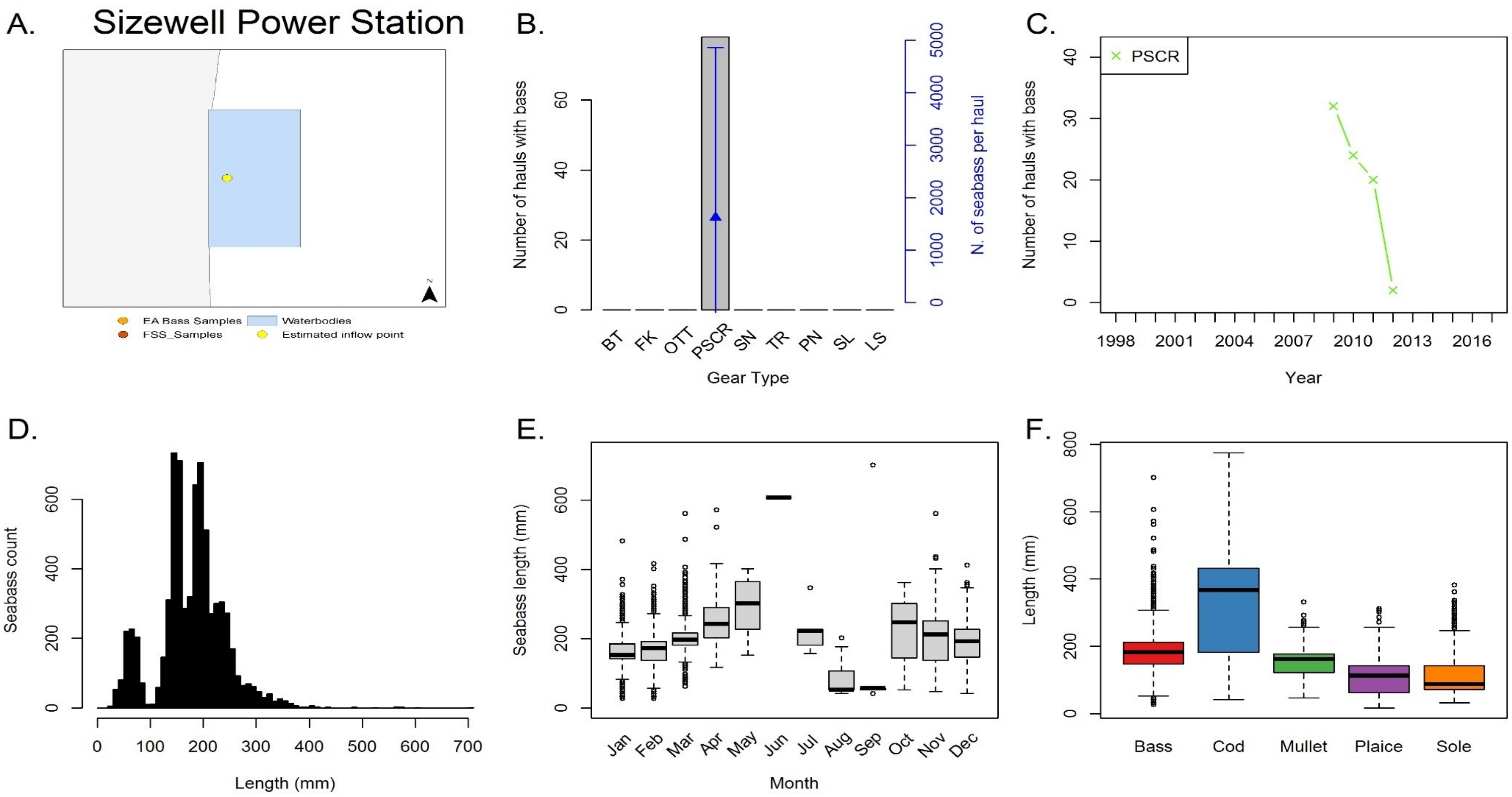

Figure 19. Assessment of the presence of sea bass and other fish at Sizewell including: the area proposed and stations sampled (A); number of samples of sea bass and number of sea bass per sample (B - BT = beam trawl, FK = fyke, LS = Larson Sprat, OTT = otter; PN = push, PSCR = power station screen, SL = Solent survey, SN = seine, TR = trammel net); number of samples by gear over time (C – codes as B); length-frequency of sea bass (D); mean length of sea bass by month (E); and length of sea bass, cod, grey mullet, plaice, and sole (F).

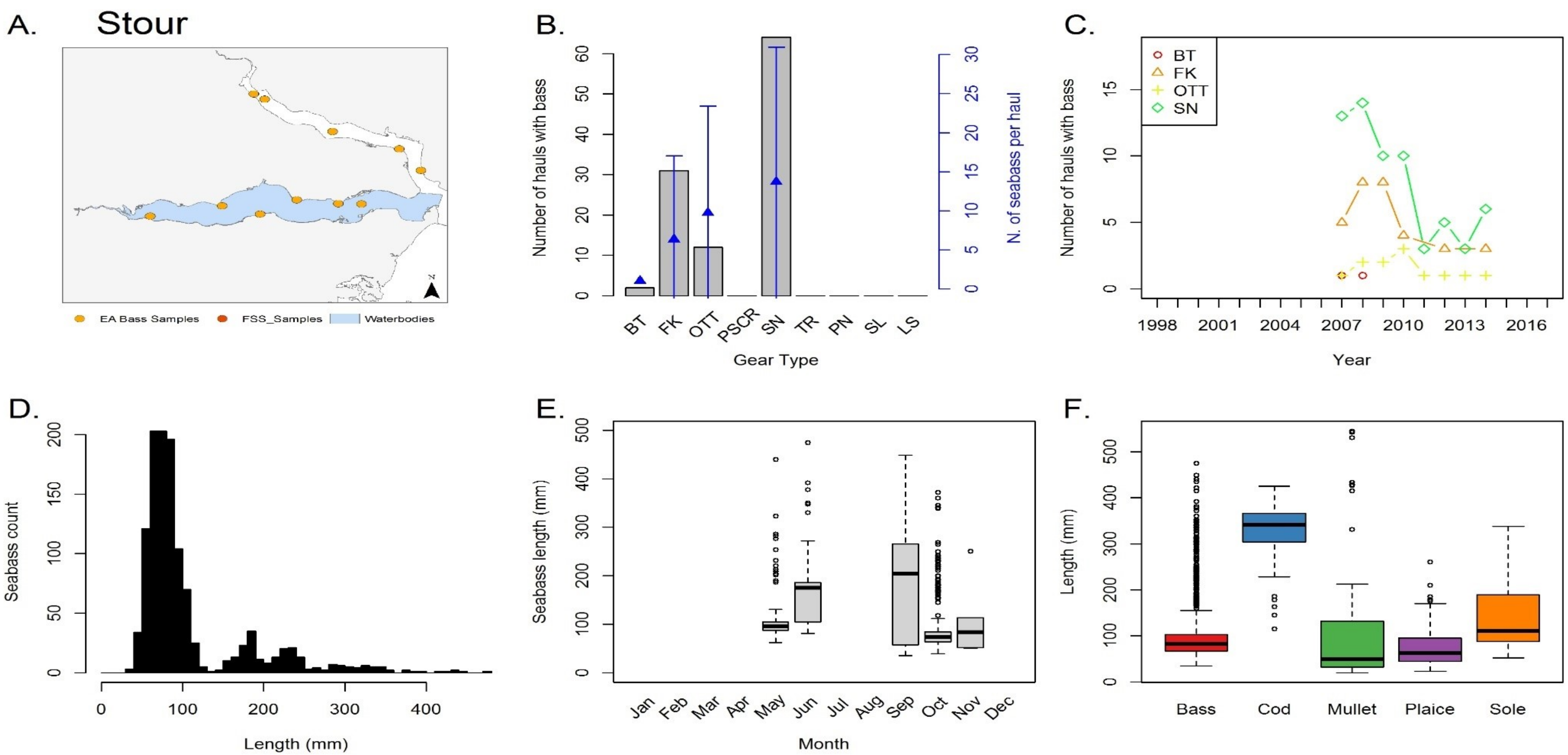

Figure 20. Assessment of the presence of sea bass and other fish in the River Stour including: the area proposed and stations sampled (A); number of samples of sea bass and number of sea bass per sample (B - BT = beam trawl, FK = fyke, LS = Larson Sprat, OTT = otter; PN = push, PSCR = power station screen, SL = Solent survey, SN = seine, TR = trammel net); number of samples by gear over time (C – codes as B); length-frequency of sea bass (D); mean length of sea bass by month (E); and length of sea bass, cod, grey mullet, plaice, and sole (F).

3.3.11. Thornham (new)

There are a number of tidal creeks on the north coast of Norfolk, comprised of small lowland rivers and large areas of draining saltmarsh and mudflats that are often bordered by sand spits (Smith and Brown, 2009). At Thornham and Titchwell twenty individuals set fixed nets for sea bass, grey mullet, and flatfish, about 12 vessels trawl for shrimps and pot for crabs, and three part-time angling boats were registered in Thornham (Walmsley and Pawson, 2007). The extensive areas of mudflats and saltmarsh are ideal habitat for juvenile sea bass, with 71 ha that includes 46 ha of saltmarsh proposed as a BNA (Table 4, Figure 7A and B, Figure 9G). No additional physical data were available, nor were surveys of fish assemblages (Table 4). In 2015, landings by under 10 m vessels from the adjacent ICES rectangle indicated that 0.4 t of sea bass were retained representing 0.1% of the catch of all species (Figure 8).

Conclusion: There were no data on the fish assemblage compiled in this study, so there is insufficient evidence at present to support the proposed BNA (Table 5). More data are required before a BNA designation could be considered.

3.3.12. Titchwell (new)

A description of the Titchwell is provided in the section on the Thornham. The extensive areas of mudflats and saltmarsh are ideal habitat for juvenile sea bass, with 20 ha that includes 13 ha of saltmarsh proposed as a BNA (Table 4, Figure 7A and B, Figure 9H). No additional physical data were available, nor were surveys of fish assemblages (Table 4). In 2015, landings by under 10 m vessels from the adjacent ICES rectangle indicated that 0.4 t of sea bass were retained representing 0.1% of the catch of all species (Figure 8).

Conclusion: There were no data on the fish assemblage compiled in this study, so there is insufficient evidence at present to support the proposed BNA (Table 5). More data are required before a BNA designation could be considered.

3.3.13. Wells (new)

There are a number of tidal creeks on the north coast of Norfolk, comprised of small lowland rivers and large areas of draining saltmarsh and mudflats that are often bordered by sand spits (Smith and Brown, 2009). At Wells, 12 vessels pot for crabs and whelks, and two vessels drift net and eight individuals set fixed nets for sea trout, sea bass, grey mullet, and flatfish in the summer (Walmsley and Pawson, 2007). The extensive areas of mudflats and saltmarsh are ideal habitat for juvenile sea bass, with 426 ha that includes 302 ha of saltmarsh proposed as a BNA (Table 4, Figure 7A and B, Figure 9I). No additional physical data were available, nor were surveys of fish assemblages (Table 4). In 2015, landings by under 10 m vessels from the adjacent ICES rectangle indicated that 0.4 t of sea bass were retained representing 0.1% of the catch of all species (Figure 8).

Conclusion: There were no data on the fish assemblage compiled in this study, so there is insufficient evidence at present to support the proposed BNA (Table 5). More data are required before a BNA derogation could be considered.

3.4. Kent and Essex

Kent and Essex IFCA currently has four existing BNAs covering the power stations at Bradwell, Grain, Kingsnorth, and Dungeness (Table 2). The proposed amendments represent new BNAs covering the Crouch and Roach, Hamford Water, and the Thames, and removal of the BNAs at Bradwell and Kingsnorth Power Stations (Table 2, Figure 5D). A summary of the Kent and Essex IFCA response to the Defra questionnaire and the evidence supporting proposed amendments are outlined in this section.

3.4.1. Summary of IFCA response

Recreational and commercial fishing for sea bass is an important activity in this district. Commercial fishing is generally by smaller inshore vessel, and recreational angling is common targeting various species including sea bass, cod, and rays. Unlicensed small-scale recreational netting is also found in the summer months. Existing BNAs were set up to provide protection for juvenile sea bass aggregating around power station outflows. There are issues with the markers for the current BNAs making enforcement difficult, so BNAs need to be related to new landmarks or defined using latitude and longitude. Changes to existing BNAs have been proposed for Bradwell and Kingsnorth as the power stations have been decommissioned. This means that no warm water is discharged, so sea bass are unlikely to aggregate in these areas and the BNAs should be removed. Recreational activity on sites can vary both from shore and boat and has generally reduced in the areas where the power station has been decommissioned. New BNAs are proposed for the Thames estuary and tributaries all year due to its importance as a fish nursery area. Evidence of the presence of sea bass can be found in the Thames Bass Survey and the presence of suitable habitats including saltmarsh. Commercial fishing is common in the Thames estuary, so the impact of additional BNAs would need to be assessed, and consultation with relevant recreational and commercial stakeholders (e.g., grey mullet fishing). Other protection is common with 70% of the district covered by at least one type of MPA, so any restriction on fishing activities for a BNA would contribute towards managing effort. Kent and Essex IFCA have also recently designated the River Medway as a fish nursery area.

3.4.2. Bradwell Power Station (no longer required)

Bradwell Power Station was situated on the River Blackwater and ceased operation in March 2002. The request for the removal of the existing BNA (Figure 9J) is based on the fact that the warm water outfall that the sea bass aggregated around is no longer present, so will not attract sea bass. No sampling data were available for the existing BNA after decommissioning, but both physical characteristics and fish assemblages were available for the Blackwater and Colne (Table 4). Detailed physical data including habitat types were available for the Blackwater and Colne systems that indicated areas of saltmarsh areas that juvenile sea bass exploit (Table 4, Figure 7A and B). Analysis showed that juvenile sea bass were caught in 48 hauls at 41 locations in surveys conducted using fyke nets, seine nets, high headline Solent bass trawl, and Larson sprat trawl during 1999-2009 (Figure 21A-C). The mean number of sea bass in the catch was up to 162 fish per haul (Figure 21B), catches contained juveniles (Figure 21D), and there was an 87% chance of catching a sea bass in a haul (Table 5). Sea bass were found between May and December and were always found during months with surveys (Figure 21E). Cod, grey mullet, plaice, and sole were also caught in the surveys, but were below the MCRS (Figure 21F). In 2015, landings by under 10 m vessels from the adjacent ICES rectangle indicated that 1.6 t of sea bass were retained representing around 2% of the catch of all species (Figure 8).

Conclusion: There is no evidence of sea bass compiled in this study for the existing Bradwell Power Station BNA, but there is good evidence for the presence of juvenile sea bass in the rest of the Blackwater. As a result, any removal of the BNA is likely to increase the pressure on sea bass, but is not related to the original protection goals. Thus, removal is supported, but a BNA for the whole of the Blackwater and Colne could be considered (Table 5).

3.4.3. Crouch and Roach (new)

The Crouch and Roach is a wide-mouthed lowland estuary with sand banks, mudflats and adjoining tidal creeks through marshland. Approximate water-filled area at low water is 12.9 km^2 with a shoreline of 126 km and tidal channels length in the region of 24 km (Smith and Brown, 2009). Charter and private angling boats targeted sea bass in summer and five full-time trawlers operated from Burnham-on-Crouch (Smith and Brown, 2009). Some netting for sea bass and grey mullet occurred in summer and drift netting for herring and sprat in winter. Green crabs were exploited and sold as angling bait (Walmsley and Pawson, 2007).

There was limited physical data for the Crouch and Roach, so no information on the habitat types in the proposed additional area was available apart from 219 ha of Saltmarsh (Table 4, Figure 7A and B). Juvenile sea bass were caught in over 72 hauls at 56 locations in surveys conducted using otter trawls, seine nets, Solent bass trawls, and Larson sprat trawls between 1999-2009 (Figure 22A-C). The mean number of sea bass in the catch was up to 372 fish per haul (Figure 22B), catches contained juveniles and adults (Figure 22D), and there was a 95% chance of catching a sea bass in a haul (Table 5). Sea bass were found between May to December and were always found in months with surveys (Figure 22E). Cod, grey mullet, plaice, and sole were also caught in the surveys, but were below the MCRS (Figure 22F). In 2015, landings by under 10 m vessels from the adjacent ICES rectangle indicated that 2 t of sea bass were retained representing 2% of the catch of all species (Figure 8).

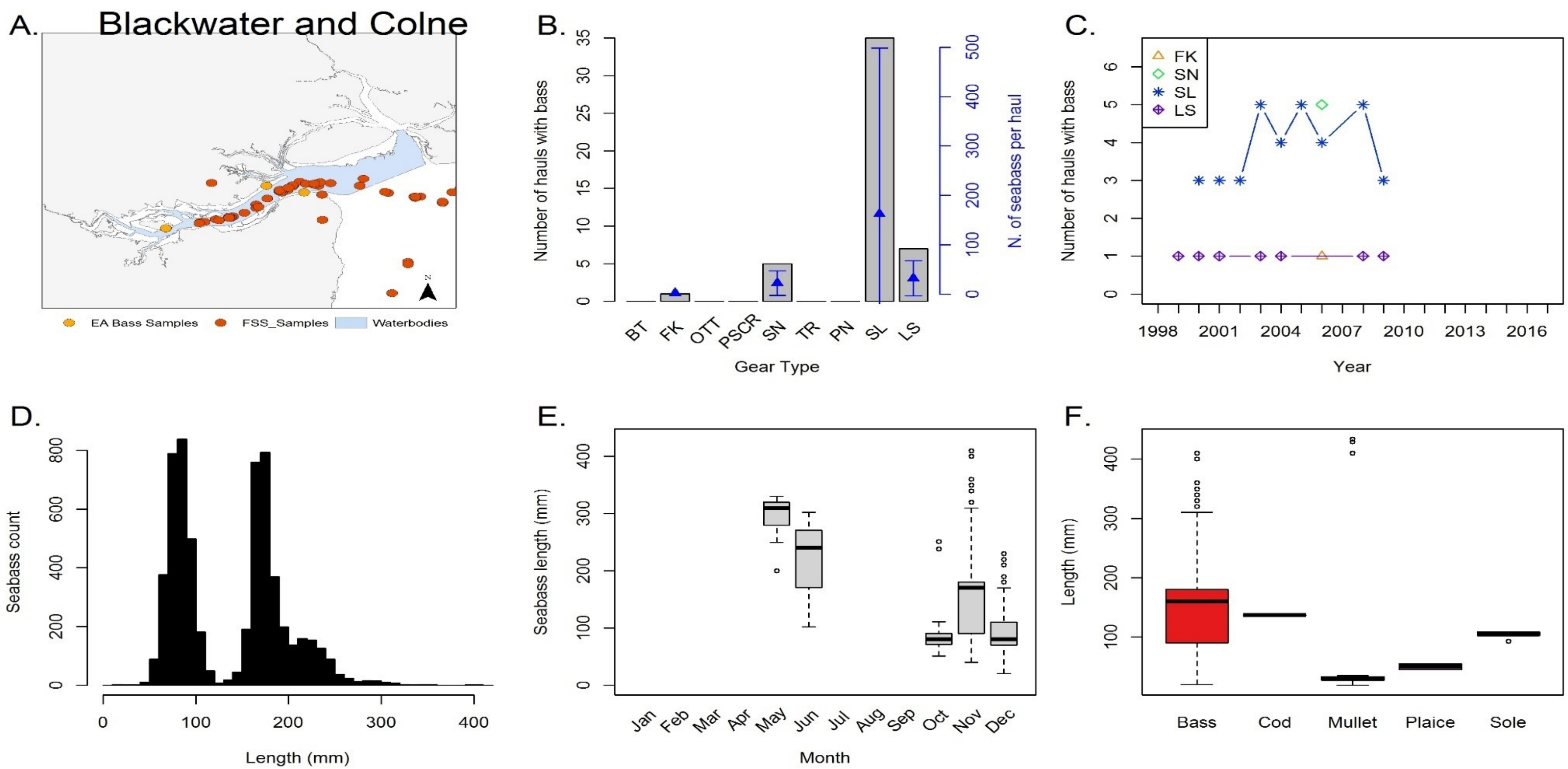

Figure 21. Assessment of the presence of sea bass and other fish in the Blackwater and Colne including: the area proposed and stations sampled (A); number of samples of sea bass and number of sea bass per sample (B - BT = beam trawl, FK = fyke, LS = Larson Sprat, OTT = otter; PN = push, PSCR = power station screen, SL = Solent survey, SN = seine, TR = trammel net); number of samples by gear over time (C – codes as B); length-frequency of sea bass (D); mean length of sea bass by month (E); and length of sea bass, cod, grey mullet, plaice, and sole (F).

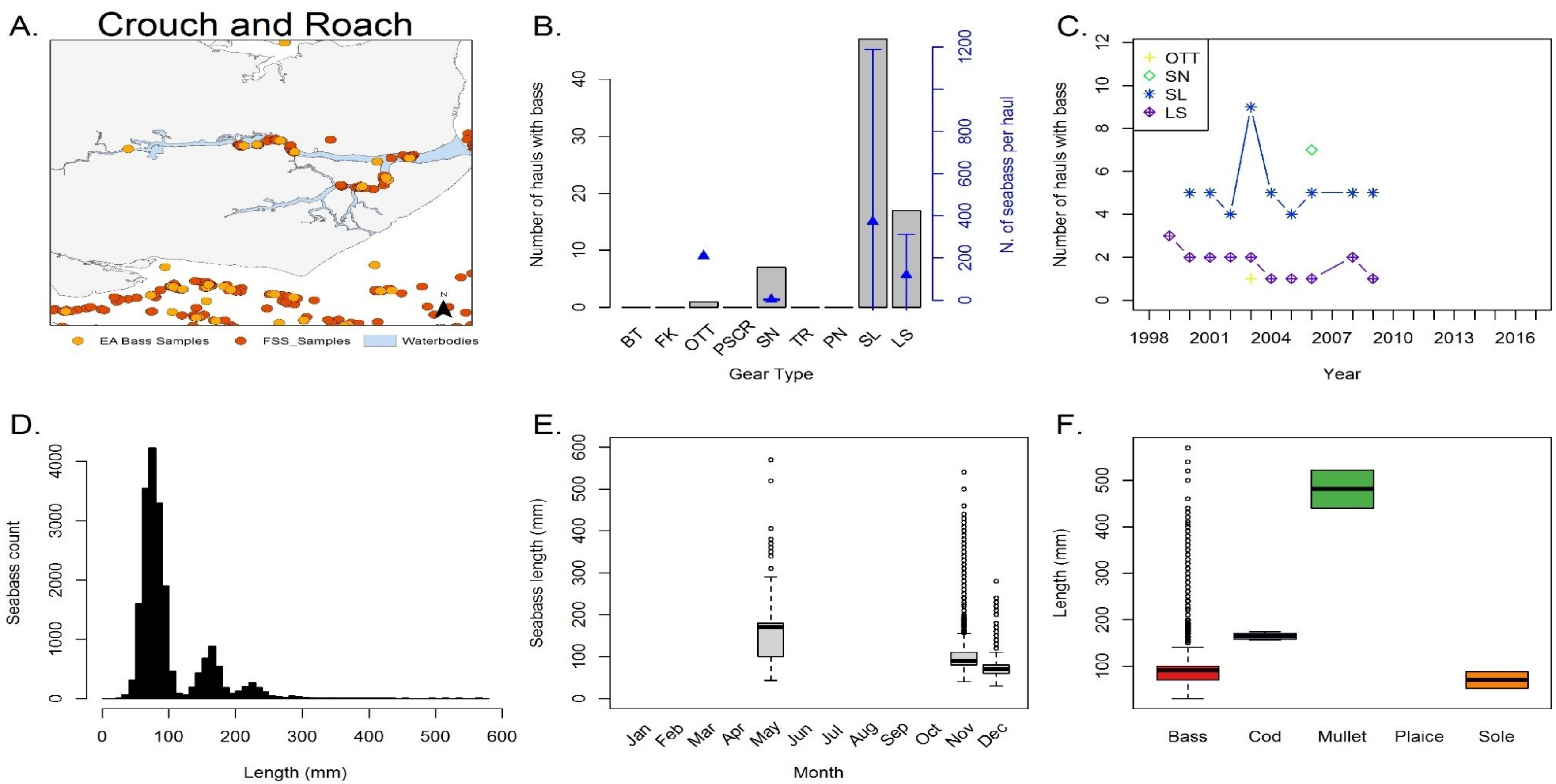

Figure 22. Assessment of the presence of sea bass and other fish in the Crouch and Roach including: the area proposed and stations sampled (A); number of samples of sea bass and number of sea bass per sample (B - BT = beam trawl, FK = fyke, LS = Larson Sprat, OTT = otter; PN = push, PSCR = power station screen, SL = Solent survey, SN = seine, TR = trammel net); number of samples by gear over time (C – codes as B); length-frequency of sea bass (D); mean length of sea bass by month (E); and length of sea bass, cod, grey mullet, plaice, and sole (F).

Conclusion: There is good evidence of juvenile sea bass from a large number of hauls and a high probability found of catching sea bass in a haul with juveniles and few fish above the MCRS (Table 5). Hence, there is evidence to support further consideration of the proposed Crouch and Roach BNA (Table 5).

3.4.4. Hamford Waters (new)

Hamford Waters is an area of tidal creeks, mudflats, islands, saltmarshes, and marsh grounds. Approximate water filled area at low water is 2.3 km^2 with a shoreline of 54 km and main tidal channel length in the region of 5 km (Smith and Brown, 2009). No information on recreational angling was available, but two part-time vessels fished regularly in the area using net and pots (Walmsley and Pawson, 2007).

There was no physical data, and the area and saltmarsh was calculated from the shapefile (Table 4, Figure 7A and B). Juvenile sea bass were caught in eight hauls at one location in surveys conducted using otter trawls during 2007-14 (Figure 23A-C). The mean number of sea bass in the catch was 15 fish per haul (Figure 23B), contained juveniles and adults (Figure 23D), and there was an 80% chance of catching a sea bass in a haul (Table 5). Sea bass were found between September to October and were found in all months where there was a survey apart from November (Figure 23E). Cod, plaice, and sole were also caught in the surveys, with some fish above the MCRS (Figure 23F). In 2015, landings by under 10 m vessels from the adjacent ICES rectangle indicated that 52 t of sea bass were retained representing 9% of the catch of all species (Figure 8).

Conclusion: There is moderate evidence of juvenile sea bass from a small number of hauls and a high probability of catching sea bass in a haul with mainly juveniles caught, but also some fish above the MCRS (Table 5). Hence, there is evidence to support further consideration of the proposed Hamford Waters BNA (Table 5).

3.4.5. Kingsnorth Power Station (no longer required)

Kingsnorth Power Station was situated on the River Medway and ceased operation in 2012. The request for the removal of the existing BNA (Figure 9K) is based on the fact that the warm water outfall that the sea bass aggregated around is no longer present, so will not attract sea bass. No sampling data were available from the existing BNA since the power station had been decommissioned, but both physical characteristics and fish assemblages were available for the Medway. Detailed physical data including habitat types were available for the Medway that indicated areas of saltmarsh areas that juvenile sea bass exploit (Table 4, Figure 7A and B). Juvenile sea bass were caught in 113 hauls at 49 locations in surveys conducted using otter trawls, seine nets, high headline Solent bass trawl, and Larson sprat trawl during 1998-2014 (Figure 24A-C). The mean number of sea bass in the catch was up to 1,013 fish per haul (Figure 24B), catches contained juveniles and adults (Figure 24D), and there was around 63% chance of catching a sea bass in a haul (Table 5). Sea bass were found between May and December and were always found in months with a survey (Figure 24E). Cod, grey mullet, plaice, and sole were also caught in the surveys, including some above the MCRS (Figure 24F). In 2015, landings by under 10 m vessels from the adjacent ICES rectangle indicated that 0.5 t of sea bass were retained representing 0.2% of the catch of all species (Figure 8).

Conclusion: There is no evidence of sea bass compiled in this study for the existing Kingsnorth Power Station BNA, but there is good evidence for the presence of juvenile sea bass in the rest of the Medway. As a result, any removal of the BNA is likely to increase the pressure on sea bass, but is not related to the original protection goals. Thus, removal is supported, but a BNA for the whole of the Medway that adds to the existing designation area could be considered (Table 5).

3.4.6. Thames (new)

The Thames estuary is a wide-mouthed lowland estuary with sand banks, mudflats and adjoining tidal creeks through marshland, and is highly urbanised in inner reaches. Approximate water-filled area at low water is 49 km^2 with a shoreline of 148 km and tidal channels length in the region of 50 km (Smith and Brown, 2009). The level of angling activity in the area was not quantified, but likely to be substantial given the high population and relatively sheltered waters. Trawlers and cockle dredgers dominated the fishing fleet based along the north side of the Thames Estuary, with otter trawlers operating from Southend, trawlers operating from Lea-on-Sea and Holehaven, and netters using gill and trammel nets. Sole, sprat, herring, and whiting were targeted. Vessels used gill and trammel nets for sea bass, grey mullet, sole, rays and cod, and set fyke nets for eel (Walmsley and Pawson, 2007). No trawling is permitted by byelaw above Coalhouse Point and sea angling from the shore is important at specific locations such as Southend, Denton (Gravesend), Grays, Greenhithe, Erith and Thamesmead. There is no sea angling above Greenwich. Sea bass juveniles penetrate in large numbers as far as Richmond in most years (Colclough *et al.*, 2002). Detailed physical data including habitat types were available for the Thames that indicated areas of saltmarsh areas that juvenile sea bass exploit (Table 4, Figure 7A and B). Due to the size of the estuary and the survey data available the Thames estuary was split into three areas for the purpose of this assessment – lower, middle, and upper (Table 4).

3.4.6.1. Thames lower

The lower Thames represents around 81% of the total area of the Thames Estuary (Table 4, Figure 7A) and is likely to contain the majority of the fishing effort. Juvenile sea bass were caught in 171 hauls at 130 locations in surveys conducted using beam trawls, otter trawls, seine nets, high headline beam trawls, and Larson Sprat trawls during 1998-2014 (Figure 25A-C). The mean number of sea bass in the catch was up to 170 fish per haul (Figure 25B), catches contained juveniles and adults (Figure 25D), and there was an 87% chance of catching a sea bass in a haul (Table 5). Bass were found between May and December and were found in all months with a survey (Figure 25E). Cod, grey mullet, plaice, and sole were also caught in the surveys, including some above the MCRS (Figure 25F). In 2015, landings by under 10 m vessels from the adjacent ICES rectangle indicated that 2 t of bass were retained representing around 0.7% of the catch of all species (Figure 8).

Conclusion: There is good evidence of juvenile sea bass from a large number of hauls and a high probability of catching sea bass in a haul with juveniles found, with some fish above the MCRS (Table 5). Hence, there is evidence to support further consideration of the proposed lower Thames BNA (Table 5).

3.4.6.2. Thames middle

The middle Thames represents around 18% of the total area of the Thames Estuary (Table 4, Figure 7A) Juvenile sea bass were caught in 190 hauls at 39 locations in surveys conducted using beam trawls, otter trawls, seine nets, high headline beam trawls, and Larson Sprat trawls during 1998-2014 (Figure 26A-C). The mean number of sea bass in the catch was up to 253 fish per survey (Figure 26B), catches contained juveniles and adults (Figure 26D), and there was a 58% chance of catching a sea bass in a haul (Table 5). Sea bass were found between May and December and were always found in months with surveys (Figure 26E). Cod, grey mullet, plaice, and sole were also caught in the surveys, including some above the MCRS (Figure 26F). In 2015, landings by under 10 m vessels from the adjacent ICES rectangle indicated that 2 t of sea bass were retained representing 0.7% of the catch of all species (Figure 8).

Conclusion: There is good evidence of juvenile sea bass from a large number of hauls and a high probability of catching sea bass in a haul with juveniles found, plus some fish above the MCRS (Table 5). Hence, there is evidence to support further consideration of the proposed middle Thames BNA (Table 5).

3.4.6.3. Thames upper

The upper Thames represents around 1% of the total area of the Thames Estuary (Table 4, Figure 7A). Juvenile sea bass were caught in 90 hauls at five locations in surveys conducted using beam trawls and seine nets during 1998-2014 (Figure 27A-C). The mean number of sea bass in the catch was up to 15 fish per haul (Figure 27B), catches contained juveniles (Figure 27D), and there was around 27% chance of catching a sea bass in a haul (Table 5). Sea bass were found between June and November and were caught in all months with surveys (Figure 27E). Grey mullet were also caught in the surveys (Figure 27F). There was no ICES rectangle adjacent to the upper Thames, so landings by under 10 m vessels were assumed to be negligible.

Conclusion: There is moderate evidence of juvenile sea bass from a large number of hauls and a moderate probability of catching sea bass in a haul with juveniles found and no fish above the MCRS (Table 5). Hence, there is evidence to support further consideration of the proposed upper Thames BNA (Table 5).

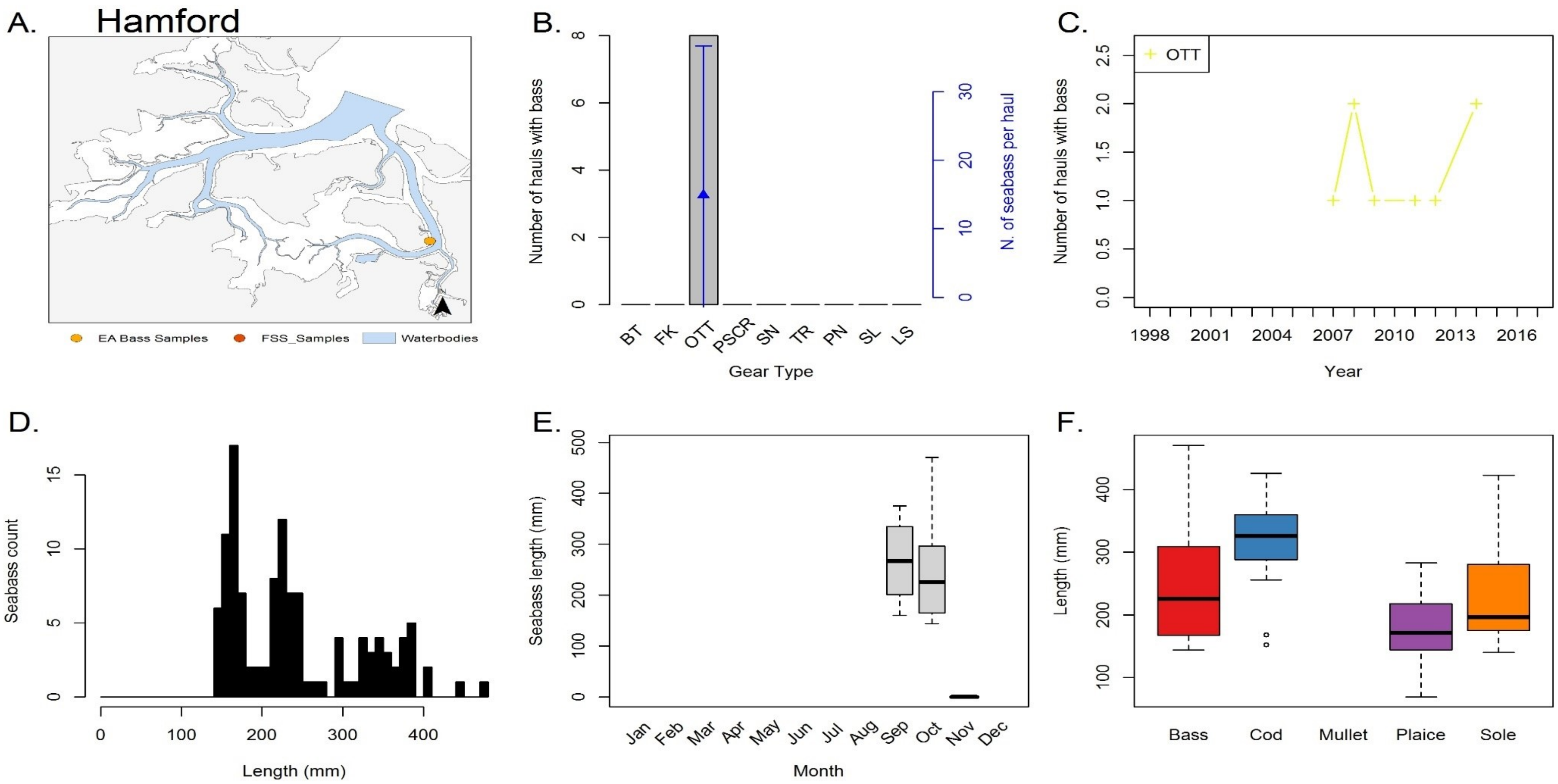

Figure 23. Assessment of the presence of sea bass and other fish in Hamford Water including: the area proposed and stations sampled (A); number of samples of sea bass and number of sea bass per sample (B - BT = beam trawl, FK = fyke, LS = Larson Sprat, OTT = otter; PN = push, PSCR = power station screen, SL = Solent survey, SN = seine, TR = trammel net); number of samples by gear over time (C – codes as B); length-frequency of sea bass (D); mean length of sea bass by month (E); and length of sea bass, cod, grey mullet, plaice, and sole (F).

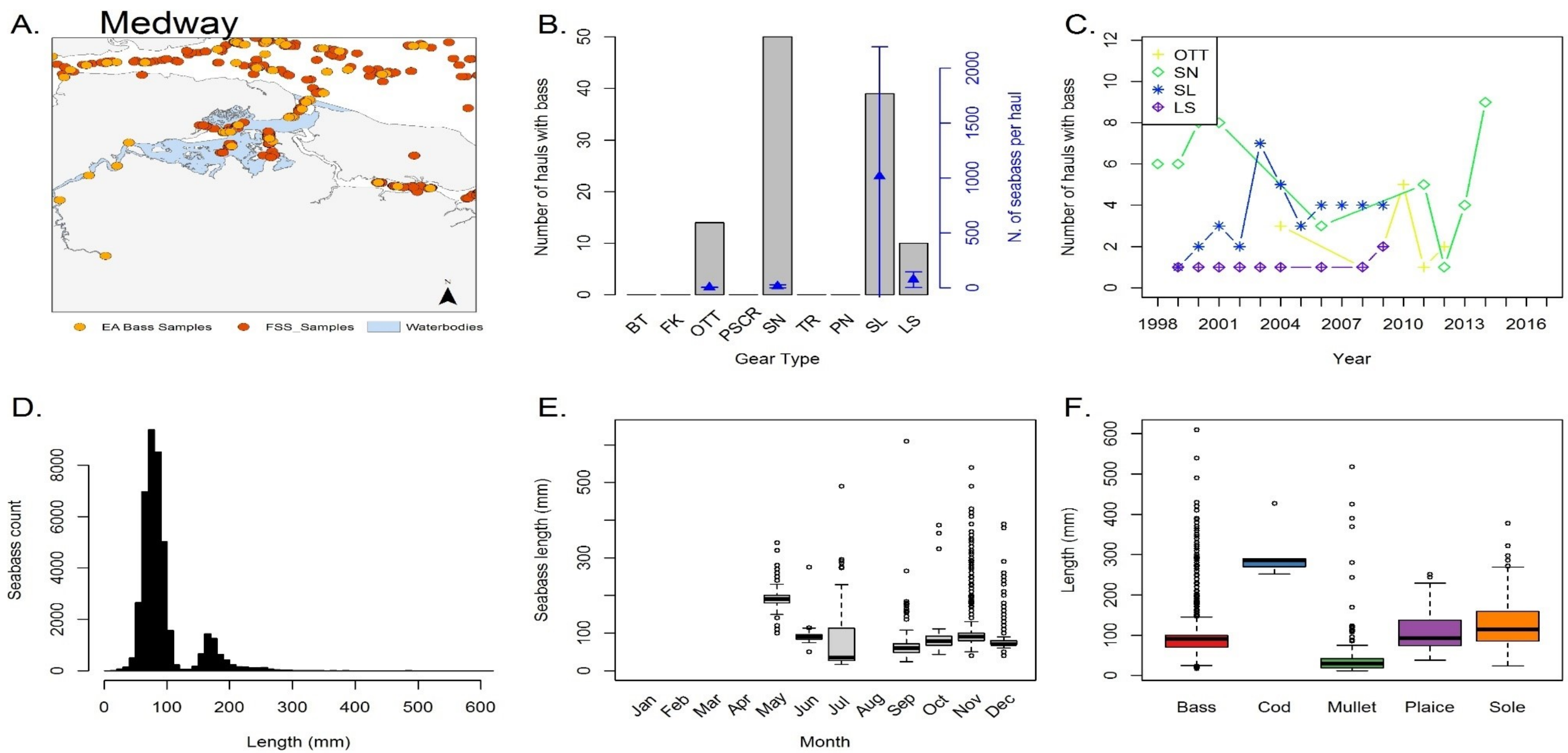

Figure 24. Assessment of the presence of sea bass and other fish in the River Medway including: the area proposed and stations sampled (A); number of samples of sea bass and number of sea bass per sample (B - BT = beam trawl, FK = fyke, LS = Larson Sprat, OTT = otter; PN = push, PSCR = power station screen, SL = Solent survey, SN = seine, TR = trammel net); number of samples by gear over time (C – codes as B); length-frequency of sea bass (D); mean length of sea bass by month (E); and length of sea bass, cod, grey mullet, plaice, and sole (F).

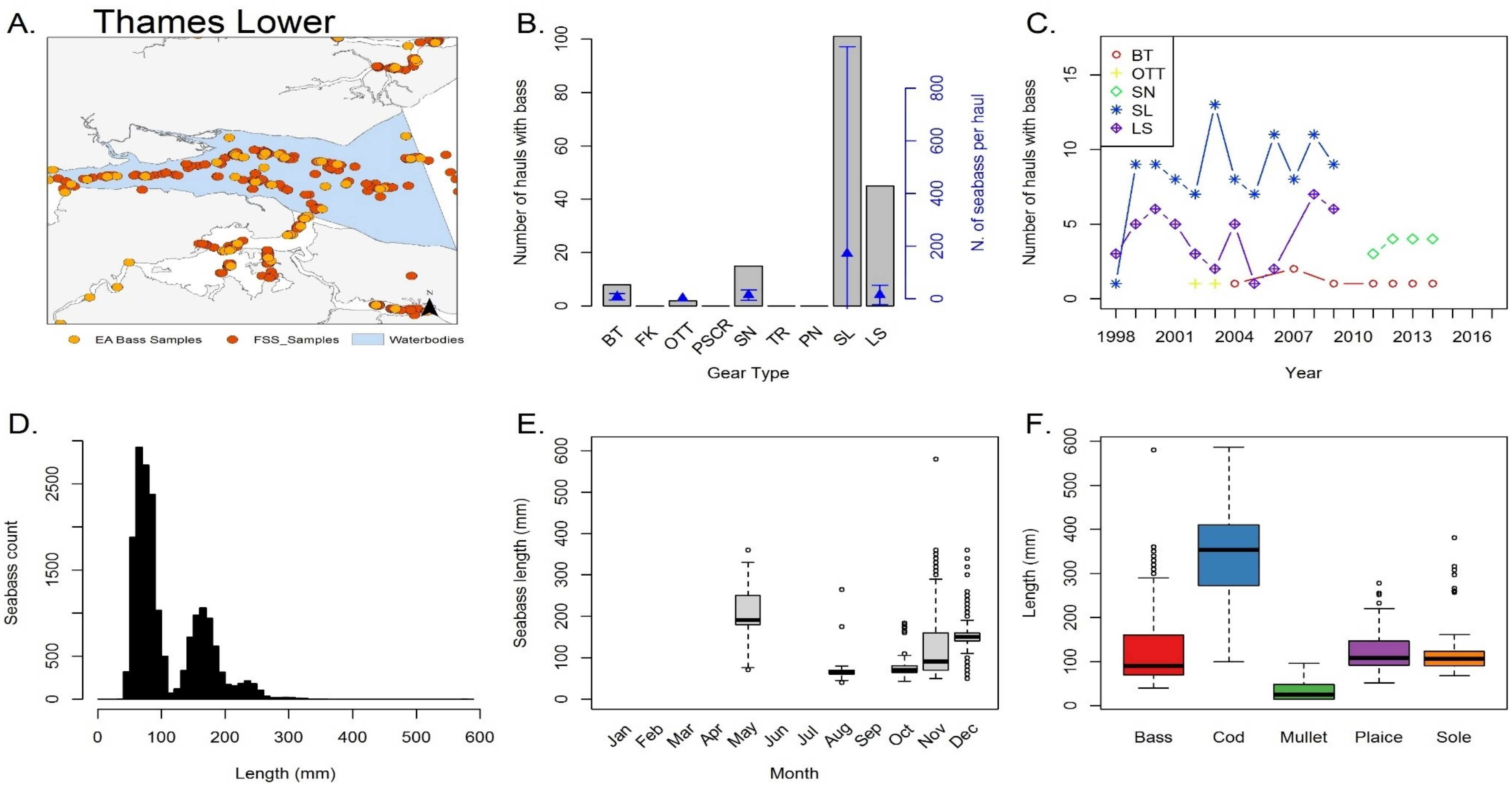

Figure 25. Assessment of the presence of sea bass and other fish in the lower River Thames including: the area proposed and stations sampled (A); number of samples of sea bass and number of sea bass per sample (B - BT = beam trawl, FK = fyke, LS = Larson Sprat, OTT = otter; PN = push, PSCR = power station screen, SL = Solent survey, SN = seine, TR = trammel net); number of samples by gear over time (C – codes as B); length-frequency of sea bass (D); mean length of sea bass by month (E); and length of sea bass, cod, grey mullet, plaice, and sole (F).

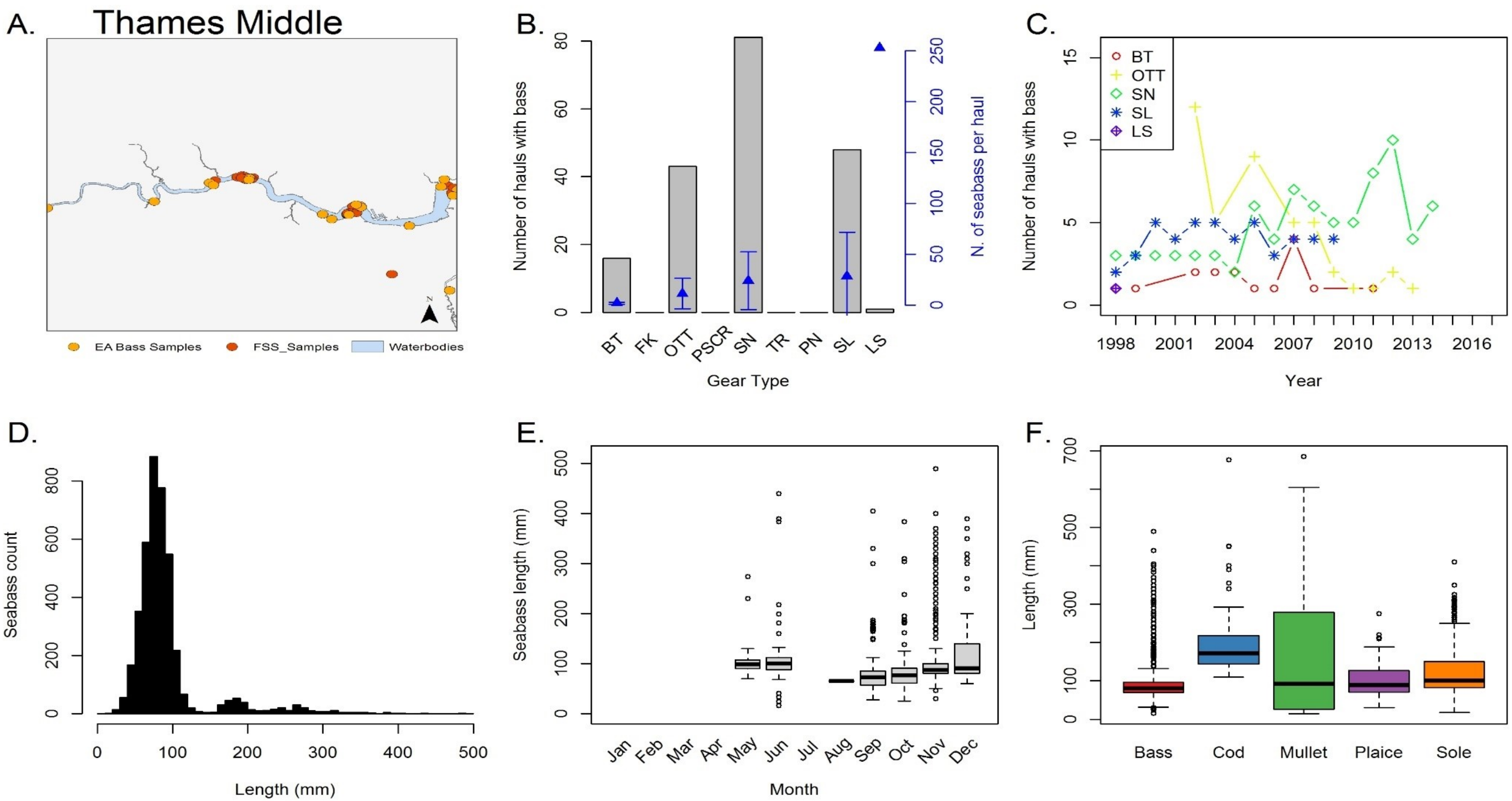

Figure 26. Assessment of the presence of sea bass and other fish in the middle River Thames including: the area proposed and stations sampled (A); number of samples of sea bass and number of sea bass per sample (B - BT = beam trawl, FK = fyke, LS = Larson Sprat, OTT = otter; PN = push, PSCR = power station screen, SL = Solent survey, SN = seine, TR = trammel net); number of samples by gear over time (C – codes as B); length-frequency of sea bass (D); mean length of sea bass by month (E); and length of sea bass, cod, grey mullet, plaice, and sole (F).

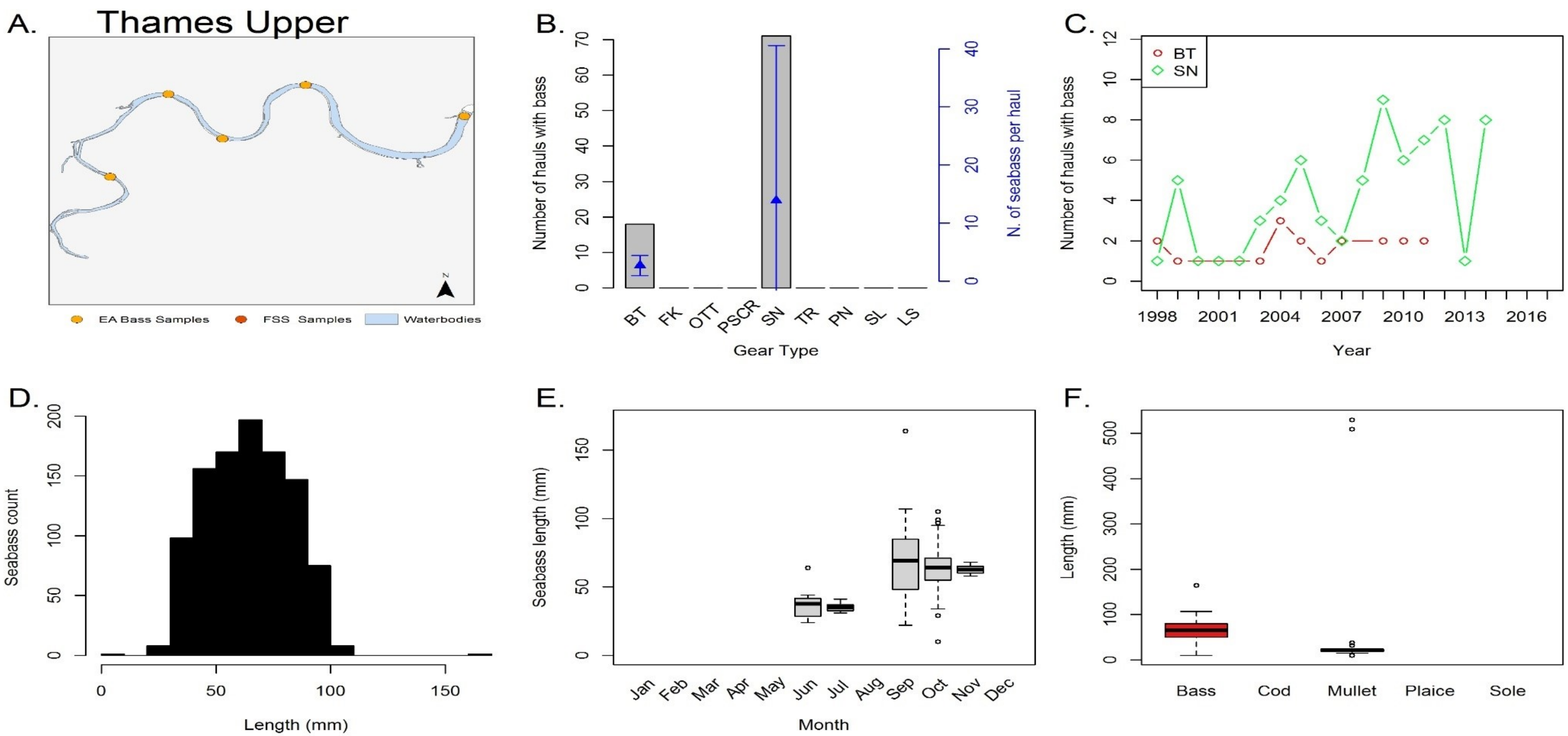

Figure 27. Assessment of the presence of sea bass and other fish in the upper River Thames including: the area proposed and stations sampled (A); number of samples of sea bass and number of sea bass per sample (B - BT = beam trawl, FK = fyke, LS = Larson Sprat, OTT = otter; PN = push, PSCR = power station screen, SL = Solent survey, SN = seine, TR = trammel net); number of samples by gear over time (C – codes as B); length-frequency of sea bass (D); mean length of sea bass by month (E); and length of sea bass, cod, grey mullet, plaice, and sole (F).

3.5. North Eastern

North Eastern IFCA has no existing BNAs, but has proposed amendments to cover the Humber estuary (Table 2, Figure 5E). A summary of the North Eastern IFCA response to the Defra questionnaire and the evidence supporting proposed amendments are outlined in this section.

3.5.1. Summary of IFCA response

There are currently no BNAs in the North Eastern IFCA district, but there is growing evidence of a targeted sea bass fishery in the Humber estuary so should be considered for designation as a BNA. Numerous recreational catch reports are available online and anecdotal information from local operators indicate that juvenile sea bass shoal in proximity to the sea forts at Haile Sands and Bull Sands. Catches from some commercial operators targeting sea bass in the Holderness region indicate a seasonal run of large individuals moving northwards from the Humber mouth area, and there is anecdotal evidence of a seasonal aggregation of sea bass at Flamborough Head. Anecdotal evidence from commercial fishers also indicated high concentrations of juvenile sea bass in the Spurn Bight area towards the flat beaches and mud runnels at Kilnsea. As water quality improves and water temperature increases, it is likely that the Humber estuary will become increasingly important for juvenile sea bass and a targeted baseline assessment should be done to determine the seasonal abundance and distribution of sea bass. Evidence is limited at presence and much of it is anecdotal. However, sampling is done by the EA to support WFD and small-scale surveys have been done within the estuary in 2015 using beach seine and small beam trawls. If considered suitable for designation as a BNA, for ease of designation and implementation, the BNA should be aligned with the current EMS seaward boundaries, to a landward boundary of the Humber Bridge. The Humber estuary is also an EMS with SAC and SPA designations, so a BNA could provide further protection to conservation features.

The Humber is recognised as a national angling venue with numerous marks throughout the lower estuary and estuary mouth, and is thought to bring significant economic benefits to the region. Angling occurs throughout the year, with seasonal variations in target species. Multiple shore angling clubs and match syndicates operate in the estuary. Several dedicated recreational vessels operate from various launches. Commercial fishing also occurs in the Humber with shrimp trawling using fine mesh trawls in proximity to the Haile Sands, with the potential for incidental capture and mortality of sea bass. One demersal trawler also operates within the estuary and Humber mouth with displacement due to BNA designation likely to have significant impact on viability. A full impact assessment and consultation with stakeholders would be necessary before designation.

3.5.2. Humber estuary (new)

The Humber estuary is a large tidal estuary that is an important area for recreational sea angling and commercial fishing. Fyke nets were set for eels, nets were used to catch salmon and sea trout, and beam trawls used to catch shrimp, and there were inshore boats based in Hull and Grimsby (Walmsley and Pawson, 2007). Detailed physical data including habitat types were available for the Humber that indicated areas of saltmarsh areas that juvenile sea bass exploit (Table 4, Figure 7A and B). Due to the size of the estuary and the survey data available the Humber was split into three areas for the purpose of this assessment – lower, middle, and upper (Figure 4).

3.5.2.1. Humber lower

The lower Humber represents around 76% of the total area of the Humber Estuary (Table 4, Figure 7A) and is likely to contain the majority of the fishing effort. Juvenile sea bass were caught in 17 hauls at four locations in surveys conducted using seine nets during 2003-14 (Figure 28A-C). The mean number of sea bass in the catch was three fish per haul (Figure 28B), catches contained juveniles (Figure 28D), and there was a 6% chance of catching a sea bass in a haul (Table 5). Sea bass were found between May and October, but were not found in surveys done in July, August, and November (Figure 28E). Cod, grey mullet, plaice, and sole were also caught in the surveys, including some above the MCRS (Figure 28F). In 2015, landings by under 10 m vessels from the adjacent ICES rectangle indicated that 2 t of sea bass were retained representing 0.1% of the catch of all species (Figure 8).

Conclusion: There is limited evidence of juvenile sea bass from a moderate number of hauls and a low probability of catching sea bass in a haul with juveniles found, but some fish above the MCRS (Table 5). Hence, there is insufficient evidence at present to support the proposed upper Humber BNA. More data are required before a BNA designation could be considered.

3.5.2.2. Humber middle

The middle Humber represents around 20% of the total area of the Humber Estuary (Table 4, Figure 7A). Juvenile sea bass were caught in 10 hauls at three locations in surveys conducted using seine nets during 2011-14 (Figure 29A-C). The mean number of sea bass in the catch was two fish per haul (Figure 29B), catches contained juveniles (Figure 29D), and there was a 7% chance of catching a sea bass in a haul (Table 5). Sea bass were found between May and October, but were not found in surveys done in July, August, and November (Figure 29E). Cod, grey mullet, plaice, and sole were also caught in the surveys, but were generally below the MCRS (Figure 29F). There was no ICES rectangle adjacent to the upper Humber, so landings by under 10 m vessels were assumed to be negligible.

Conclusion: There is limited evidence of juvenile sea bass from a small number of hauls and a low probability of catching sea bass in a haul with juveniles found, but fish generally below the MCRS (Table 5). Hence, there is insufficient evidence at present to support the proposed upper Humber BNA. More data are required before a derogation could be considered.

3.5.2.3. Humber upper

The upper Humber represents around 4% of the total area of the Humber estuary (Table 4, Figure 7A). Juvenile sea bass were caught in seven hauls at two locations in surveys conducted using seine nets during 2006-14 (Figure 30A-C). The mean number of sea bass in the catch was around one fish per haul (Figure 30B), catches contained juveniles (Figure 30D), and there was around 8% chance of catching a sea bass in a haul (Table 5). Sea bass were found in September and were always found in months with surveys (Figure 30E). Plaice were also caught in the surveys, but were below the MCRS (Figure 30F). There was no ICES rectangle adjacent to the upper Humber, so landings by under 10 m vessels were assumed to be negligible.

Conclusion: There is limited evidence of juvenile sea bass from a small number of hauls and a low probability of catching sea bass in a haul with juveniles found, but fish generally below the MCRS (Table 5). Hence, there is insufficient evidence at present to support the proposed upper Humber BNA. More data are required before a derogation could be considered.

3.6. North Western

North Western IFCA has one BNA at Heysham Power Station and borders the existing BNA for the River Dee (Table 2, Figure 5F). No amendments were proposed as no data are available on the presence of sea bass in North Western Rivers. As sea bass move northwards, it is likely that rivers in the north west will become more important for juvenile sea bass in future. The IFCA are planning to start small fish surveys and hope to build a data set that will assist in providing evidence for any new areas requiring protection in future.

3.7. Northumberland

Northumberland IFCA has proposed the removal of the existing BNA within their district at Blyth Power Station (Table 2, Figure 5G). A summary of the Northumberland IFCA response to the Defra questionnaire and the evidence supporting proposed amendments are outlined in this section.

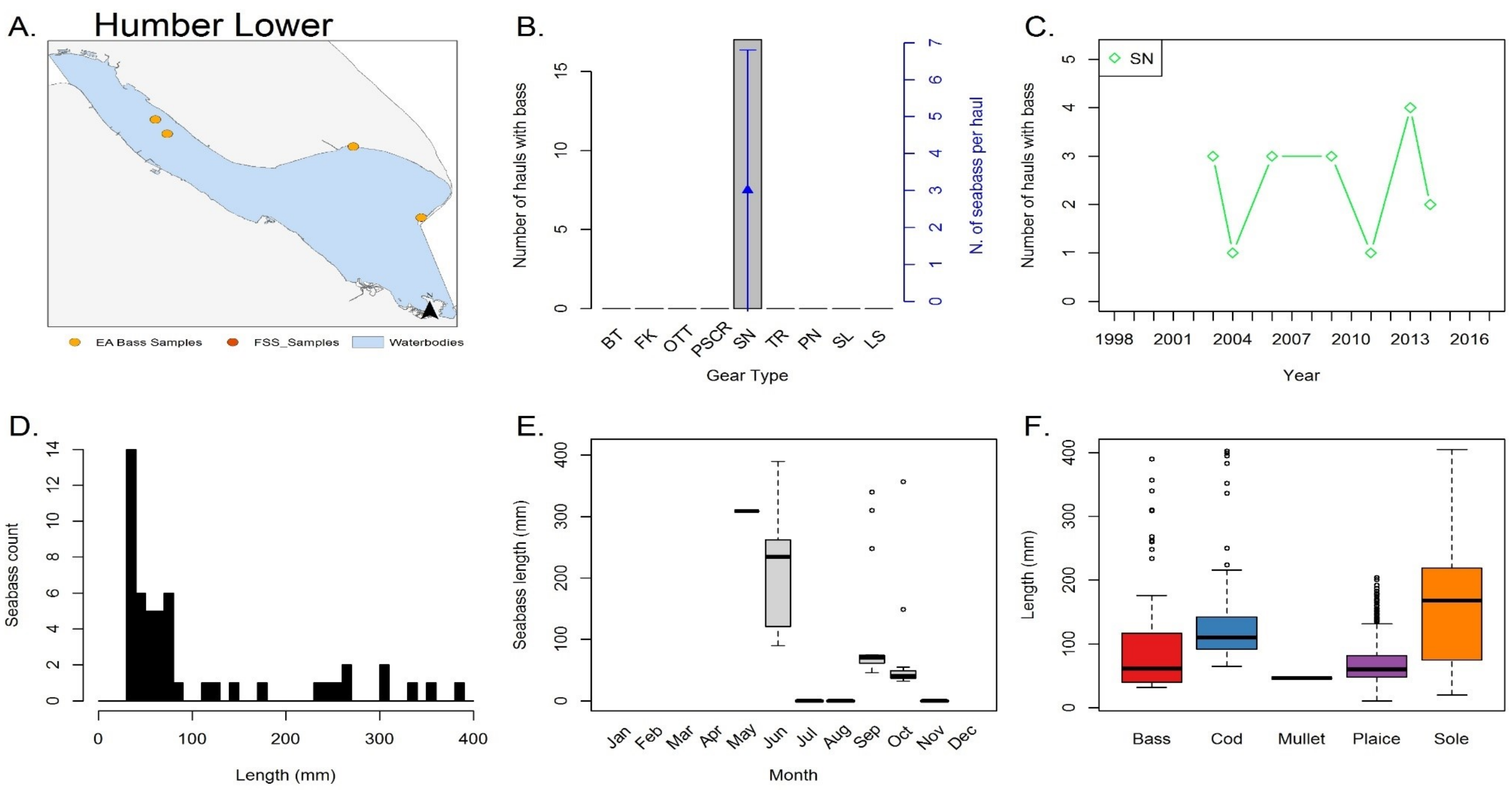

Figure 28. Assessment of the presence of sea bass and other fish in the lower River Humber including: the area proposed and stations sampled (A); number of samples of sea bass and number of sea bass per sample (B - BT = beam trawl, FK = fyke, LS = Larson Sprat, OTT = otter; PN = push, PSCR = power station screen, SL = Solent survey, SN = seine, TR = trammel net); number of samples by gear over time (C – codes as B); length-frequency of sea bass (D); mean length of sea bass by month (E); and length of sea bass, cod, grey mullet, plaice, and sole (F).

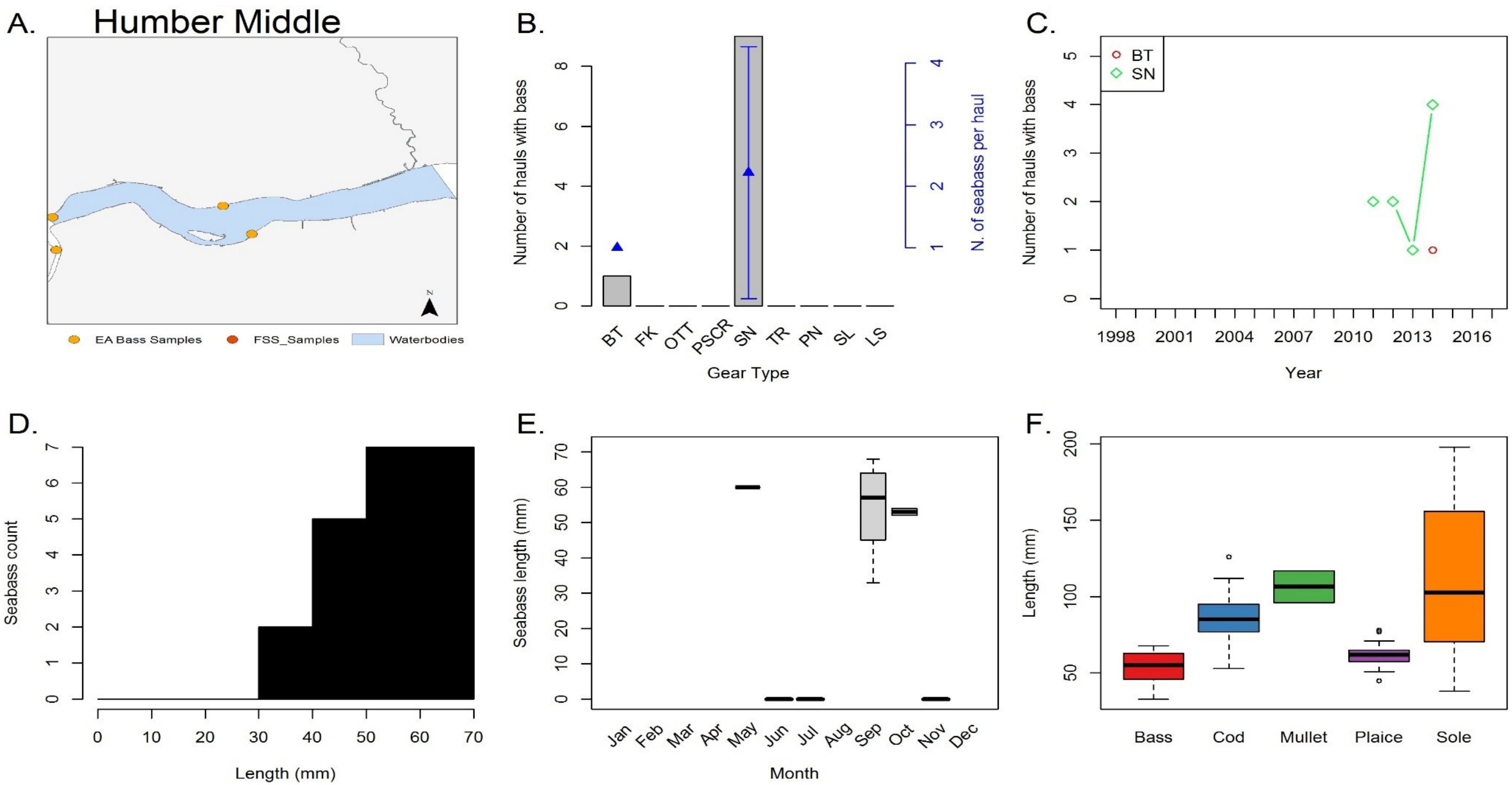

Figure 29. Assessment of the presence of sea bass and other fish in the middle River Humber including: the area proposed and stations sampled (A); number of samples of sea bass and number of sea bass per sample (B - BT = beam trawl, FK = fyke, LS = Larson Sprat, OTT = otter; PN = push, PSCR = power station screen, SL = Solent survey, SN = seine, TR = trammel net); number of samples by gear over time (C – codes as B); length-frequency of sea bass (D); mean length of sea bass by month (E); and length of sea bass, cod, grey mullet, plaice, and sole (F).

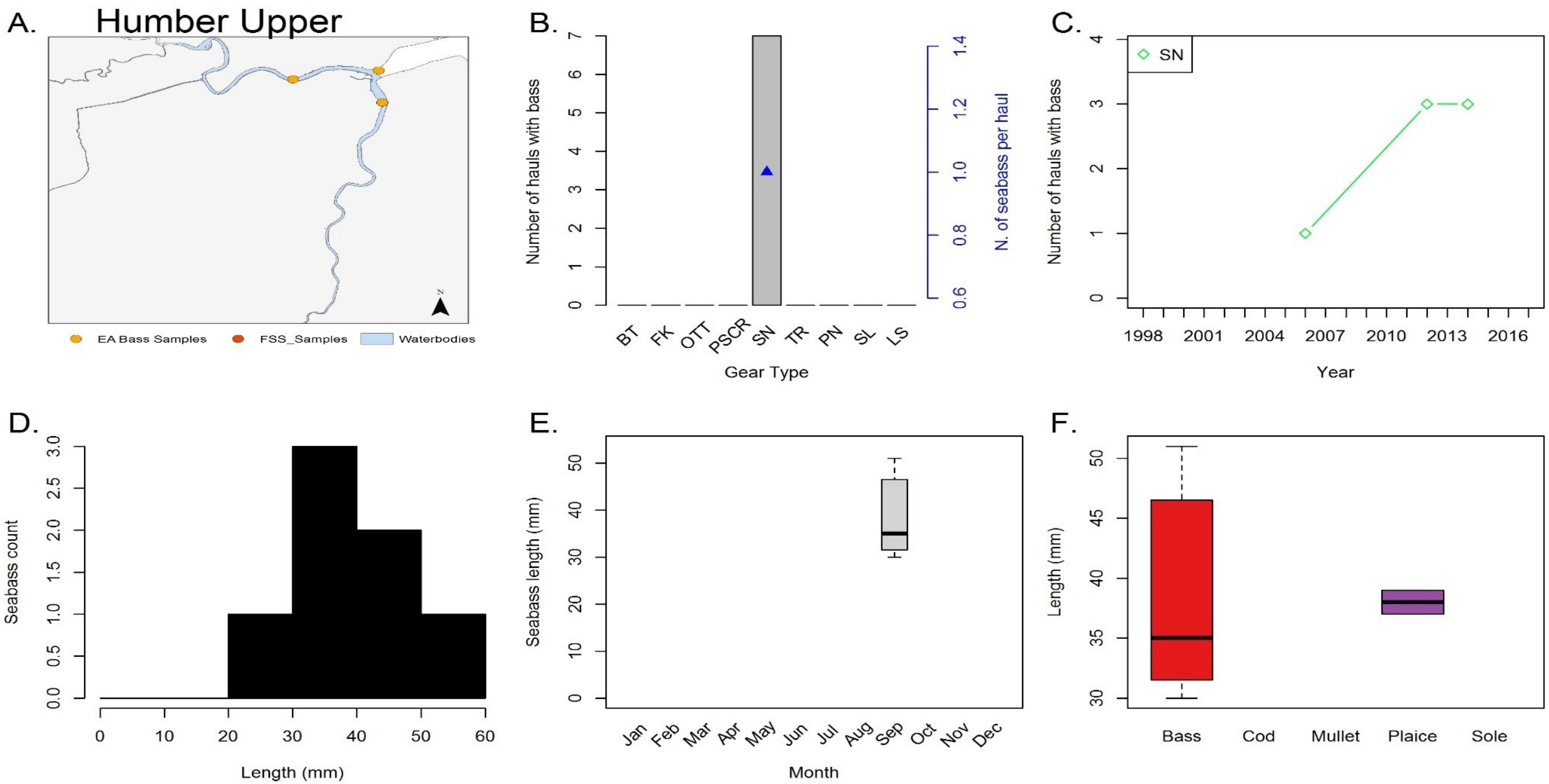

Figure 30. Assessment of the presence of sea bass and other fish in the upper River Humber including: the area proposed and stations sampled (A); number of samples of sea bass and number of sea bass per sample (B - BT = beam trawl, FK = fyke, LS = Larson Sprat, OTT = otter; PN = push, PSCR = power station screen, SL = Solent survey, SN = seine, TR = trammel net); number of samples by gear over time (C – codes as B); length-frequency of sea bass (D); mean length of sea bass by month (E); and length of sea bass, cod, grey mullet, plaice, and sole (F).

3.7.1. Summary of IFCA response

There is only one BNA in the Northumberland IFCA at Blyth Power Station, where fishing was restricted around the warm water outflow pipe in the area where sea bass were known to aggregate. Commercial fishers were not able to set static gillnets close to the outfall pipe, although fishermen were allowed to trawl as long as any sea bass caught whilst inside the area were not retained. The power station ceased production in 2001 and the warm water outfall pipe was demolished, and no commercial or recreational fishers are now seen in the area. The towers that were markers for the BNA have been demolished, so there is no longer clear demarcation of the area. Very few sea bass are caught within the NIFCA district as it is close to the northern limit of the species, and only found as very limited bycatch by commercial fishers using beach nets in the summer to target salmon and sea trout. Given that there is now limited recreational and commercial activity in this area, confusion over the location, and the removal of the feature that caused the aggregation of sea bass, the Blyth Power Station BNA should be revoked.

3.7.2. Blythe Power Station (no longer required)

Blyth Power Station is situated on the River Blyth and ceased operation in 2001. The request for the removal of the existing BNA (Figure 9L) is based on the fact that the warm water outfall that the sea bass aggregated around is no longer present, so swill not attract sea bass. No sampling data were available from the existing BNA or the River Blyth, with only summary physical characteristics available for the whole of the River Blyth estuary (Table 4, Figure 7A). In 2015, landings by under 10 m vessels from the adjacent ICES rectangle indicated that less than 1 t of sea bass were retained representing less than 1% of the catch of all species (Figure 8).

Conclusion: There is no evidence compiled in this study to support the presence of sea bass in this area and is not related to the original protection goals, so the removal of Blyth Power Station BNA is supported (Table 5).

3.8. Southern

Southern IFCA currently has seven existing BNAs covering Chichester Harbour, Fawley Power Station, Langstone Harbour, Poole Harbour, Portsmouth Harbour, Southampton Water, and the Fleet (Table 2, Figure 5H). The proposed amendments represent new BNAs covering Beaulieu, Christchurch Harbour, Keyhaven, Lymington, Medina, Portland Harbour, Wootton Creek, and the River Yar at Bembridge (Table 2, Figure 5H). A summary of the Southern IFCA response to the Defra questionnaire and the evidence supporting proposed amendments are outlined in this section.

3.8.1. Summary of IFCA response

Sea bass are an important recreational and commercial species in the Southern IFCA district. The current BNAs are thought to play an important role in reducing exploitation activities likely to take juvenile sea bass in areas where most fish are juvenile and below the MCRS. A balanced approach to protecting juveniles coupled with the MCRS is important for management as it deters illegal harvest of juvenile fish, reduces pressure in certain inshore areas, and enables a recreational fishery. Protection all year round would also increase the value of the BNAs, but there is no scientific study of the impact of BNAs on the overall stock levels or resilience.

BNAs in the Southern IFCA district have restricted the commercial fishery, but have enabled the continuation of a recreational fishery. The impact of the BNA is that the inshore commercial and recreational fishermen have reduced access to the fish above the MCRS, an impact which will be particularly acute for fishery participants whose home or port is within or adjacent to the nursery. Recreational fishing in BNAs is extensive from both shore and from boats, with sheltered waters and proximity to urban areas meaning large numbers of small private angling vessels are either based or launched into the BNAs. The largest impact of BNAs is likely to be on small inshore commercial fishers. Commercial fishing activities are currently permitted in many of the BNAs including fixed nets, although these methods are generally only used occasionally and restricted by the fixed engine closure byelaw which was introduced for the protection of migratory salmonid species. Drift, encircling, and ring nets are commonly used in BNAs to target grey mullet. Several enforcement activities have taken place with one verbal warning and three offence reports from around 70 inspections each year. The ban on use of sandeels should be maintained, but additional management measures could include restricting all live baits by recreational anglers and only allow permitted netting. Other marine protected areas (MPAs) exist in the district that afford protect to sea bass including the Solent Maritime EMS (designated as an SPA, SAC and Ramsar Site), the Rivers Test and Itchen SACs, The Chesil and the Fleet and Poole SPAs, and the seagrass at the mouths of the River Yar.

Some adjustments are needed to the existing BNAs. Fawley Power Station was decommissioned, so the BNA enclosed by a circle drawn with a radius of 556 metres around the outfall should be revoked. A number of proposed new BNAs were identified based on anecdotal evidence of the presence of sea bass and habitat that is suitable for juvenile sea bass. The areas proposed are: River Yar (Bembridge), River Medina, and Wootton Creek on the Isle of Wight, the Keyhaven, Beaulieu and Lymington estuaries, and Christchurch Harbour. On the Isle of Wight, there is limited commercial sea bass fishing activity within these areas, so any impact is likely to be on recreational fishing. The Keyhaven, Beaulieu and Lymington estuaries contain large areas of saltmarsh and are areas where sea bass are observed to concentrate. Keyhaven and Lymington already have restrictions on the use of fixed nets, and Christchurch Harbour is an important for sea bass and fishing, but nets are already restricted by IFCA bylaw and through private fishery rights. Additional data sets were identified that might help support the designation of new

BNAs including the Solent Bass Survey (Brown, 2013; Pickett *et al.*, 2002), monitoring done by the Environment Agency for WFD (Longley and Rudd, 2014) and survey data held by Local Records Centre on Isle of Wight estuaries.

3.8.2. Beaulieu (new)

The proposed new BNA at Beaulieu (Figure 9M) was based on its on large areas of saltmarsh areas that juvenile sea bass exploit, and proximity to Solent Bass Survey tows where sea bass have been recorded. However, the closest sampling point to the mouth of the estuary is over 500 m away, so this was not likely to be representative of the Beaulieu. No further sampling data were available for the river, with only summary physical characteristics available and saltmarsh area for the whole of the estuary (Table 4, Figure 7A and B). In 2015, landings by under 10 m vessels from the adjacent ICES rectangle indicated that 39 t of sea bass were retained representing 2% of the catch of all species (Figure 8).

Conclusion: There were no data on the fish assemblage compiled in this study for the Beaulieu estuary, so there is insufficient evidence at present to support the proposed BNA (Table 5). More data are required before a derogation could be considered.

3.8.3. Christchurch Harbour (new)

The proposed new BNA at Christchurch Harbour was based on its similarity and proximity to other BNAs (Figure 9N). No sampling data were available for the river, with only summary physical characteristics and saltmarsh area available for the whole of the estuary (Table 4, Figure 7A and B). In 2015, landings by under 10 m vessels from the adjacent ICES rectangle (Smith and Brown, 2009) indicated that 39 t of sea bass were retained representing 2% of the catch of all species (Figure 8).

Conclusion: There were no data on the fish assemblage compiled in this study for Christchurch Harbour, so there is insufficient evidence at present to support the proposed BNA (Table 5). More data are required before a derogation could be considered.

3.8.4. Fawley Power Station (no longer required)

Fawley Power Station is situated on the Solent and ceased operation in March 2013. The request for the removal of the existing BNA is based on the fact that the warm water outfall that the sea bass aggregated around is no longer present and will not attract sea bass. Physical data were only available for Southampton Water (Table 4, Figure 7A and B), the area proposed was derived from the shapefile. Fawley Power Station BNA was sampled as part of the Solent Bass Survey after the power station was decommissioned. Juvenile sea bass were sampled in three hauls at one location in the surveys conducted using a high-headline sea bass trawl during 2013-15 (Figure 31A-C). The mean number of sea bass in the catch was six fish per haul (Figure 31B), catches contained juveniles and adults (Figure 31D), and sea bass were caught in every haul (Table 5). Sea bass were found in September and were present in all other months where surveys were done (Figure 31E). Cod, grey mullet, plaice, and sole were not caught in the survey tows in the BNA (Figure 31F). In 2015, landings by under 10 m vessels from the adjacent ICES rectangle indicated that 39 t of sea bass were retained representing 2% of the catch of all species (Figure 8).

Conclusion: There is limited evidence of sea bass in the existing Fawley Power Station BNA even after decommissioning, but removal of the BNA is likely to increase the pressure on sea bass. However, removal of the warm water outflow is likely to stop aggregations in this specific area and make it similar to the adjacent area, and reduce the impact of removal. The existing BNA is not related to the original protection goals, so the removal of Fawley Power Station BNA is supported (Table 5). However, there is evidence of juvenile sea bass in these areas, so an extension of the Southampton Water BNA to cover larger areas of the Solent could be considered.

3.8.5. Keyhaven (new)

Keyhaven is a natural harbour formed in the lee of the spit leading out to Hurst Castle, with an approximate water-filled area at low water of 0.18 km^2, a shoreline of 12 km and tidal channel length in the region of 2.8 km (Smith and Brown, 2009). Several boats offer charter angling trips and number of commercial fishers set pots, dredge oysters, trawl, and tangle nets (Walmsley and Pawson, 2007). The proposed new BNA (Figure 9O) was based on the presence of large areas of saltmarsh where juvenile sea bass aggregate. No sampling data were available for the river, with physical characteristics derived from shapefiles (Table 4, Figure 7A and B). In 2015, landings by under 10 m vessels from the adjacent ICES rectangle indicated that 39 t of sea bass were retained representing 2% of the catch of all species (Figure 8).

Conclusion: There were no data on the fish assemblage compiled in this study for the Keyhaven estuary, so there is insufficient evidence at present to support the proposed BNA (Table 5). More data are required before a BNA designation could be considered.

3.8.6. Lymington (new)

Lymington Harbour is a small lowland estuary with the entrance channel lying between saltmarshes. Approximate water-filled area at low water is 0.53 km^2 with a shoreline of 15 km and tidal channels length in the region of 5.2 km (Smith and Brown, 2009). Sport angling from private and specialist charter vessels was popular in this area and some commercial fishermen also offered charter angling trips during the summer. Lymington has a small harbour that supported 19 boats of 7-12 m with trawling and netting for white fish and cuttlefish, dredging for oysters, netting and lining for sea bass, and potting for lobsters and crab (Walmsley and Pawson, 2007). The proposed new BNA at Lymington (Figure 9P) was based on its large areas of saltmarsh areas that juvenile sea bass exploit. No sampling data were available for the river, with only summary physical characteristics available for the whole of the estuary (Table 4, Figure 7A and B). In 2015, landings by under 10 m vessels from the adjacent ICES rectangle indicated that 39 t of sea bass were retained representing 2% of the catch of all species (Figure 8).

Conclusion: There were no data on the fish assemblage compiled in this study for the Lymington estuary, so there is insufficient evidence at present to support the proposed BNA (Table 5). More data are required before a BNA designation could be considered.

3.8.7. Medina (new)

The River Medina runs from hills on the south of the Isle of Wight, with a navigable tidal estuary from Newport northwards. The estuary is urbanised at its head and around the mouth, with an approximate water-filled area at low water of 0.91 km^2, a shoreline of 16 km, and tidal channels of 7.2 km (Smith and Brown, 2009). Around eight boats fished from the Medina port of Cowes and nearby Wootton using pots and nets, and two may join the regulated oyster fishery in winter. Eels, grey mullet, flounders, and sea bass were netted in the tidal reaches of the River Medina (Walmsley and Pawson, 2007). The proposed new BNA at Medina (Figure 9Q) was based on its large areas of saltmarsh areas that juvenile sea bass exploit. No sampling data were available for the river, with only summary physical characteristics available for the whole of the estuary (Table 4, Figure 7A and B). In 2015, landings by under 10 m vessels from the adjacent ICES rectangle indicated that 39 t of sea bass were retained representing around 2% of the catch of all species (Figure 8).

Conclusion: There were no data on the fish assemblage compiled in this study for the Medina estuary, so there is insufficient evidence at present to support the proposed BNA (Table 5). More data are required before a BNA designation could be considered.

3.8.8. Portland Harbour (new)

Portland Harbour is a large man-made harbour with four breakwaters with a total length of over 4.5 km. Around 40 commercial boats were moored in Weymouth and Portland mainly potting for crabs and lobster, but many of the small boats used rod and line or handlines or gill nets to target grey mullet and sea bass in the summer (Walmsley and Pawson, 2007). Charter angling trips and private angling boats are also common in this area. No physical data was available for the proposed new BNA at Portland Harbour (Figure 9R), so the area was estimated from the shapefile (Table 4, Figure 7A). In 2015, landings by under 10 m vessels from the adjacent ICES rectangle indicated that 45 t of sea bass were retained representing 3% of the catch of all species (Figure 8).

Conclusion: There were no data on the fish assemblage compiled in this study for Portland Harbour, so there is insufficient evidence at present to support the proposed BNA (Table 5). More data are required before a BNA designation could be considered.

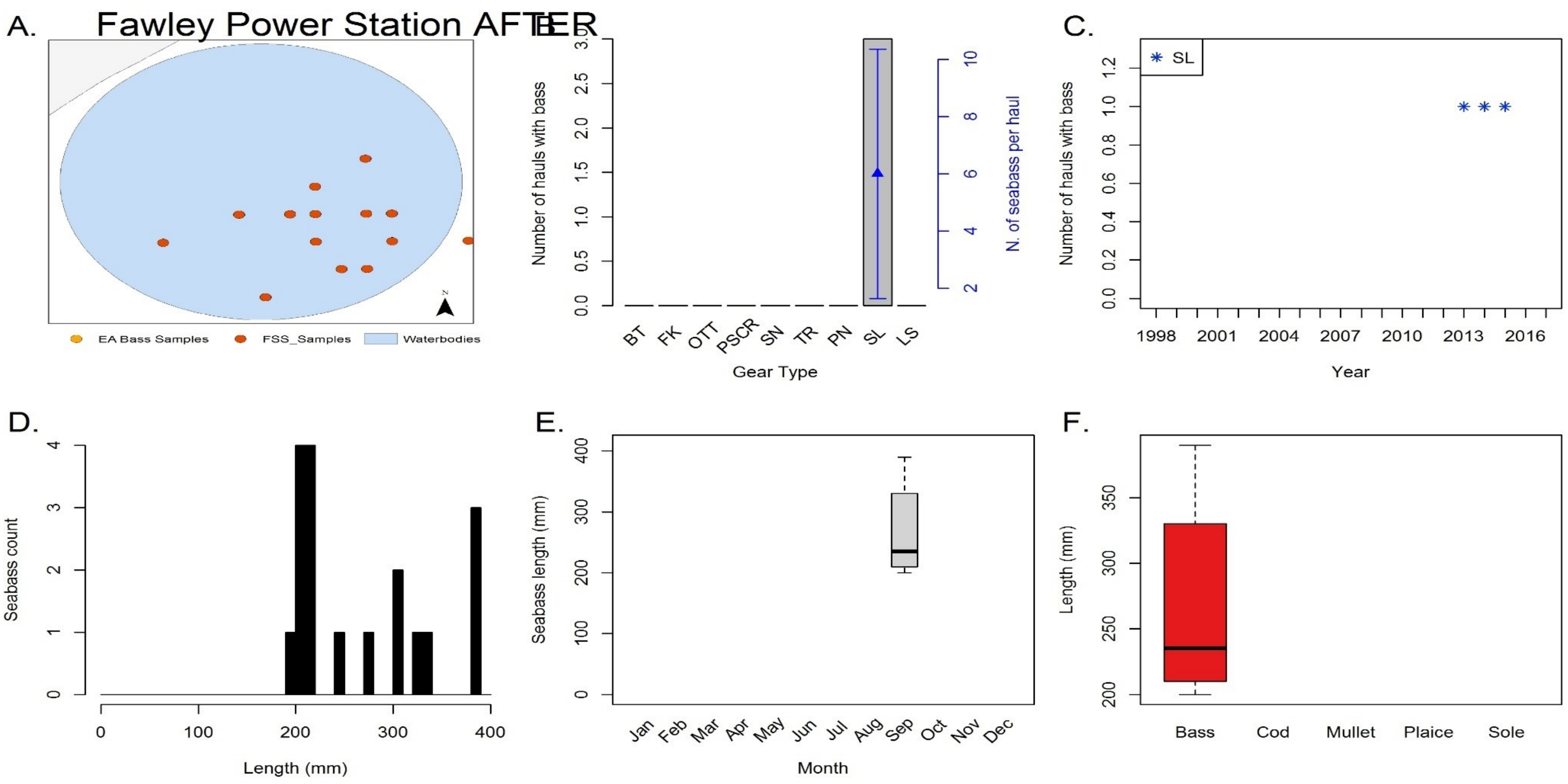

Figure 31. Assessment of the presence of sea bass and other fish at Fawley Power Station including: the area proposed and stations sampled (A); number of samples of sea bass and number of sea bass per sample (B - BT = beam trawl, FK = fyke, LS = Larson Sprat, OTT = otter; PN = push, PSCR = power station screen, SL = Solent survey, SN = seine, TR = trammel net); number of samples by gear over time (C – codes as B); length-frequency of sea bass (D); mean length of sea bass by month (E); and length of sea bass, cod, grey mullet, plaice, and sole (F).

3.8.9. The Fleet (change)

The Fleet is a stretch of brackish water behind Chesil beach. The proposed extension of the existing BNA at The Fleet was to cover the whole Ferry Bridge Channel (Figure 9S). No sampling data were available, with only summary physical characteristics available for the whole of the Fleet (Table 4, Figure 7A and B). In 2015, landings by under 10 m vessels from the adjacent ICES rectangle indicated that 45 t of sea bass were retained representing 3% of the catch of all species (Figure 8).

Conclusion: There were no data on the fish assemblage compiled in this study for the Fleet extension so there is insufficient evidence at present to support the proposed BNA (Table 5). More data are required before a BNA designation could be considered.

3.8.10. Wootton Creek (new)

Wootton Creek is a tidal estuary that flows into the Solent on the north of the Isle of Wight. Around eight boats fished from Cowes and Wootton using pots and nets (Walmsley and Pawson, 2007). The proposed new BNA at Wootton Creek (Figure 9T) was based on its on large areas of saltmarsh in areas that juvenile sea bass exploit. No sampling data were available for the river, with only summary physical characteristics available for the whole of the estuary (Table 4, Figure 7A and B). In 2015, landings by under 10 m vessels from the adjacent ICES rectangle indicated that 39 t of sea bass were retained representing around 2% of the catch of all species (Figure 8).

Conclusion: There were no data on the fish assemblage compiled in this study for Wootton Creek, so there is insufficient evidence at present to support the proposed BNA (Table 5). More data are required to before a BNA designation could be considered.

3.8.11. Yar (Bembridge) (new)

The River Yar or Eastern Yar is a short river on the Isle of Wight. Around 30 boats fished regularly around Bembridge using pots, but some boats netted for sea bass, cod, and rays, and fyke nets were set for eels in the river (Walmsley and Pawson, 2007). The proposed new BNA at the River Yar (Bembridge) (Figure 9U) was based on its on large areas of saltmarsh areas that juvenile sea bass exploit. No sampling data were available for the river, with only summary physical characteristics available for the whole of the estuary (Table 4, Figure 7A and B). In 2015, landings by under 10 m vessels from the adjacent ICES rectangle indicated that 39 t of bass were retained representing around 2% of the catch of all species (Figure 8).

Conclusion: There were no data on the fish assemblage compiled in this study for the Yar estuary, so there is insufficient evidence at present to support the proposed BNA (Table 5). More data are required before a BNA designation could be considered.

3.9. Sussex

Sussex IFCA currently has one existing BNAs in Chichester Harbour that it shares with Southern IFCA (Table 1). The proposed amendments represent new BNAs covering the Adur, Cuckmere, Medmerry, Sussex Ouse, Pagham Harbour and Shoreham Power Station (Table 2, Figure 5I). A summary of the Sussex IFCA response to the Defra questionnaire and the evidence supporting proposed amendments are outlined below.

3.9.1. Summary of IFCA response

IFCA small fish surveys show that juvenile sea bass are significant and sizeable in Medmerry where the managed realignment scheme has created a significant new estuary south east of Bracklesham Bay, and the Cuckmere Estuary. Pagham Harbour is likely to be an important site due to the similarity of the habitat to the existing BNA at Chichester Harbour. Juveniles aggregate in larger numbers at the Shoreham Power Station warm water discharge. Any rivers within that offer intertidal habitats in the lower tidal reaches could have value as sea bass nursery areas, including the Adur and Ouse.

Although Sussex IFCA young fish surveys significantly contribute to the understanding of some areas where no national data collection program exists, the information available from IFCA surveys, enforcement patrols, and information provided by anglers is currently limited. Other data sets could also provide further evidence including: the Solent Bass Survey (Pickett *et al.*, 2002) and IFCA small fish survey, specific EA surveys for WFD (Nelson, 2014). Both fixed net and drift net are used with commercial fisheries for grey mullet, trawling for cuttlefish, and dredging for oysters. Any additional management leading to displacement of these activities would lead to higher travel costs and reduced landings, with the exception of dredging for oysters that cannot be done elsewhere. This area is important for recreational angling both from the shore and boats, so any changes to BNAs may impact on recreational angling. The restriction on the use of live sand eels should be maintained, but not extended to other baits.

3.9.2. Adur (new)

The River Adur is a downland river entering the sea through the harbour at Shoreham, where a power station outfall has also been put forward as a potential BNA. The Adur's water-filled area at low water is 0.8 km^2, with a shoreline of 26 km, and tidal channels of 7.3 km (Smith and Brown, 2009). Shoreham harbour had 25 boats between 4-12 m (13 full-time) with inshore craft targeting whelks with pots, trammel nets were used to target flatfish, fixed nets for cuttlefish, and sea bass and grey mullet were taken in drift nets (Walmsley and Pawson, 2007). Around 35 fishing vessels were based in nearby Brighton Marina using static gear (netting and potting) and drift nets to catch sea bass, but sole was also important (Walmsley and Pawson, 2007). Approximately 100 small boats were launched along the beach for pleasure angling, a few of which set nets and pots (Walmsley and Pawson, 2007). Sea bass represented a large proportion of the value of the landings onto the beach at Worthing (Walmsley and Pawson, 2007).

Detailed physical data including habitat types were available for the whole of Adur that indicated small areas of saltmarsh that juvenile sea bass may exploit (Table 4, Figure 7A and B). Juvenile sea bass were caught in 88 hauls at six locations in surveys conducted using beam trawls, fyke nets, and seine nets during 2005-14 (Figure 32A-C). The mean number of sea bass in the catch was up to 18 fish per haul (Figure 32B), catches contained juveniles (Figure 32D), and there was a 61% chance of catching a sea bass in a haul (Table 5). Sea bass were found between May and November and were always found in months with surveys (Figure 32E). Grey mullet, plaice, and sole were also caught in the surveys, but were below the MCRS (Figure 32F). In 2015, landings by under 10 m vessels from the adjacent ICES rectangle indicated that 66 t of sea bass were retained representing 3% of the total catch (Figure 8).

Conclusion: There is good evidence of juvenile sea bass from a large number of hauls and a high probability of catching sea bass in a haul with juveniles found and no fish above the MCRS (Table 5). Hence, there is evidence to support further consideration of the proposed Adur BNA (Table 5).

3.9.3. Cuckmere (new)

The Cuckmere is a short river flowing into the sea in Sussex situated between Brighton and Eastbourne. The fisheries around Brighton are described above. In Eastbourne there were around 25 boats that set nets and pot and use otter trawls to target a variety of species (Walmsley and Pawson, 2007). Angling is popular with several charter boats operating in this area.

There was limited physical data for the Cuckmere, so no information on the habitat types in the proposed additional area was available apart from saltmarsh area (Table 4, Figure 7A and B). Juvenile sea bass were caught in 35 hauls at seven locations in surveys conducted using seine nets during 2005-14 (Figure 33A-C). The mean number of sea bass in the catch was 28 fish per haul (Figure 33B), catches contained juveniles (Figure 33D), and there was an 80% chance of catching a sea bass in a haul (Table 5). Sea bass were found between May and October and were found in all months with surveys (Figure 33E). Grey mullet and sole were also caught in the surveys, but were below the MCRS (Figure 33F). In 2015, landings by under 10 m vessels from the adjacent ICES rectangle indicated that 112 t of sea bass were retained representing around 3% of the catch of all species (Figure 8).

Conclusion: There is good evidence of juvenile sea bass from a large number of hauls and a high probability of catching sea bass in a haul with juveniles found and no fish above the MCRS (Table 5). Hence, there is evidence to support further consideration of the proposed Cuckmere BNA (Table 5).

3.9.4. Medmerry (new)

The Medmerry managed realignment scheme between Selsey and Bracklesham in West Sussex created around 180 ha of important wildlife habitat, including saltmarshes and lagoons. The fisheries around Brighton are described above. The closest port is at Selsey and had 14 potters that targeted lobster, crabs, and whelk, but also used trammel or drift nets for sole, plaice, turbot, skate, mackerel, pollack and grey mullet. Four vessels targeted sea bass full-time during the season and a further 20 part-time boats occasionally used trammels and beach seines (Walmsley and Pawson, 2007). Angling is popular with several charter boats operating in this area.

There was no physical data for Medmerry, so the area was derived from the shapefile (Table 4, Figure 7A and B), but it was clear from the managed realignment scheme that it contains habitat that supports juvenile sea bass. Juvenile sea bass were caught in 33 hauls at 13 locations in surveys conducted using fyke and seine nets during 2014-16 (Figure 34A-C). The mean number of sea bass in the catch was up to 21 fish per haul (Figure 34B), catches contained juveniles (Figure 34D), and there was a 77% chance of catching a sea bass in a haul (Table 4). Sea bass were found between June and October and were always found in months with surveys (Figure 34E). Grey mullet, plaice, and sole were also caught in the surveys, but were below the MCRS (Figure 34F). In 2015, landings by under 10 m vessels from the adjacent ICES rectangle indicated that 66 t of sea bass were retained representing 3% of the catch of all species (Figure 8).

Conclusion: There is good evidence of juvenile sea bass from a large number of hauls and a high probability of catching sea bass in a haul with juveniles found and no fish above the MCRS (Table 5). Hence, there is evidence to support further consideration of the proposed Medmerry BNA (Table 5).

3.9.5. Ouse and Tide Mill Creek (new)

The Sussex Ouse is a short river flowing into the English Channel that includes the Port of Newhaven. There were around 45 boats in Newhaven that fished using set nets and otter trawls to target flatfish, pollack, ling, sea bass and bream (Walmsley and Pawson, 2007). There were also potters that target lobsters and crabs (Walmsley and Pawson, 2007). Angling is popular with several charter boats operating in this area.

There was limited physical data for the Ouse, so no information on the habitat types in the proposed additional area was available (Table 4, Figure 7A and B). Juvenile sea bass were caught in four hauls at three locations in surveys conducted using push, fyke and seine nets between 1999 and 2017 (Figure 35A-C). The mean number of sea bass in the catch was up to 50 fish per haul (Figure 35B), catches contained juveniles (Figure 36D), and sea bass were caught in every haul (Table 4). Sea bass were found in August and September (Figure 35E) and no other species were caught (Figure 35F). In 2015, landings by under 10 m vessels from the adjacent ICES rectangle indicated that 178 t of sea bass were retained representing 3% of the catch of all species (Figure 8).

Conclusion: There is moderate evidence of juvenile sea bass from a small number of hauls, but a high probability of catching sea bass in a haul with juveniles found and no other fish found (Table 5). Hence, there is evidence to support further consideration of the proposed Sussex Ouse BNA (Table 5).

3.9.6. Pagham Harbour (new)

Pagham Harbour is a natural harbour in West Sussex that includes saltmarsh and mudflats. There were a small number of boats that operate in this area that used pots for lobster and some gill netting for sea bass (Walmsley and Pawson, 2007). The proposed new BNA at Pagham was based on its large areas of saltmarsh areas that juvenile sea bass exploit.

There was limited physical data for the Pagham Harbour, so no additional information on the habitat types in the proposed additional area was available apart from the saltmarsh extent (Table 4, Figure 7A and B). Juvenile sea bass were caught in 99 hauls at six locations in a survey conducted using a seine and fyke nets from 1999-2016 (Figure 36A-C). The mean number of sea bass in the catch was up to 19 fish per haul (Figure 36B), catches contained juveniles (Figure 36D), and there was a 86% chance of catching a sea bass in a haul (Table 4). Sea bass were found between June and September (Figure 36E) and only mullet were caught (Figure 36F). In 2015, landings by under 10 m vessels from the adjacent ICES rectangle indicated that 66 t of sea bass were retained representing 3% of the total catch (Figure 8).

Conclusion: There is good evidence of juvenile sea bass from a large number of hauls and a high probability of catching sea bass in a haul with juveniles found, and mullet was the only other fish caught (Table 5). Hence, there is evidence to support further consideration of the proposed Sussex Ouse BNA (Table 5).

3.9.7. Shoreham Power Station

Shoreham Power Station is situated on the River Adur (see above). The request for the new BNA is based on the fact that the warm water outfall causes sea bass to aggregate in the area, so would protect concentrations of juvenile sea bass. Physical data were only available for Adur, so the area of the proposed BNA was derived from the shapefile (Table 4, Figure 7A and B). Juvenile sea bass were found in 32 samples from the power station screens in 2000-08 (Figure 37A-C). The mean number of sea bass per sample was four fish (Figure 37B), the samples contained juveniles (Figure 37D), and there was a 68% chance of finding sea bass in a sample. Sea bass were found between January and April (Figure 37E). Grey mullet, plaice and sole were also found in the samples (Figure 37F). In 2015, landings by under 10 m vessels from the adjacent ICES rectangle indicated that 66 t of sea bass were retained representing 3% of the catch of all species (Figure 8).

Conclusion: There is good evidence of sea bass in the Shoreham Power Station BNA from a large number of hauls and a high probability of catching sea bass in a haul, with juveniles found and no other fish above the MCRS (Table 5). Hence, there is evidence to support further consideration of the proposed Shoreham Power Station BNA (Table 5).

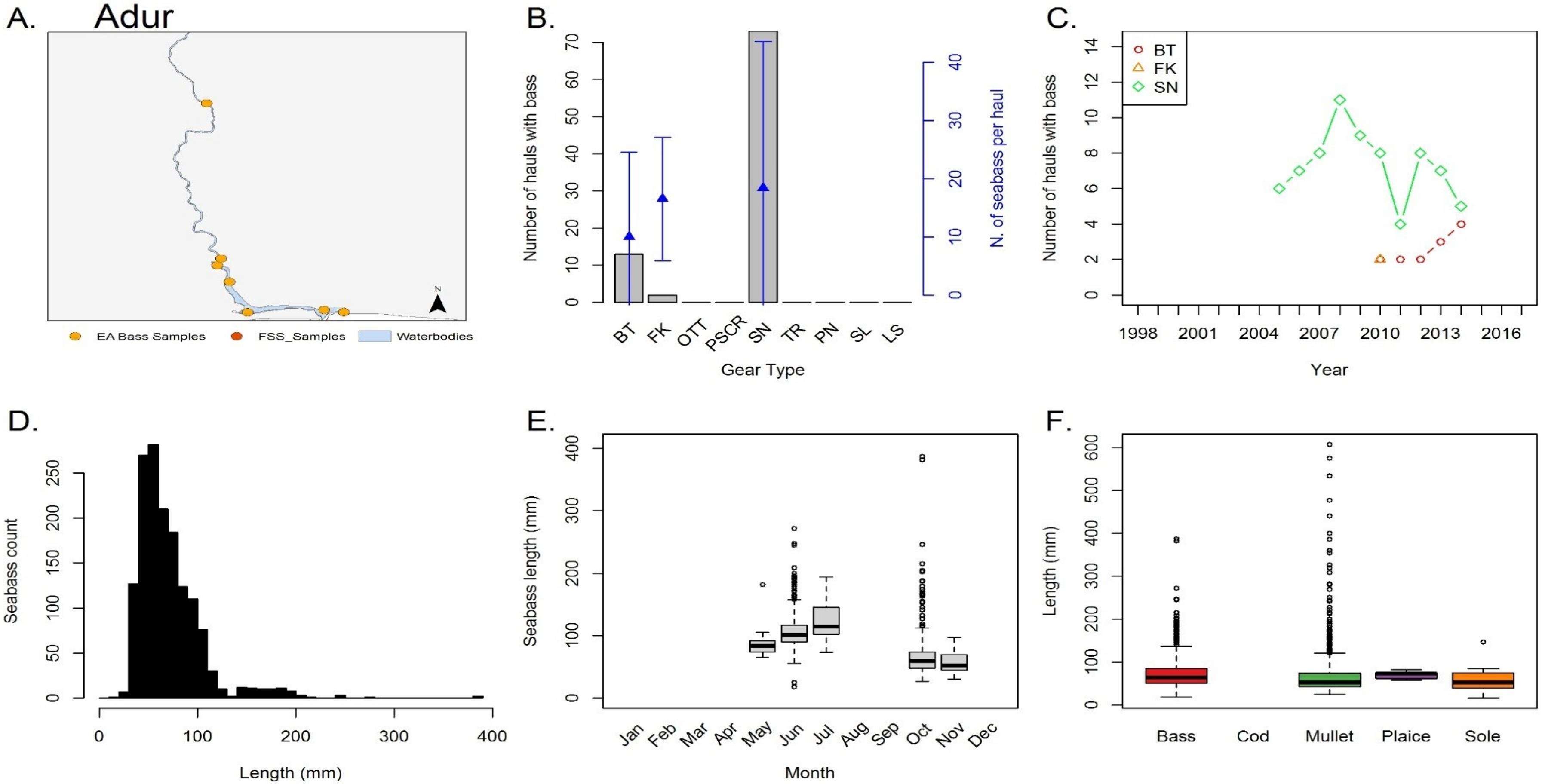

Figure 32. Assessment of the presence of sea bass and other fish in the River Adur including: the area proposed and stations sampled (A); number of samples of sea bass and number of sea bass per sample (B - BT = beam trawl, FK = fyke, LS = Larson Sprat, OTT = otter; PN = push, PSCR = power station screen, SL = Solent survey, SN = seine, TR = trammel net); number of samples by gear over time (C – codes as B); length-frequency of sea bass (D); mean length of sea bass by month (E); and length of sea bass, cod, grey mullet, plaice, and sole (F).

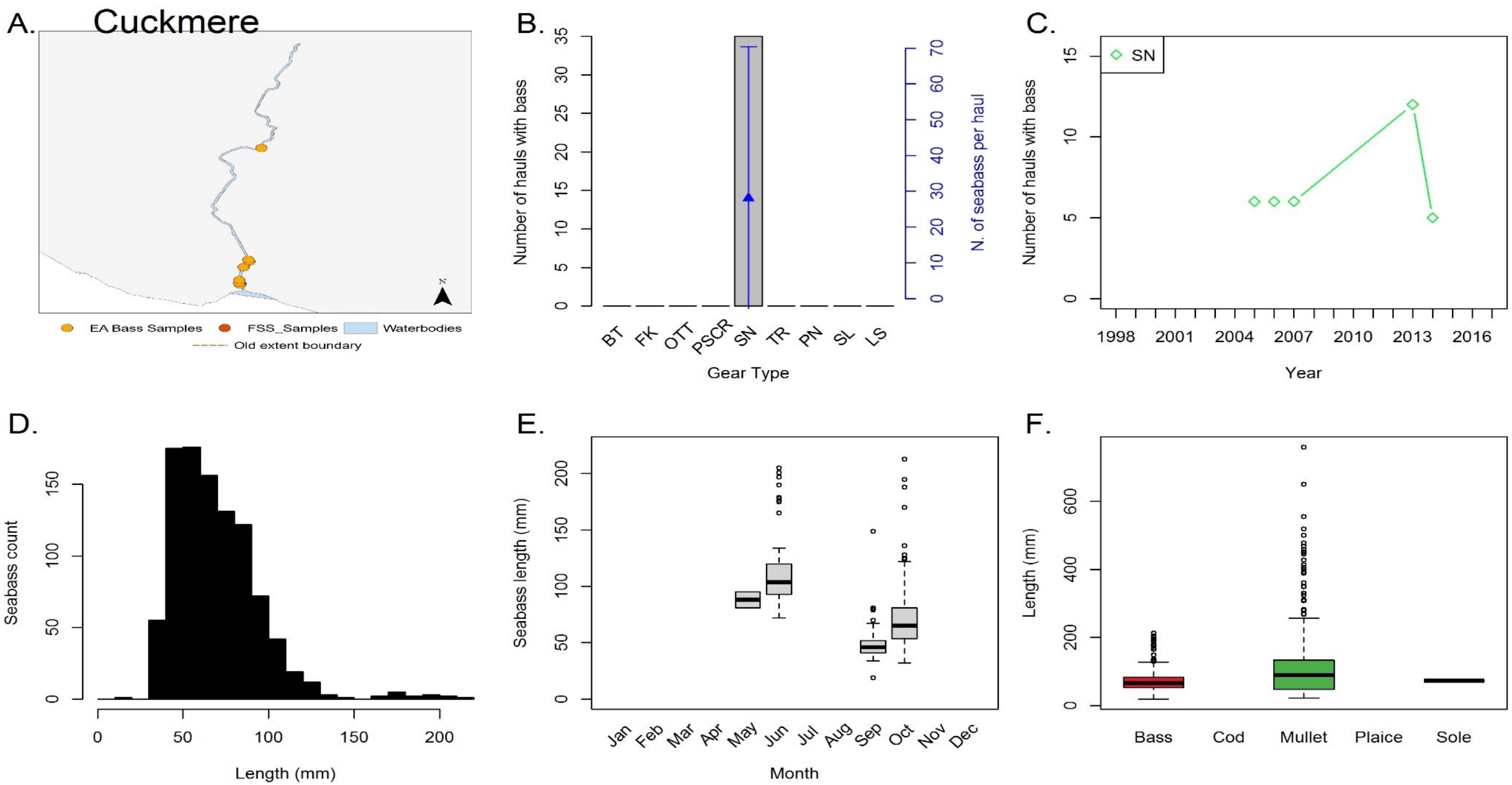

Figure 33. Assessment of the presence of sea bass and other fish in the River Cuckmere including: the area proposed and stations sampled (A); number of samples of sea bass and number of sea bass per sample (B - BT = beam trawl, FK = fyke, LS = Larson Sprat, OTT = otter; PN = push, PSCR = power station screen, SL = Solent survey, SN = seine, TR = trammel net); number of samples by gear over time (C – codes as B); length-frequency of sea bass (D); mean length of sea bass by month (E); and length of sea bass, cod, grey mullet, plaice, and sole (F).

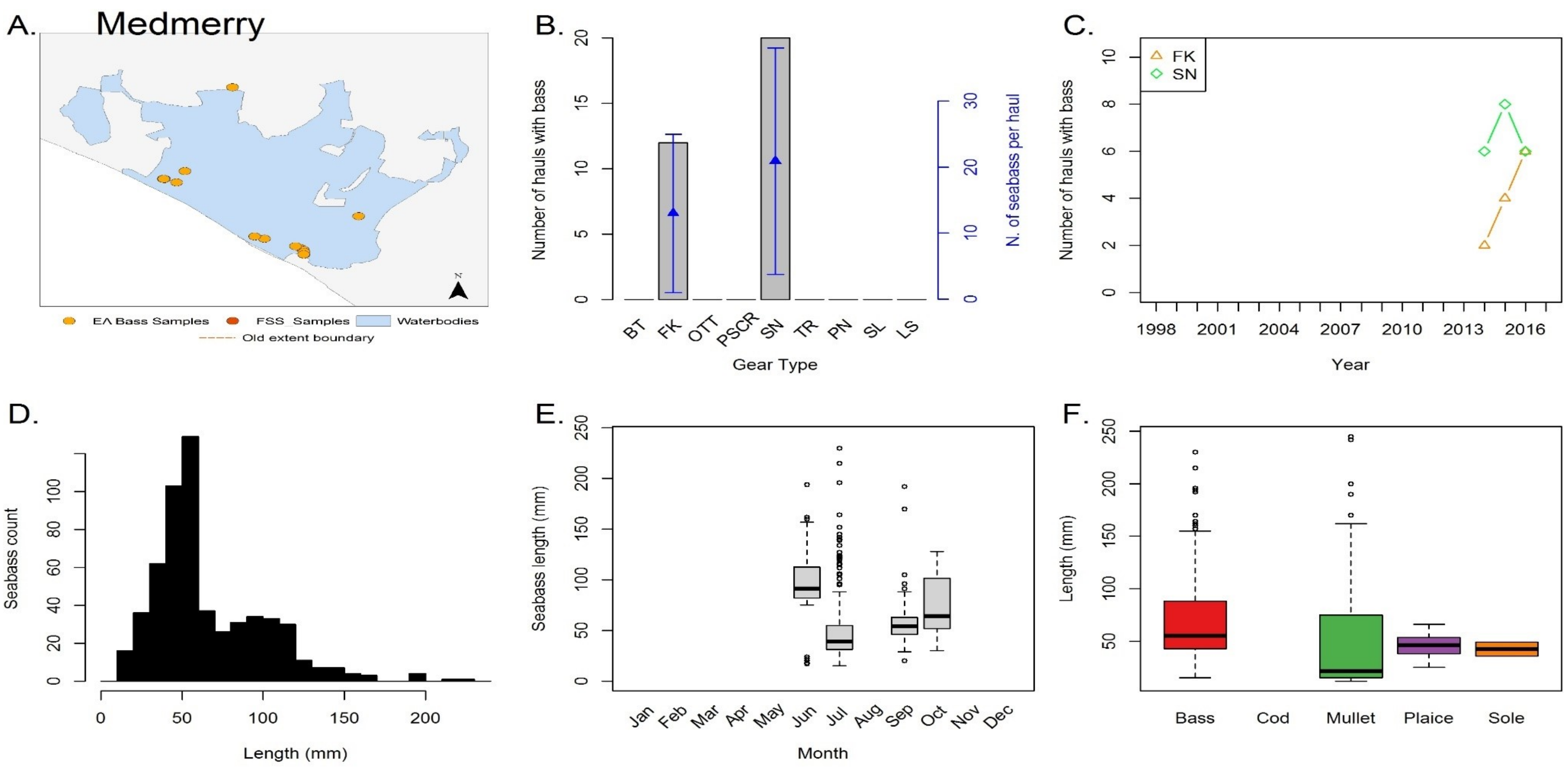

Figure 34. Assessment of the presence of sea bass and other fish in the River Medmerry including: the area proposed and stations sampled (A); number of samples of sea bass and number of sea bass per sample (B - BT = beam trawl, FK = fyke, LS = Larson Sprat, OTT = otter; PN = push, PSCR = power station screen, SL = Solent survey, SN = seine, TR = trammel net); number of samples by gear over time (C – codes as B); length-frequency of sea bass (D); mean length of sea bass by month (E); and length of sea bass, cod, grey mullet, plaice, and sole (F).

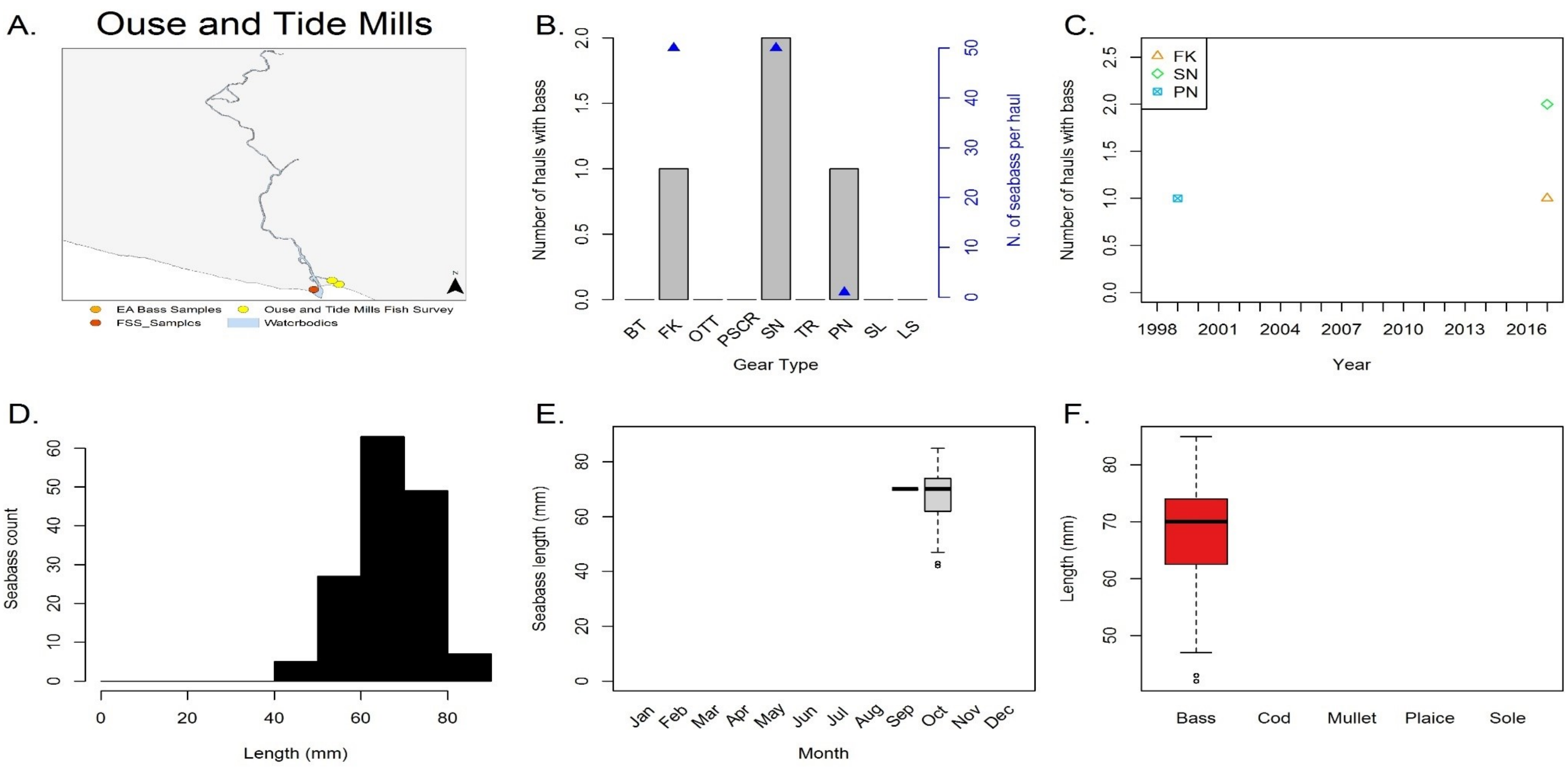

Figure 35. Assessment of the presence of sea bass and other fish in the River Ouse and Tide Mill Creek including: the area proposed and stations sampled (A); number of samples of sea bass and number of sea bass per sample (B - BT = beam trawl, FK = fyke, LS = Larson Sprat, OTT = otter; PN = push, PSCR = power station screen, SL = Solent survey, SN = seine, TR = trammel net); number of samples by gear over time (C – codes as B); length-frequency of sea bass (D); mean length of sea bass by month (E); and length of sea bass, cod, grey mullet, plaice, and sole (F).

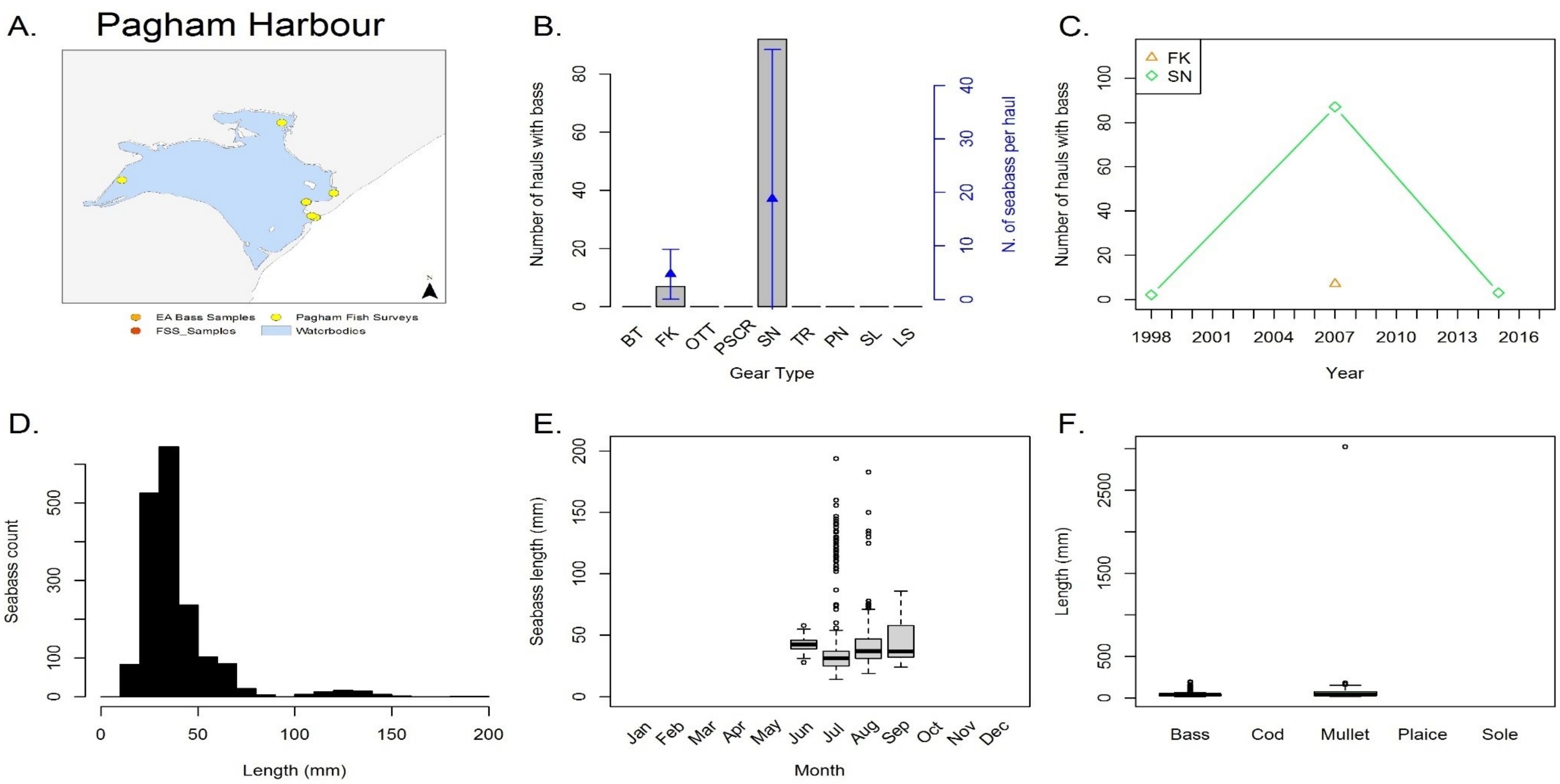

Figure 36. Assessment of the presence of sea bass and other at Pagham Harbour including: the area proposed and stations sampled (A); number of samples of sea bass and number of sea bass per sample (B - BT = beam trawl, FK = fyke, LS = Larson Sprat, OTT = otter; PN = push, PSCR = power station screen, SL = Solent survey, SN = seine, TR = trammel net); number of samples by gear over time (C – codes as B); length-frequency of sea bass (D); mean length of sea bass by month (E); and length of sea bass, cod, grey mullet, plaice, and sole (F).

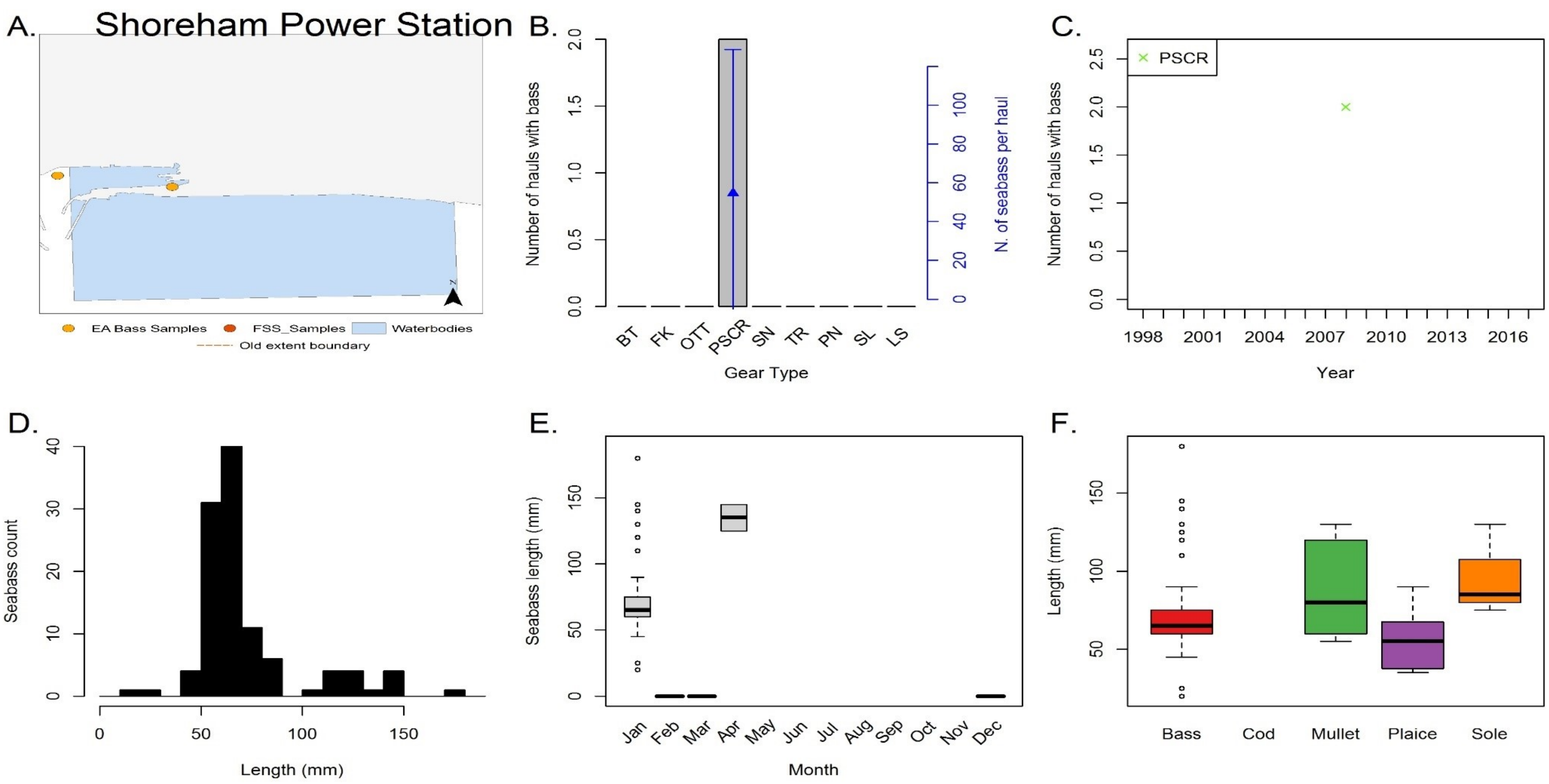

Figure 37. Assessment of the presence of sea bass and other at Shoreham Power Station including: the area proposed and stations sampled (A); number of samples of sea bass and number of sea bass per sample (B - BT = beam trawl, FK = fyke, LS = Larson Sprat, OTT = otter; PN = push, PSCR = power station screen, SL = Solent survey, SN = seine, TR = trammel net); number of samples by gear over time (C – codes as B); length-frequency of sea bass (D); mean length of sea bass by month (E); and length of sea bass, cod, grey mullet, plaice, and sole (F).

4. Discussion

4.1. Purpose of BNA designation

The sheltered waters of estuaries, saltmarshes, coastal lagoons, harbours, and other semi-enclosed water bodies provide essential habitat for the early juvenile stages of sea bass, representing the entire habitat for sea bass during the first few years of their lives. Productivity of sea bass populations therefore depend critically on the quality of these habitats to promote early-stage survival, but at the same time the aggregation of young sea bass in these habitats makes them particularly vulnerable to fishing. The primary objective of the existing BNAs is to minimise fishing on immature sea bass so that recruitment to the spawning stock is maximised, and to allow more fish to grow to a larger size before capture and hence improve long-term yields. The current 37 BNAs represent only part of the total area of sea bass nursery areas around the European coast, although they include many of the larger ones found in England and Wales. The designation of new BNAs, or extensions to existing ones to extend the area of protection of juvenile sea bass, will provide additional protection depending on how much of the total recruitment of sea bass to local populations is sourced from these areas. The present analysis cannot answer this last question, and can only provide the evidence from a range of local surveys to indicate the presence and size of juvenile sea bass, not the total abundance of juveniles in the water body. In many of the cases, further information would be needed before designation as a BNA could be considered.

4.2. Assessment of the proposed amendments to BNAS

Assessment of the proposed amendments to the BNAs provides evidence to support further consideration of 26 out of the 48 proposals, but more data are required for the remaining 22 proposals before designation as a BNA could be considered (total includes the partitioning of the Thames and Humber). It was not possible to look at spatial or temporal distribution of sea bass in individual areas within this analysis, as there was insufficient coverage in most estuaries. There is some evidence that the characteristics of an estuary is indicative of its potential as a BNA (Pickett and Pawson, 1994) with the distribution of sea bass in estuaries related to salinity and depth (Kelley, 1988) and habitats like saltmarsh are important for juvenile sea bass (Colclough *et al.*, 2005; Fonseca, 2009; França and Cabral, 2016). Stylised representations are available, but it is unclear exactly how sea bass use nursery areas as they grow during the first few years of life (Figure 2). Research is underway to assess the presence, abundance, and distributions of sea bass within estuaries, but was not available for this analysis.

During the first and second years of life, sea bass are typically found in the higher reaches of estuaries and often in shallower water utilising saltmarsh and other intertidal habitats for feeding (Kelley, 1988; Pickett and Pawson, 1994; Colclough *et al.*, 2005; Fonseca, 2009;).

Larger juvenile sea bass will use deeper areas of the estuaries (Pickett and Pawson, 1994) and may therefore encounter fisheries. As a result, it is important to consider the potential for larger juvenile sea bass to be captured and discarded by any fishing activities allowed to take place. Within estuaries, coastal lagoons and similar habitats, most fishing is likely to be using hook-and line or gillnets by commercial and recreational fishers. The IFCAs provided some qualitative information on the existence of fisheries in the proposed new or amended BNAs, but more detailed information would be needed to fully evaluate the nature and extent of fishing in each area, the sizes of fish being caught, the mesh sizes of nets being used, and the extent of discarding. Studies on size selectivity of gill nets to capture sea bass (Table 6) show that a mesh size of 100 mm would be compatible with minimising the catch of sea bass under 36 cm (Reis and Pawson, 1992; Revill *et al.*, 2009). Sea bass released by recreational anglers will suffer low levels of post release mortality (Lewin *et al.*, 2018), but is dependent on many factors (Bartholomew and Bohnsack, 2005; Lewin *et al.*, 2018). Changes in management measures such as MCRS and bag limits will affect the number of sea bass being released after capture.

Table 6. Sea bass gillnet selectivity from two studies for different mesh sizes. Length and spread of the selectivity curves are provided.

Study	Gear	Mesh size (mm)	Length of sea bass (cm)
Reis and Pawson (1992)	Gillnet	70	32 (29-36)
		82	36 (29-49)
		89	39 (29-51)
		92	44 (34-51)
Revill *et al.* (2009)	Gillnet	90	41±5, 42±3, 41±3
		100	48±5, 46±4, 45±3
		108	52±6, 50±4, 49±3
		120	56±6, 56±4, 54±4

Assessment of the impact of the proposed amendments to the BNAs on the status of the stock is very difficult. In the original designation of BNAs, the impact of MCRS and mesh sizes was assessed using a yield-per-recruit analysis (Pawson and Pickett, 1987), but this did not assess the impact of BNAs in isolation of the other measures. Instead, the argument was made that it was possible to recognise distinct nursery areas for juvenile sea bass, where juvenile sea bass were particularly vulnerable, so protection of these areas provided protection against mortality other than that due to natural causes. Using BNAs to project juvenile sea bass from unwanted fishing effort appeared to be supported by the size distributions inside and outside the areas (Pickett *et al.*, 1995). Increased survival of juvenile sea bass after 1,000 days from tagging studies before and after the establishment of the BNAs (Pickett *et al.*, 2004) was suggested to have driven some of the improvement in the yield-per-recruit (ICES, 2002; Pickett *et al.*, 2004). However, it is very challenging to estimate the impact of BNAs on the stock in a meaningful manner, as it involves knowing the relative contribution of individual nursery areas to the adult stock and density dependent mechanisms that could reduce the survival on nursery grounds (e.g., cannibalism - Henderson and Corps, 1997).

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6. References

Armstrong, M., Brown, A., Hargreaves, J., Hyder, K., Munday, M., Proctor, S., Roberts, A., Roche, N., and Williamson, K., 2013. Sea Angling 2012 – a survey of recreational sea angling activity and economic value in England. Defra, London, UK. 16pp.

Armstrong, M., and Walmsley, S., 2012. Maturity of sea bass sampled around the UK. Working Document IBP-NEW 2012 meeting, Cefas, Lowestoft, UK. 14pp.

Auber, A., Travers-Trolet, M., Villanueva, M.C., and Ernande, B., 2015. Regime Shift in an Exploited Fish Community Related to Natural Climate Oscillations. PLoS One 10, e0129883.

Bartholomew, A., and Bohnsack, J.A., 2005. A review of catch-and-release angling mortality with implications for no-take reserves. Reviews in Fish Biology and Fisheries 15, 129–154.

Bastreri, D., Hussey, S., Arnold, R., and Colclough, S., 2014. Management of Marine Fish Resources , Fisheries and Conservation in the Inner Severn Estuary. Thompson Unicomarine Limited. 79pp.

Beraud, C., Molen, J. Van Der, Armstrong, M., Hunter, E., Fonseca, L., and Hyder, K. 2017. The influence of oceanographic conditions and larval behaviour on settlement success—the European sea bass *Dicentrarchus labrax* (L.). ICES Journal of Marine Science, doi:10.1093/icesjms/fsx195.

Brown, M., 2013. Cefas Solent Bass Survey 2013. Cefas, Lowestoft, UK. 4pp.

Cardoso, J.F.M.F., Freitas, V., Quilez, I., Jouta, J., Witte, J.I., and Van Der Veer, H.W., 2015. The European sea bass *Dicentrarchus labrax* in the Dutch Wadden Sea: from visitor to resident species. Journal of the Marine Biological Association of the United Kingdom 95, 839–850.

Coates, S., Waugh, A., Anwar, A., and Robson, M., 2007. Efficacy of a multi-metric fish index as an analysis tool for the transitional fish component of the Water Framework Directive. Marine Pollution Bulletin 55, 225–240.

Colclough, S., 2015. Institute of Fisheries Management call for IFCA evidence for a review of Bass Nursery Areas (BNAs). Institute of Fisheries Management, Hull, UK. 2pp.

Colclough, S., Fonseca, L., Astley, T., Thomas, K., and Watts, W., 2005. Fish utilisation of managed realignments. Fisheries Management and Ecology 12, 1–10.

Colclough, S. R., Gray, G., Bark, A., and Knights, B. 2002. Fish and fisheries of the tidal Thames: management of the modern resource, research aims and future pressures. Journal of Fish Biology 61: 64–73.

Doyle, T.K., Haberlin, D., Clohessy, J., Bennison, A., and Jessopp, M., 2017. Localised residency and inter-annual fidelity to coastal foraging areas may place sea bass at risk to local depletion. Scientific Reports 8, 45841.

Environment Agency, 2011. The extent of saltmarsh in England and Wales: 2006-2009.

Available at
https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/291573/LIT_5799_a4e627.pdf.

EU, 2015a. Council Regulation (EU) 2015/104 of 19 January 2015 fixing for 2015 the fishing opportunities for certain fish stocks and groups of fish stocks, applicable in Union waters and, for Union vessels, in certain non-Union waters, amending Regulation (EU) No 43. Official Journal of the European Union L22, 1–160.

EU, 2015b. Council Regulation (EU) 2015/523 of 25 March 2015 amending Regulations (EU) No 43/2014 and (EU) 2015/104 as regards certain fishing opportunities. Official Journal of the European Union L84, 1-21.

EU, 2015c. Council REgulation (EU) 2015/960 of 19 June 2015 amending Regulation (EU) 2015/104 as regards certain fishing opportunities. Official Journal of the European Union L157, 1–19.

EU, 2015d. Commission Implementing Regulation (EU) 2015/1316 of 30 July 2015 derogating from Council Regulation (EC) No 850/98, as regards the minimum conservation reference size for sea bass (*Dicentrarchus labrax*). Official Journal of the European Union L203, 9–10.

EU, 2016. Council Regulation (EU) 2016/ 72 of 22 January 2016 fixing for 2016 the fishing opportunities for certain fish stocks and groups of fish stocks, applicable in Union waters and, for Union fishing vessels, in certain non-Union waters, and amending Regulation (EU) 2015/104. Official Journal of the European Union 22(1380), 1–165.

EU, 2017. Council regulation (EU) 2017/127 of 20 January 2017 fixing for 2017 the fishing opportunities for certain fish stocks and groups of fish stocks, applicable in Union waters and, for Union fishing vessels, in certain non-Union waters. Official Journal of the European Union L24, 1–162.

Fahy, E., Forrest, N., Shaw, U. and G.P., 2000. Observations on the status of bass *Dicentrarchus labrax* stocks in Ireland in the late 1990s. Irish Fish. Investig. 5, 27.

Fonseca, L., 2009. Fish Utilisation of Saltmarshes and Managed Realignment in areas SE England. PhD thesis, Queen Mary, University of London, UK. 223pp.

França, S., and Cabral, H.N., 2016. Predicting fish species distribution in estuaries: Influence of species’ ecology in model accuracy. Estuarine, Coastal and Shelf Science 180, 11–20.

Fritsch, M., Morizur, Y., Lambert, E., Bonhomme, F., and Guinand, B., 2007. Assessment of sea bass (*Dicentrarchus labrax*, L.) stock delimitation in the Bay of Biscay and the English Channel based on mark-recapture and genetic data. Fisheries Research 83, 123–132.

Green, B.C., Smith, D.J., Grey, J., and Underwood, G.J.C., 2012. High site fidelity and low site connectivity in temperate salt marsh fish populations: a stable isotope approach. Oecologia 168, 245–255.

Hambidge, C. and Phelan, N., 2014. Saltmarsh mapping standardisation for the Water Framework Directive, online Pdf available at http://www.nmbaqcs.org/news/nmbaqcnews/saltmarsh-mapping-standardisation-for-the-water-framework-directive/.

Harwood, A., and Perrow, M., 2016. Blakeney Point seine net surveys in summer 2015. Conducted by ECON Ecological Consultancy Ltd, Norwich, in partnership with National Trust, Blakeney, UK. 11pp.

Henderson, P. A., and Corps, M. 1997. The role of temperature and cannibalism in interannual recruitment variation of bass in British waters. Journal of Fish Biology 50: 280–295.

Hyder, K., Radford, Z., Prellezo, R., Weltersbach, M.S., Lewin, W.-C., Zarauz, L., Ferter, K., Ruiz, J., Townhill, B., Mugerza, E., and Strehlow, H. V., 2017. Research for PECH Committee - Marine recreational and semi-subsistence fishing - its value and its impact on fish stocks. European Parliament, Policy Department for Structural and Cohesion Policies, Brussels, belgium. 134pp.

Hyder, K., Weltersbach, M.S., Armstrong, M., Ferter, K., Townhill, B., Ahvonen, A., Arlinghaus, R., Baikov, A., Bellanger, M., Birzaks, J., Borch, T., Cambie, G., de Graaf, M., Diogo, H.M.C., Dziemian, Ł., Gordoa, A., Grzebielec, R., Hartill, B., Kagervall, A., Kapiris, K., Karlsson, M., Kleiven, A.R., Lejk, A.M., Levrel, H., Lovell, S., Lyle, J., Moilanen, P., Monkman, G., Morales-Nin, B., Mugerza, E., Martinez, R., O'Reilly, P., Olesen, H.J., Papadopoulos, A., Pita, P., Radford, Z., Radtke, K., Roche, W., Rocklin, D., Ruiz, J., Scougal, C., Silvestri, R., Skov, C., Steinback, S., Sundelöf, A., Svagzdys, A., Turnbull, D., van der Hammen, T., van Voorhees, D., van Winsen, F., Verleye, T., Veiga, P., Vølstad, J.-H., Zarauz, L., Zolubas, T., and Strehlow, H. V., 2018. Recreational sea fishing in Europe in a global context-Participation rates, fishing effort, expenditure, and implications for monitoring and assessment. Fish and Fisheries 19, 225–243.

ICES, 2002. Report of the study group on sea bass. ICES CM 2002/ACFM: 11, Copenhagen, Denmark. 59pp.

ICES, 2012. Report of the working group on assessment of new MoU species (WGNEW). ICES CM 2012/ACOM:20, Copenhagen, Denmark. 260pp.

ICES, 2014. Report of the Inter-Benchmark Protocol for Channel and Southern North Sea (IBP Bass) ICES CM 2014/ACOM:45, Copenhagen, Denmark. 216pp.

ICES, 2016. Report of the Working Group on Celtic Seas Ecoregion (WGCSE). ICES CM 2016/ACOM:13, Copenhagen, Denmark. 1033pp.

Jennings, S., and Ellis, J.R., 2015. Bass (Moronidae), in: Heessen, H.J.L., Daan, N., Ellis, J.R. (Eds.), Fish Atlas of the Celtic Sea, North Sea, and Baltic Sea. Wageningen Academic Publishers / KNNV Publishing. 324–327 pp.

Jessop, R.W., Strigner, R., Thompson, S., and Welby, P.R., 2013. Eastern IFCA research report 2013. Eastern IFCA, Kings Lynn, UK. 339pp.

Kelley, D.F., 1988. The importance of estuaries for sea-bass, *Dicentrarchus labrax* (L.). Journal of Fish Biology 33, 25–33.

Kennedy, M., and Fitzmaurice, P., 1972. The Biology of the Bass, *Dicentrarchus Labrax*, in Irish Waters. Journal of the Marine Biological Association of the United Kingdom 52, 557.

Kenny, A.J., Skjoldal, H.R., Engelhard, G.H., Kershaw, P.J., and Reid, J.B., 2009. An integrated approach for assessing the relative significance of human pressures and environmental forcing on the status of large marine ecosystems. Progress in Oceanography. 81, 132–148.

Laffaille, P., Lefeuvre, J.C., Schricke, M.T., and Feunteun, E., 2001. Feeding ecology of o-group sea bass, *Dicentrarchus labrax*, in salt marshes of Mont Saint Michel Bay (France). Estuaries 24, 116–125.

Lepage, M., Harrison, T., Breine, J., Cabral, H., Coates, S., Galván, C., García, P., Jager, Z., Kelly, F., Mosch, E.C., Pasquaud, S., Scholle, J., Uriarte, A., and Borja, A., 2016. An approach to intercalibrate ecological classification tools using fish in transitional water of the North East Atlantic. Ecological Indicators 67, 318–327.

Lewin, W.C., Strehlow, H.V., Ferter, K., Hyder, K., Niemax, J., Herrmann, J.-P., and Weltersbach, M.S., 2018. Estimating post-release mortality of European sea bass based on experimental angling. ICES Journal of Marine Science 75, 1483-1495.

Longley, D., and Rudd, P., 2014. Solent & South Downs Fish Monitoring Report 2014. Environement Agency, Bristol, UK. 71pp.

MAFF, 1990. Bass – nursery areas and other conservation measures. Ministry of Agriculture, Fisheries and Food. MAFF Publications, London, UK. 15pp.

Nelson, K., 2014. Small fish surveys – 2014. Sussex IFCA, Shoreham-by-Sea, UK. 16pp

Nelson, K., 2017. Tide Mills small fish survey. Sussex IFCA, Shoreham-by-Sea, UK. 5pp

Pawson, M.G., Brown, M., Leballeur, J., and Pickett, G.D., 2008. Will philopatry in sea bass, *Dicentrarchus labrax*, facilitate the use of catch-restricted areas for management of recreational fisheries? Fisheries Research 93, 240–243.

Pawson, M.G., and Eaton, D.R., 1999. The influence of a power station on the survival of juvenile sea bass in an estuarine nursery area. Journal of Fish Biology 54, 1143–1160.

Pawson, M.G., and Pickett, G.D., 1996. The Annual Pattern of Condition and Maturity in Bass, *Dicentrarchus Labrax*, in Waters Around England and Wales. Journal of the Marine Biological Association of the United Kingdom 76, 107–125.

Pawson, M.G., and Pickett, G.D., 1987. The bass (*Dicentrarchus labrax*) and management of its fishery in England and Wales. Laboratory Leaflet No. 59, Cefas, Lowestoft, UK. 38pp.

Pawson, M.G., Pickett, G.D., and Kelley, D.F., 1987. The distribution and migrations of bass, *Dicentrarchus labrax* L., in waters around England and Wales as shown by tagging. Journal of the Marine Biological Association of the United Kingdom 67, 183–217.

Pawson, M.G., Pickett, G.D., Leballeur, J., Brown, M., and Fritsch, M., 2007. Migrations, fishery interactions, and management units of sea bass (*Dicentrarchus labrax*) in

Northwest Europe. ICES Journal of marine Science 64, 332–345.

Pawson, M.G., Pickett, G.D., and Smith, M.T., 2005. The role of technical measures in the recovery of the UK sea bass (*Dicentrarchus labrax*) fishery 1980-2002. Fisheries Research 76, 91–105.

Pickett, G.D., Brown, M., Harley, B., and Dunn, M.R., 2002. Surveying fish populations in the solent and adjacent harbours using the cefas bass trawl. Science series technical report Number 118, Cefas, Lowestoft, UK. 16pp.

Pickett, G.D., Eaton, D.R., Cunningham, S., Dunn, M.R., Potten, S.D., and Whitmarsh, D., 1995. An appraisal of the UK bass fishery and its management. Laboratory Leaflet No. 75, Cefas, Lowestoft, UK. 85pp.

Pickett, G.D., Kelley, D.F., and Pawson, M.G., 2004. The patterns of recruitment of sea bass, *Dicentrarchus labrax* L. from nursery areas in England and Wales and implications for fisheries management. Fisheries Research 68, 329–342.

Pickett, G.D., and Pawson, M.G., 1994. Sea Bass Biology, exploitation and conservation. Fish & Fisheries Series 12, Chapman & Hall, London UK.

Reis, E.G., and Pawson, M.G., 1992. Determination of gill-net selectivity for bass (*Dicentrarchus labrax* L.) using commercial catch data. Fisheries Research 13, 173–187.

Revill, A., Wade, O., Holst, R., Ashworth, J., and Stead, N., 2009. Fisheries Science Partnership. Final report of Programme 8: bass gillnet selectivity. Lowestoft, UK. 17pp.

Rogers, S., and Millner, R., 1996. Factors affecting the annual abundance and regional distribution of English inshore demersal fish populations: 1973 to 1995. ICES Journal of Marine Science 53, 1094–1112.

Rogers, S.I., Millner, R.S., and Mead, T.A., 1998. The distribution and abundance of young fish on the east and south coast of England (1981-1997). Science series technical report Number 118, Cefas, Lowestoft, UK. 131pp.

Smith, M.T., and Brown, M., 2009. Preliminary review of potential new nursery areas. Cefas, Lowestoft, UK. 50pp.

Tebb, A., Lawes, E., and Nelson, K. 2015. Pagham Harbour Pilot Small Fish Survey 2015. Sussex IFCA, Shoreham, UK. 14pp.

Thomas, M., 1998. Temporal changes in the movements and abundance of Thames estuary fish populations. In A Rehabilitated Estuarine Ecosystem: The Environment and Ecology of the Thames Estuary (Attrill, M. J., ed.). Kluwer Academic Publishers, London, UK. 115–139pp.

Turnpenny, A.W.H., 1988. Fish impingement at estuarine power stations and its significance to commercial fishing. Journal of Fish Biology 33, 103–110.

Walmsley, S., 2005. Solent bass trawl survey. Cefas, Lowestoft, UK. 25pp.

Walmsley, S., 2006. Thames bass trawl survey. Cefas, Lowestoft, UK. 25pp.

Walmsley, S., 2007. Survey Manual : The Thames herring trawl survey. Cefas, Lowestoft, UK. 30pp.

Walmsley, S., and Pawson, M., 2007. The coastal fisheries of England and Wales, Part V: A review of their status 2005–6. Science Series Technical Report 140, Cefas, Lowestoft, UK. 83pp.

Weijerman, M., Lindeboom, H., and Zuur, A., 2005. Regime shifts in marine ecosystems of the North Sea and Wadden Sea. Marine Ecology Progress Series 298, 21–39.

Appendix 1. Existing BNAs

The existing BNAs are defined in “Statutory Instrument 1999 No 75 The Bass (Specified Areas) (Prohibition of Fishing) (Variation) Order 1999”. The nursery areas comprise river estuaries, harbours, and power station outfalls where juvenile sea bass usually predominate and are more easily caught, particularly during the summer months. In certain nursery areas, fishing may also be subject to other restrictions implemented by the local sea fisheries committee or the Environment Agency (National Rivers Authority). Such restrictions may include prohibitions on the setting of fixed nets or restrictions on the use of mobile gear. The prohibition on sea bass fishing in nursery areas does not apply to fishing from the shore. However, it is expected that shore anglers and their associations will respect the need for this prohibition and return to the sea any sea bass caught within nursery areas.

Table A1. Existing BNAs defined in Statutory Instrument 1999 Number 75.

BNA	Description of area	Period	Area (ha)
1. Blyth Power Station	All tidal waters enclosed by a line in the south bearing 108.5º true from the Blyth Power Station chimneys in transit, to the east by a line bearing 173.5º true from a transit of the Alcan Power Station chimney and the western pylon of the northern pair of measured mile markers and to the north by a line bearing 111º true being a transit of the yellow “X” Northumberland Water Authority pipeline markers	All year	80
2. Bradwell Power Station	The area between the Baffle Wall and the Bradwell foreshore enclosed by lines drawn perpendicular (145º true) from the NE and SW corners of the Baffle Wall to the shore	All year	9
3. Grain Power Station	The area enclosed by a line drawn 120º true through Grain Martello Tower and Grain Hard buoy to Garrison point, and a line drawn 114º true from the foreshore at Grain Power Station to the western extremity of the Ro-Ro terminal, and the Isle of Grain and Sheerness foreshores	All year	180
4. Kingsnorth Power Station	The area enclosed by Bee Ness jetty and a line drawn 204º true to the tip of Oakham Ness jetty, thence 260º true to the SE tip of Kingsnorth jetty, and along the seaward arm of Kingsnorth jetty and then 298º true to the Kingsnorth Power Station foreshore	All year	381
5. Dungeness Power Station	All tidal waters enclosed by a line drawn 180º true from the eastern end of the Dungeness ‘A’ building to a point 600 m below MLW springs, thence 270º true for a distance of 1 km, thence 000º true to the shore marked by an isolated building “hangar B1” situated between the Dungeness ‘B’ complex and the power station	All year	58
6. Chichester harbour	All tidal waters enclosed by a line drawn 192º true from Eastoke point to Chichester Bar beacon, then 078º true to Cakeham tower	30 Apr – 1 Nov	3,325
7. Langstone harbour	All tidal waters enclosed by a line drawn 153º true from the Gunnery Range light at Eastney point to Langstone Fairway buoy (50º 46.25N 01º 01.27W), then 033º true to the foreshore east of Gunner point	30 Apr – 1 Nov	2,068
8. Portsmouth harbour	All tidal waters enclosed by a line drawn from Gilkicker point to Southsea castle	30 Apr – 1 Nov	1,880
9. Southampton water	All tidal waters enclosed by a line drawn 090º true from the Cadland foreshore to the Warsash foreshore passing through the north-west extremity of the Esso tanker jetty but excluding those waters above the Redbridge causeway on the River Test	30 Apr – 1 Nov	2,388
10. Fawley Power Station	The area enclosed by a circle drawn with a radius of 556 metres around the outfall from Fawley Power Station	all year	97
11. Poole harbour	All tidal waters enclosed by a line drawn 011º true from Jerry’s point, through Branksea castle to Salterns pier	30 Apr – 1 Nov	2,878
12. The Fleet	all tidal waters of the Fleet inside Ferry bridge	all year	495
13. River Exe, Devon	All tidal waters enclosed by a line drawn 068º true from Langstone point to Orcombe point	30 Apr – 1 Nov	1,838

BNA	Description of area	Period	Area (ha)
14. River Teign	All tidal waters enclosed by a line drawn 000º true from the Ness to the southernmost leading light	30 Apr – 1 Nov	359
15. River Dart, Devon	All tidal waters enclosed by a line drawn 064º true from Combe point to Inner Froward point	30 Apr – 1 Jan	867
16. Salcombe harbour	All tidal waters enclosed by a line drawn 090º true from Splat point to Limebury point	30 Apr – 1 Jan	592
17. River Avon, Devon	All tidal waters enclosed by a line drawn 206º true from Warren point at Bigbury-on-sea to Burgh island, and a line drawn 090º true from the southern tip of Burgh island to the coast	30 Apr – 1 Jan	211
18. River Yealm	All tidal waters enclosed by a line drawn 205º true from Season point to Mouthstone point	30 Apr – 1 Jan	212
19. Plymouth rivers	All tidal waters enclosed by a line drawn from the western end of Mountbatten pier 268º true to the landing beacon at Wilderness point in the River Tamar	All year	2,864
20. River Fowey	All tidal waters enclosed by a line drawn 270º true from Penleath point to the opposite shore	30 Apr – 1 Jan	233
21. Fal estuary	All tidal waters enclosed by a line drawn 045º true from Weir point to Turnaware point	30 Apr – 1 Jan	811
22. Percuil River	All tidal waters enclosed by a line drawn 151º true from St Mawes castle to Carricknath point	30 Apr – 1 Jan	201
23. Helford River	All tidal waters enclosed by a line drawn 199º true from Rosemullion head to Dennis head	30 Apr – 1 Jan	553
24. Camel estuary	All tidal waters enclosed by a line drawn 020º true from Stepper point to Pentire point	30 Apr – 1 Dec	1,071
25. River Torridge	All tidal waters enclosed by a line drawn 290º true from Zeta berth to the opposite shore	30 Apr – 1 Nov	188
26. River Taw	All tidal waters enclosed by a line drawn 190º true from the western end of Braunton pill to the site of the former power station at Yelland	30 Apr – 1 Nov	624
27. Aberthaw Power Station	All tidal waters enclosed by a line drawn at a radius of 1 nautical mile from Breaksea point	All year	690
28. Burry inlet	All tidal waters enclosed by a line drawn 071º true from Whiteford lighthouse to Llanelli docks and a line drawn 180º true from Whiteford lighthouse to the shore	30 Apr – 1 Nov	3,422
29. Taf, Tywi and Gwendraeth estuary	All tidal waters enclosed by a line drawn 119º true from Ginst point to Pen Towyn point	30 Apr – 1 Nov	2,212
30. Milford Haven	All tidal waters enclosed by a line drawn from the shore along the eastern side of the Texaco Terminal approach jetty to the southernmost part of the T jetty thence eastwards along the southern edge of the jetty to the extremity at No. 3 berth (51º 41.87N, 04º 57.58W) and then 098º true through the Pennar beacon to the Llanreath foreshore (51º 41.55N, 04º 57.58W) and by a line drawn 162º true along the seaward side of the Pembroke to Neyland road bridge	30 Apr – 1 Nov	1,899
31. Teifi estuary	All tidal waters enclosed by a line drawn from the boathouse, Penrhyn to the Cliff hotel, Gwbert	30 Apr – 1 Nov	616
32. River Dyfi	All tidal waters enclosed by a line drawn 168º true from Trefeddian hotel (52º 32.8N, 04º 03.6W) to the flag pole at Ynys Las (52º 31.4N, 04º 03.8W)	30 Apr – 1 Nov	1,413
33. River Mawddach	All tidal waters enclosed by a line drawn 226º true from the flagpole at Barmouth (52º 43.1N, 04º 03.1W) to the perch at 52º 42.7N, 04º 03.7W thence 155º true to the corner of the sea wall at Fairbourne (52º 42.5N, 04º 03.6W)	30 Apr – 1 Nov	952
34. Dwyryd/Glaslyn estuary	All tidal waters enclosed by a line drawn 152º true from the White House (52º 54.4N, 04º 09.1W) to Harlech point (52º 53.7N, 04º 08.5W)	30 Apr – 1 Nov	1,059
35. Conwy estuary	All tidal waters enclosed by a line drawn in a northerly direction from Penmaen-bach point 001º true to the most westerly point of Great Ormes head	30 Apr – 1 Nov	1,541
36. Dee estuary	All tidal waters enclosed by a line drawn 213º true from Hilbre point to Mostyn quay	30 Apr – 1 Oct	8,356
37. Heysham Power Station	All tidal waters enclosed by a line drawn 085º true from No. 7 buoy (54º 01.22N, 002º 56.28W) to the shore, a line drawn 020º true from No. 7 buoy towards the Dolphin (54º 02.40N, 02º 55.52W), and a line drawn 102º true through the leading lights to Heysham harbour	All year	137

Appendix 2. Defra BNA questionnaire

A questionnaire was sent by Defra to the IFCAs and MMO on the BNAs, with the request to include specific evidence or detailed scientific data along with responses. The following questions were asked relating to general information, existing and new BNAs, enforcement, and other fisheries:

1. Have BNAs have been effective in protecting juvenile bass in your area?
2. Do you consider BNAs to have also provided protection of bass above the current 36 cm MLS?
3. Are the boundaries of the existing BNAs correct as set out in the current Statutory Instrument (please confirm in the response which BNAs you are referring to, using the list attached)?
4. If the answer to 3 is no, could you suggest new boundaries for the BNAs and the rationale for those?
5. Are there any BNAs which are no longer justified (e.g., because of a shift in habitat utilisation, or habitat quality)? If so, could you explain why?
6. Some of the BNAs are seasonal. Do you consider this to be appropriate? If not, can you suggest new periods, including any justification for the change?
7. Are there new areas where significant or sizeable populations of juvenile bass can be found that might benefit from protection from exploitation either now or in the future? If so, can you give a brief outline of the location?
8. Are there any sources of catch data to support any suggested new areas?
9. How would you describe levels of compliance to BNA regulations within your organisation’s jurisdiction?
10. Can you provide a description of the enforcement your organisation has undertaken in regard to BNAs over the past five years? Should this information be available for a longer (or shorter) period, please provide and specify the period. Please also provide figures relating to inspections, warnings, or prosecutions.
11. What activities other than enforcement does your organisation do to aid compliance to BNAs e.g., notices to fishermen, website, articles etc.? Have these activities been reviewed for their effectiveness and if so, how effective are they?
12. What are the main obstacles, if any, to enforcement?
13. There is currently a prohibition on fishing with sand eels. Should this prohibition be maintained? Would it be appropriate to extend the prohibition to other baits?
14. Are there any other types of activity in nursery areas that impact on enforcement? If so how this could be addressed?
15. Would additional protective measures for BNAs have an impact on the protection of other species e.g., grey mullet, black bream?
16. Are there any other measures which could be taken to improve enforcement of BNAs? For example, deeming clauses, permanent closures etc.?
17. Do fishing activities for other species potentially impact on bass juveniles?
18. If the fishing activities for other species were restricted in the BNAs, would the vessels affected be:
    a. Able to fish elsewhere with little or no effect?

    b. Able to fish elsewhere, but with increased costs (e.g., increased fuel use due to travelling to other areas further away)?
    c. Able to fish elsewhere but with reduced landings (e.g., due to exploiting less rich fishing grounds)?
    d. Unable to fish elsewhere?

19. What level of recreational fishing activity takes place in the BNA? Is this from the shore or boats?
20. Do you have any evidence of survivability of juveniles from angling in BNAs?
21. Are you aware of other interested organisations in your local area who should be contacted in connection with this review?
22. Could BNAs in your area support the fulfilment of any other legal requirements (e.g., if they fall within European Marine Sites, or MCZs)?
23. Could BNAs provide secondary environmental benefits such as reduction in fish discards, or reduction in seabird bycatch?
24. Could BNAs provide any other socio-economic benefits in your local area (e.g., educational, cultural, and recreational)?
25. Do you have any other observations or comments in relation to BNAs?

Centre for Environment Fisheries & Aquaculture Science

World Class Science for the Marine and Freshwater Environment

We are the government's marine and freshwater science experts. We help keep our seas, oceans and rivers healthy and productive and our seafood safe and sustainable by providing data and advice to the UK Government and our overseas partners. We are passionate about what we do because our work helps tackle the serious global problems of climate change, marine litter, over-fishing and pollution in support of the UK's commitments to a better future (for example the UN Sustainable Development Goals and Defra's 25 year Environment Plan).

We work in partnership with our colleagues in Defra and across UK government, and with international governments, business, maritime and fishing industry, non-governmental organisations, research institutes, universities, civil society and schools to collate and share knowledge. Together we can understand and value our seas to secure a sustainable blue future for us all, and help create a greater place for living.

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