C-Bass insights

Population studies in support of the conservation of the European sea bass (C-Bass)

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These excerpts and notes aim to provide a summary of some of the key features of the above report and associated research papers (see below), which may be of interest to BASS members.

Introduction

This important Defra-funded project ran from 2013 – 2020. From 2018 – 2020 it was joined by a sister project, Sea Bass Fisheries Conservation UK (reported separately), which aimed to engage with a broader range of stakeholders to gather knowledge of regional and seasonal movements and distribution of bass throughout their life stages. The outputs from several other research projects also contributed to the final report. Throughout the duration of C-Bass, Cefas collaborated with French colleagues at Ifremer, who released over 1400 DST- tagged bass during a four-year research programme (BARGIP, 2013-2017).

The overall aim of C-Bass was to build the evidence base and methods required to successfully manage European sea bass (referred to as bass hereafter), and understand how these methods can be applied to other species that are important to both commercial fishers and recreational anglers. The overall aim was also to achieve a more comprehensive overview of bass stock structure and distribution, and to better understand the life-history movements of bass.

C-Bass has established a clear spatial picture of the fishing pressures on bass, and how fishing mortality is generated by the distribution and movements of the fish relative to fishing pressure zones. Adult bass migrate annually to offshore waters where international fleets operate, but tend to return to the same coastal locations where persistent localized depletion could potentially occur dependent on the fishing effort exerted there.

Migrations and movements

C-Bass used Data Storage Tags (DSTs) to track fish over the duration of the survey. These were programmed to record the sea temperature (every 10 minutes) and depth (every minute) experienced by fish. In this way, it is possible to geolocate fish, and to reconstruct their movement trajectories.

244 adult (>42cm) bass were tagged with DSTs at five locations on the English coastline between 2014 – 2019. By April 2020, fifty-five (25%) of the DSTs had been returned.

The maximum distances travelled from the point of release were 419 km in the English Channel, 668 km in the southern North Sea, and 419 km in the Irish Sea.

Across all areas there was movement from shallow inshore areas in the summer (presumed feeding grounds) to deeper waters in the winter (presumed spawning grounds) notably the deeper waters near the Hurd Deep in the English Channel, Western Deep Water in the southern North Sea and St George’s Channel in the Celtic Sea.

Channel sea bass returned to shallow grounds from April onwards then again migrated to deeper waters between January and April the following year.

The reconstructed daily positions of the 55 returned DSTs suggests ‘breeding partial migration’, where resident and migratory bass separate to breed, with substantial mixing between the English Channel, the North Sea, and the Irish Sea. Some fish appear to migrate to spawning grounds which are more local to the areas where they are normally resident over the summer, while others migrate to more distant areas to breed - for example, sea bass tagged off the coast in the North Sea migrating to the English Channel.

Differences in behavioural strategies are difficult to disentangle without more returns, though results suggest that smaller bass released in the English Channel were more likely to be migratory than larger counterparts released from the same area. Large fish remaining more resident may still be spawning but in the local area rather than further afield.

Previous studies showed that the southwest and west coasts had high levels of immigration from other regions, in contrast to the southeast (southern North Sea), which appears to be a net exporter of sea bass. Similar patterns were found in the present study, with English Channel released sea bass mostly remaining resident and around half of the east coast releases migrating. It may be that bass preferentially adopt the southwest and west coasts as their summer feeding areas, possibly linked to food availability.

Movement between areas appears rapid with most migrations being made along the coast. This could be significant e.g. for anglers or commercials targeting migrating bass.

Stock structure & distribution

Stock structure remains a key uncertainty, alongside the level of mixing between the northern and Biscay management areas. Both recapture locations and reconstructed daily positions indicated considerable mixing between sea bass tagged in the English Channel, North Sea, and the Irish Sea.

Initial results suggest that a separate Irish Sea stock is unlikely, as all recovered fish from the eastern Irish Sea releases (n=12) exhibited migrations into the Celtic Sea during winter, remaining in the deep waters of the Celtic Sea until the end of March, before returning to shallow waters of the Irish Sea. The Northern stock covers the North Sea, English Channel, Celtic Sea and Irish Sea.

The results of this study suggest that there is considerable potential for genetic mixing because of larval dispersal leading to weak stock differentiation.

Spawning

There appears to be three main spawning areas. These are in the English Channel near Hurd’s Deep (an underwater valley northwest of Guernsey), Western Deep Water in the southern North Sea and St George’s Channel, a sea channel connecting the Irish Sea to the north and the Celtic Sea to the southwest (situated between Fishguard and Rosslare). The suggested spawning area in the southern North Sea has not previously been described but has been the subject of intense local debate by stakeholders.

Adult bass migrate to pre-spawning areas in the western English Channel between October and December as females seek water warmer than 9°C. Spawning then starts offshore in the Celtic Sea and western English Channel from February and spreads east as the water attains 9°C.

As the spawning season progresses, and particularly in years with stronger westerly winds and warmer conditions, spawning is likely to penetrate farther east in the Channel and into the North Sea.

Spawning commences earlier as you go further south. In Ireland, it occurs from April to mid-June, in Brittany from February to May and in Cadiz (southern coast of Spain) from October to January. The onset of spawning is thought to be triggered by photoperiod (day length) rather than an increase in temperature.

Fig. 3**.** Below shows a schedule for spawning migrations. Outer circle: migration to (pre-spawning areas) is triggered by Sea Surface Temperature (SST) and can take place between October and March. Inner circle: spawning takes place within offshore spawning patches appearing February–May.

N.D. Walker, et al. *Ecological Modelling 431 (2020) 109179*

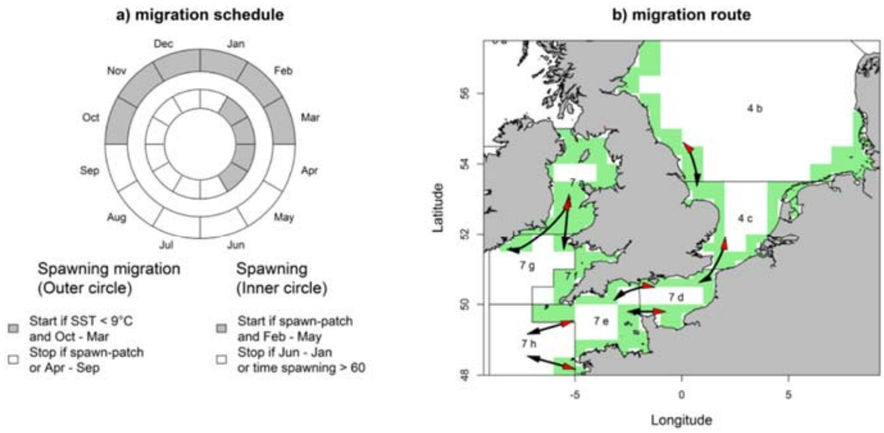


Fig. 3. (a) Schedule for spawning migrations. Outer circle: migration to (pre-)spawning areas is triggered by SST and can take place between October and March. Inner circle: spawning takes place within offshore spawning patches appearing February–May. b) Mature individuals migrate following the hypotheses of Pawson et al. (1987, 2007). Arrows show movement around the coast to and from the English Channel and Celtic Sea (although movement offshore can occur anywhere temperature conditions are satisfied) with black arrow heads representing the spawning migration and red arrow heads the feeding migration. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

Once offshore, the individual moves randomly within spawning patches until assumed spent after spawning, which occurs either after spending 60 days offshore or on 1 June, whichever occurs first.

Spawning involves the release of ripe ova in two to three batches over a two- to three-week period. Larger fish with higher fat reserves can produce more eggs (i.e., have higher potential fecundity) than smaller fish, so the more mature fish there are, the greater their collective realised fecundity.

If the mature fish have had access to abundant energy, there is more left to produce eggs after the necessary allocation to maintenance and growth. There is some evidence that fish that have had access to better nutrition may also be able to produce higher quality eggs, which may increase larval survival and stock recruitment. Individuals in warmer sea temperatures may ingest more energy, grow faster and have higher levels of reserves from which to produce eggs.

Spatial management measures to reduce targeting of spawning aggregations in only some areas could have a disproportionate benefit on settlement of young sea bass in nursery areas, with the strongest transport connectivity with the spawning sites being protected. For example, protection of spawning aggregations in the northeast Celtic Sea and off the Bristol

Channel might have greatest benefit for settlement to sea BNAs (Bass Nursery Areas) in the Bristol Channel, southwest Wales, parts of southeast Ireland, and in the Irish Sea. Conversely, protection of aggregations only in the Western Channel would mainly benefit nursery areas in both sides of the English Channel depending on the wind conditions and residual current patterns driving the larval transport. Finally, protection of spawning aggregations farther east in the English Channel and in the southern North Sea would have greatest benefits for nursery areas in the eastern Channel and North Sea.

Recruitment/settlement

The recruitment process (i.e., the surviving from egg through larval stages to a harvestable fish) is particularly precarious and influenced by many drivers, the result of which can be observed as recruitment rates with high levels of inter-annual variation. These drivers include winter SST and wind direction and strength in year of spawning, SST in the first winter on the nursery ground and river flow.

The pelagic phase (period of time during the life cycle after spawning spent floating freely in the water column, usually as a larval constituent of plankton) of bass lasts between 50 and 70 days, and dispersal brings a proportion of the larvae to the vicinity of nursery grounds in estuaries, salt marshes, and other sheltered coastal sites.

Dispersal is driven mainly by the influence of wind on residual currents and water temperature, with warmer temperatures reducing the duration of the pelagic phase, and stronger currents increasing the potential to drift further. Larval duration was driven by water temperature and showed an increase in duration from the southwest to northeast areas of the northern stock.

The number of larvae that make it through to be juvenile fish is dependent on their growth rate, which in turn depends on food availability, temperature, and the density of competitors. The daily pelagic mortality rate is far greater than the adult mortality, so there is a substantial payoff to growing faster to escape the pelagic phase earlier.

Given the high influence of environmental conditions on survivability and growth of juveniles, there is no clear stock-recruitment (S-R) relationship for European sea bass.

The study compared settlement (assumed to mean the arrival of fry in nursery areas) in a Good Spawning Year (GSY), with a Poor Spawning Year (PSY). In the GSY, winds were relatively strong and homogeneous westerlies, but in the PSY, average winds were more variable with no particularly clear directionality or strength.

Settlement in the northern stock is highly correlated with temperature with poor settlement in cold years. During the spawning period, the area delimited by the 9°C isotherm in the GSY gradually expanded with time, whereas in the PSY, this area contracted slightly over the first two months and then expanded in April.

More eggs were spawned in the GSY as warmer sea temperatures increased the area available for spawning.

Limited larval dispersal in the PSY meant that only the southern North Sea was reached in the PSY, but settlement occurred in the northern North Sea nursery areas in the GSY.

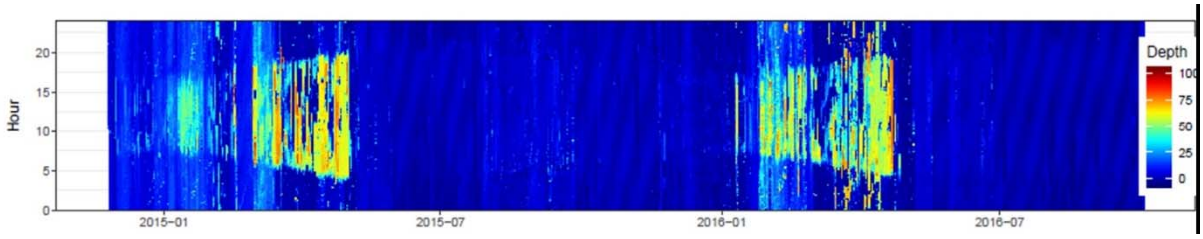
Nursery areas around southwest England, southwest Wales and coastal sites in northwest Brittany and southeast Ireland, are likely to have high settlement rates with relatively short larval transport connections with the main spawning sites in the western English Channel and Celtic Sea. As the spawning season progresses, and particularly in years with stronger westerly winds and warmer conditions, spawning is likely to penetrate farther east in the Channel and into the North Sea. In years with stronger penetration of warmer water into the southern North Sea, spawning there can lead to advection (horizontal transport), of larvae into nursery areas such as in the Wadden Sea (an intertidal zone in the southeastern part of the North Sea which lies between the coast of northwestern continental Europe and the range of low-lying Frisian Islands, forming a shallow body of water with tidal flats) and estuaries in the Netherlands, or in the Thames.

Environmental drivers

Prey availability and temperature are two key environmental drivers that affect rates of growth and reproduction in bass and ultimately population dynamics.

Information on prey availability and temperature are derived from two satellite products: chlorophyll concentration, which the authors use as a proxy for prey availability, and SST. Local food density available to sea bass can be represented by observed phytoplankton density. Areas of high phytoplankton density are likely favourable to all trophic levels; that is, they will correlate with high densities of species that directly consume phytoplankton and consequently will be attractive to species that prey upon these secondary consumers and a continuation of this pattern up the food chain. There is likely a delay in time from a large amount of energy being present in the form of phytoplankton till it is available to sea bass as a range of prey.

There is individual variability in the vertical behaviour of bass (more information will be published on this in the coming months). The figure below represents a single bass track which was released and recovered from the English Channel. This fish spent all its time in shallow water while inshore during the summer, regardless of the time of day, only moving up or down the water column a little with the tides. When offshore (Jan – April) it moved into shallower water at night.



Interaction with other species

A stable isotope analysis was used to investigate the potential consequences that growing gilthead sea-bream populations might have on bass, by examining the potential for resource competition between juveniles. Although both species appeared to be feeding on similar prey, they also seem to have different realised niches within the study system.

Future research

In the section on future research needs, there are some things that BASS members may be able to help with. For example:

Under Stock delineation, the report mentions a large-scale mark-recapture programme. This is something we have helped Cefas with before, back in the early 2000's. There is however some doubt about whether licencing and research oversight arrangements would allow this today.

Under Stock dynamics, the report notes that surveys that catch bass are limited. If I have interpreted this correctly, with appropriate safeguards regarding mark confidentiality, there is a possibility that members may be willing to help with this.

Under variation in year class strength, the report notes that further studies are needed for a broader range of estuaries to understand both drivers of year class strength and the contribution of different nursery areas to the stock. BASS is currently involved in two FISP applications which could have a bearing on this, and I have been liaising with Steve Colclough about possibly providing training for BASS members to help them get involved with/set up juvenile bass surveys in their areas.

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With thanks to Dr Kieran Hyder and Dr Serena Wright of Cefas.

Associated research papers

A spatially explicit individual-based model to support management of commercial and recreational fisheries for European sea bass *Dicentrarchus labrax.* Ecological modelling 431 (2020) 109179.

Assessing the sublethal impacts of anthropogenic stressors on fish: An energy-budget approach. Fish and Fisheries. 2020;21:1034–1045.

Incorporating environmental variability in a spatially-explicit individual-based model individual-based model of European sea bass. Ecological modelling 466 (2022) 109878.

The influence of oceanographic conditions and larval behaviour on settlement success—the European sea bass Dicentrarchus labrax (L.) ICES Journal of Marine Science (2017), doi:10.1093/icesjms/fsx195