Review of protection measures for Atlantic salmon and sea trout in inshore waters

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1 Background

This review has been produced by the Environment Agency to support the Inshore Fisheries and Conservation Authorities (IFCAs) in managing the exploitation of sea fisheries resources in order to protect migratory fish species which spend part of their lifecycle within the marine environment.

This follows a series of legal discussions between the IFCAs, Marine Management Organisation (MMO), Defra and the Environment Agency which concluded that the MaCAA *(*Marine and Coastal Access Act, 2009) provides IFCAs with the duty to protect migratory salmonids from sea fisheries resource exploitation (Defra letter, 2014). There is a clear distinction between the Environment Agency statutory duty to manage migratory salmonid fisheries and the IFCAs duty to manage sea fisheries resource exploitation so that it does not impact upon other marine fauna, including migratory salmonids. In respect of this, Defra also recognised the need for the Environment Agency to take the lead in providing the IFCAs with the evidence to support the implementation or retention of local management measures to protect migratory fish species. For migratory salmonids, this should include a comprehensive package of the best available information regarding migratory salmonid biology, behaviour at sea, life cycle and conservation challenges. This document specifically considers the national level evidence relating to Atlantic salmon (*Salmon salar*) and sea trout (*Salmo trutta*). Further local and river specific evidence will also be provided by the Environment Agency to IFCAs in support of byelaws to protect these species.

The ecology and life cycle of Atlantic salmon and sea trout have been extensively reviewed elsewhere (e.g. Hendry & Cragg-Hine, 2003; Klemetsen et al, 2003; Harris & Milner, 2007) and are not considered here. Figure 1.1 below provides an overview of the lifecycle of migratory salmonids to assist with understanding the terminology used in this document.

This review considers specifically the potential impacts of non-target[1] inshore sea fisheries on Atlantic salmon (*Salmo salar*) and sea trout (*Salmo trutta*), providing the evidence base to support appropriate mitigation measures to protect migratory salmonids at various stages of their lifecycle whilst migrating through, and feeding in, inshore (within 6 nautical miles) coastal areas.

The review includes:

- A review of the potential impacts of indirect fisheries on Atlantic salmon and sea trout
- A review of existing protection measures for Atlantic salmon and sea trout in each IFCA region
- A review of the evidence for appropriate protection measure for salmonids in inshore fishery areas, including best practice recommendations

[1] Non-target fisheries are considered to be those which are not licensed by the Environment Agency to catch salmon or sea trout but which may do so incidentally in the process of capturing other target species.

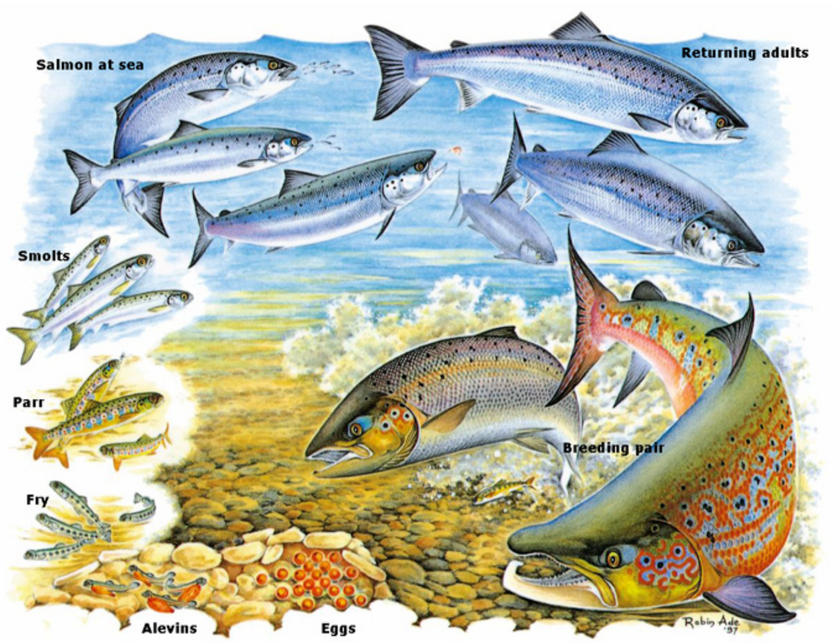

Figure 1.1: Lifecycle of Atlantic salmon showing terminology for the various life stages and the habitat (freshwater / sea) in which they are found. Sea trout have a similar lifecycle although some adults may mature in freshwater and don't undergo seaward migration. *Source – Atlantic Salmon Trust.*

2 Potential impacts of indirect fisheries

This section reviews the evidence regarding the overall risk to salmonids from capture by indirect fisheries; this evidence underpins the need for any subsequent protection measures.

2.1 Consequences of entrainment by indirect fisheries

The incidental capture of salmon and sea trout by fishermen targeting other species is not an offence but where they are caught, legislation (Salmon and Freshwater Fisheries Act) states that they cannot be retained and must be returned. The fate of these returned fish is an important consideration in determining the potential impacts of non-licensed fisheries on salmonid stocks. In some fisheries, immediate mortality of salmonids has been observed to be low (approximately 5%, e.g. Vander Haeger et al, 2004; Raby et al, 2012). However, there are growing concerns that this may underestimate the overall potential impacts by failing to consider delayed mortality, and other sub-lethal effects such as failure to breed, occurring days to weeks after release.

Physical damage as a result of capture and/or handling and release will vary in severity by gear type, retention time, species and handler but can typically include mucous and scale loss, net marks, abrasions, fin tear and loss, visceral damage, haemorrhaging and barotrauma (Potter & Pawson, 1991; Chopin & Arimoto, 1995; Makinen et al, 2000; Vander Haegen et al, 2004; Baker et al, 2013; Nguyen et al, 2014). Haemorrhaging appears to be more common in salmonids than in other species potentially due to the prolific network of capillaries around the muscles (Potter & Pawson, 1991). Injury can also cause stress, potentially exacerbated by air exposure on removal, which can increase susceptibility to pathogens (Baker & Schindler, 2009; Baker et al, 2013; Nguyen et al, 2014), resulting in delayed mortality. It is considered that fish that become enmeshed in gillnets cannot generally be released unharmed unless removed within seconds of capture (Potter and

Maoiléidigh, 2006). Internal injury sufficient to result in mortality can occur without evidence of external physical damage (e.g., Makinen et al, 2000).

A number of studies have sought to quantify delayed mortality in fisheries for a range of salmonid species. Early estimates of delayed mortality in Pacific salmon fisheries is between 80 and 100% for fish escaping from gillnets (Chopin & Arimoto, 1995 and references there in), although these estimates are considered unrealistic by some (Potter & Pawson, 1991). Potter & Pawson (1991), however, recorded relatively high recapture rates (>25%) of fish previously caught and released from the north-east coast drift net fishery concluding that the fishes' chance of survival after release from the nets were very high.

More recent studies, involving radio-telemetry tracking and more realistic capture/retention scenarios suggest a more complex picture to a fishes' chances of survival. Whilst studies are often variable in their approach, there are two key findings consistently supported throughout. The first of these is that fish which encounter netting suffer increased mortality compared to fish that have not. Delayed mortality of Chinook salmon captured and released from 8″ and 5.5″ gillnets was estimated to be 49% and 43% respectively compared to control fish (Vander Haeger et al, 2004). Similarly, Baker and Schindler (2009) observed that pre-spawning mortality of gillnet injured sockeye salmon, naturally escaped from downstream commercial fisheries, was significantly greater than that of uninjured control fish (51% compared to 6%). With the incidence of past entanglement in commercial gillnets given as 11, 18 and 28% in three years of study, this could represent a significant reduction in the reproductive capacity of the stock. Nguyen et al (2014) also found that survival to spawning rivers by net injured fish was reduced by 14.5% compared to control fish, although this study may be considered less representative as fish were intentionally injured in experimental simulations rather than escaping genuine fishery capture.

The second key finding is that delayed mortality is linked with severity of injury. Baker and Schindler (2009) observed that survival of salmonids on the spawning grounds was inversely correlated with the severity of injury: 16% mortality for minor injuries, 80% for moderate injuries and 95% for severe injuries (6% mortality in controls). Injury rates were strongly associated with fungal infection and linked to the inhibition in development of sexual morphological traits (Baker & Schindler, 2009; Baker et al, 2013). Raby et al (2012) similarly found that migration success of released coho salmon was linked to reflex impairment indicators, supporting that the degree of injury from fishery entrainment is linked to survival prospects.

There is evidence that the survival and reproductive fitness of salmonids which have encountered fishing nets can be significantly reduced and therefore measures to minimise the risk of incidental capture by non-target fisheries is an important component in efforts to conserve Atlantic salmon and sea trout stocks.

2.2 Risk of capture by non-target fisheries

Emigrating juvenile salmon and sea trout (termed smolt), are generally considered to be at lower risk of incidental capture than adult salmonids. Their small size, surface orientation and diet composition mean that they are unlikely to be intercepted by the majority of inshore fishing vessels. The greatest risk is posed by fisheries targeting species with overlapping diet and size range which for salmonid smolts includes pilchard/sardine (*Sardinia pilchardus*), herring (*Clupea harengus*), sprat (*Sprattus sprattus*) and mackerel (*Scomber scombrus*). Recent trends show landings of both herring and mackerel by UK vessels has increased; herring by 52% since 2011 (total catch of 94,000 tonnes) and mackerel by 59% since 2006 (total catch of 164,000 tonnes) (Radford, 2014), though statistics do not indicate if this is in inshore or offshore waters. Open water trawls for salmon post-smolts frequently observe a by-catch of both herring and mackerel (Shelton et al, 1997; Reddin et al, 2006) and therefore it is reasonable to assume that salmonid smolts have the potential to be caught in fisheries targeting these species where they occur during migratory periods (see Section 4.2.1).

For adult salmon and sea trout, the risk of capture by non-target fisheries is increased. Nets with a mesh size between 100 and 135 mm are generally used to target salmon and sea trout (Figure 2.1) (Potter & Pawson, 1991). More specifically, a mesh size of 120-130 mm is generally used for salmon as it is considered to be the optimum size to catch grilse. A slightly smaller net size of 102 mm is considered optimum for sea trout.

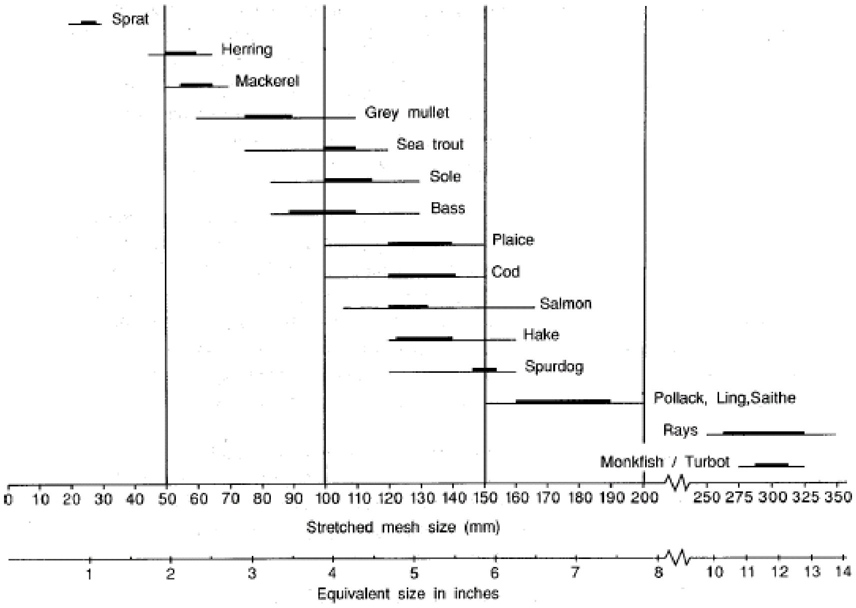

Figure 2.1: Mesh size ranges used in gillnet fisheries in England and Wales (from Potter & Pawson, 1991)

These net sizes generally overlap with those of a number of other species. Figure 2.1 provides a general indication of fisheries targeting other species which may be more likely to result in the incidental capture of salmon and sea trout, i.e. those which use an overlapping net size and occur in the same waters. For adult salmon, the fisheries considered most likely to result in incidental captures are those for sea trout, bass (*Dicentrarchus labrax)* and grey mullet (*Chelon labrosus)* (Potter & Pawson, 1991). For adult sea trout, fisheries for Atlantic salmon, bass, grey mullet, sole (*Solea solea*) and plaice (*Pleuronectes platessa)* are the most likely (Potter & Pawson, 1991). In July 2015 it was announced that European Union Member States voted to increase the minimum conservation size for bass to 42 cm (from 37.5 cm). This is likely to increase net dimensions for bass fisheries and could potentially increase the likelihood of salmon and sea trout being enmeshed within nets targeting bass.

The overlap of these species is further supported by capture data from drift and beach net fisheries off the coast of East Anglia. Pawon (2008) reviews the complex inshore and beach netting fishery of the area and highlights a number of licensed and unlicensed sea trout fisheries where bass, grey mullet, herring, mackerel, and a variety of flatfish are also targeted.

An investigation into illegal salmon poaching in the Thames estuary also identified gill and drift netting that target sea bass and grey mullet as the most common methods of catching salmonids (Waugh, 2004). Sea trout have also historically been recorded as being caught in drift nets set for bass and mullet off the Norfolk coast (Gray, 1995). Assessments of unreported catches of Atlantic salmon in England and Wales for ICES also recognises that unlicensed catches tend to arise as by-catch taken by nets legitimately targeting bass and other marine species (CEFAS & Environment Agency, 2007).

3 Existing protective measures

There are 10 regional IFCA's for England each with the individual responsibility for determining local byelaw restrictions. Consequently, existing protection measures for salmonids vary between regions. This may be due to over-riding local factors or due to a previous lack of evidence to inform management decisions. A summary of existing protection measures for salmonids in each IFCA region is presented in Table 3.1. More detailed information on the specific byelaws can be found on the IFCA websites as detailed in the table.

The existing protection measures consist of a mixture of physical (depth), temporal (seasonal) and spatial (geographical) restrictions on fixed netting activity. The majority relate to fixed engine methods only, with measures for drift netting in place only in the North Western and South West districts.

Table 3.1: Summary of existing protection measures detailed in existing byelaws in each IFCA district

IFCA region	Physical*	Temporal	Spatial
Cornwall Cornwall IFCA byelaws	3 m headline	All year	In the following 9 inshore areas associated with migratory salmonids; – Rumps Point – Trevose Head – Towan Head – Ligger Point – Rosemullion Head – Black Head – Nare Head – Zone point – Dodman Point – Greeb Point – Pencarrow Head – Black Head – Rame Head – Hore Stone – St Ives Bay – Mount Bat
	Total fixed net ban	All year	All estuaries in Cornwall: – Camel – Gannel – Hayle – Helford – Fal – Fowey – Looe – Tamar – Crantock Beach – Porth Beach – Boscastle
	Total mobile net ban	1^{st} May – 30^{th} Dec	– Fowey – Camel

	All sea fish netting ban	All Year	– Tamar – Lynher
Devon & Severn Devon & Severn IFCA byelaws	Total fixed net ban	All year	In any inshore waters for the following estuaries or harbours; – River Axe – River Otter – River Exe – River Teign – River Dart – Salcombe – River Avon – River Erme – River Yealm – River Plym – River Tamar – River Lyn – River Severn
	3 m headline	All year	In the following areas within one nautical mile of the shore as defined by the lowest astronomical tide; – From Humble Point to Branscombe Mouth – From Salcombe Mouth to Torquay Harbour – From Mewstone to Langerstone Point – From Warren Point to St Anchorite's Rock – From Yealm Head to Rame Head – From Blackchurch Rock to Baggy Point – From Morte Point to Bull Point – From Beacon Point to Rillage Point – From Duty Point to Foreland Point

	Total sea fish netting ban (all nets)	All year	– River Tamar – River Plym – River Yealm – River Exe
Eastern Eastern IFCA byelaws	None	None	None
Isles of Scilly Isles of Scilly byelaws	none	none	none
Kent & Essex Kent & Essex IFCA byelaws	Total fixed net ban	1st April – 30th Sept	To 1.5 nautical miles in the following area; Richborough power station (Area A)
	Total fixed net ban	All year	Yanlet Creek to Crow Stone (Area A)
	1.5 m headline (fixed, gill or drift nets)	1st May – 30th Sept	Area B (former Sussex Sea Fisheries Committee regulation)
	Total netting ban (except historic)	All year	Area C (former Eastern Sea Fisheries Joint Committee regulation)
North Eastern North Eastern IFCA byelaws	4 m headline & set seaward of 5 m contour line	1st Nov – 25th March	– Area D (Tees, Wear and Tyne)
	4 m headline & set seaward of 10 m contour line	26th Mar – 31st Oct	– Area D (Tees, Wear and Tyne)
	Nets for taking inter-tidal and sub-tidal bass: permit only (limited to 5 per calendar year) and with the requirement to report capture of salmon between 1st – 30th April which may result in fishery closure until 15th Oct.	15th Oct – 30th April	– Area C (The Holderness Coast)

	Total fixed net ban	All year	In the following estuaries (tidal waters inland of the IFCA boundary); – River Wear – River Tees – River Esk – River Humber
North Western North Western IFCA byelaws	Total fixed net ban (unless authorised)	1st May – 30th Nov	In the following 7 inshore areas; – Duddon estuary – Leven estuary – Kent estuary – Keer estuary – Ribble estuary – Lune estuary – Wyre estuary
	Total mobile net ban (unless authorised)	1st May – 30th Nov	In the following 7 inshore areas; – Duddon estuary – Leven estuary – Kent estuary – Keer estuary – Ribble estuary – Lune estuary – Wyre estuary
Northumberland Northumberland IFCA byelaws	Total ban	All year	River Tweed estuary (Tweed box)
	4 m headline & not in water shallower than 7 m total depth (other than authorised T&J nets)	26th Mar – 31st Oct	In the following 2 inshore areas: – South Shields – Marsden Point – Hauxley Point – Coquet Island Light House – Seaton Point

	4 m headline	1^{st} Nov – 25^{th} Mar	In the following 3 inshore areas: – Tyne Playground – Wansbeck Playground – Coquet Playground
Southern Southern IFCA byelaws	Total ban, except licensed fyke	1^{st} Apr – 30^{th} Sept	In the following 5 inshore areas associated with migratory salmonids; – Poole Harbour – Keyhaven – Lymington – Test and Itchen – River Meon
	3 m headline	1st May – 31st July	– In the following inshore area; – Lyme Bay
	Total fixed net ban	16^{th} Feb – 30^{th} Sept	– Christchurch harbour
Sussex Sussex IFCA byelaws	Total ban	1^{st} May – 30^{th} Sept	In the following 6 inshore areas associated with migratory salmonids; – Rye Harbour. – Cuckmere Haven – Newhaven Harbour – Brighton Marina – Shoreham Harbour – Littlehampton Harbour
	Total ban, except licensed fyke	1^{st} May – 30^{th} Sept	In the following inshore area; – Chichester Harbour
	Total ban	1^{st} Oct – 30^{th} April	In the following inshore area; – Chichester Harbour
	1.5 m headline	1^{st} May – 30^{th} Sept	All other areas in the district

* the depth below which the headline of fixed nets must be set at all states of tide
+ no byelaws specific to Kent & Essex but Area B was formerly part of Sussex Sea Fisheries Committee and therefore previous byelaws apply

4 The evidence base for protective measures

Section 3 identified the range of protection measures currently in place to protect migratory salmonids in English inshore areas. This section reviews the supporting evidence for each of these measures and for any new measures that could be considered appropriate. Best practise recommendations are made and measures should be considered in combination to identify the correct balance to maximise protection for migratory salmonids in inshore areas whist minimising unnecessary impacts to local fisheries interests.

4.1 Physical protective measures

The existing protection measures around the country often involve a depth restriction below which the headline of nets must be set, recognising previous evidence to suggest that adult salmonids are predominantly surface orientated whilst in inshore areas (Hawkins et al, 1979). Current depth restrictions have been identified as being between 1.5 m and 4 m below the surface (see Table 3.1). This section reviews the best available evidence on swimming depth of Atlantic salmon and sea trout in inshore areas to inform best practise.

A number of studies have looked to investigate the vertical distribution of adult salmon employing various tracking methods (Potter, 1985; Holm et al, 2006; Sturlargsson et al, 2009; Davidsen et al, 2013; Godfrey et al, 2014). Whilst the number of fish in many tracking studies is small (for example only 4 in Holm et al, 2006 and only 2 in Sturlargsson et al, 2009), collectively they provide evidence to support that adult salmon are located close to the surface (< 5 m) the majority of the time whilst in coastal areas and undertake irregular, but frequent, deeper dives of short-duration.

Tracking of a small number of Atlantic salmon returning to rivers on the north-east coast, Potter (1985) documented that the fish spent the majority of their time in water less than 4 m depth. Holm et al (2006) documented that salmon feeding in the open ocean stay in the upper 5 m of water for 60 per cent of the time, with dives reported as deep as 280 m. Davidsen et al (2013) recorded slightly shallower mean swimming depths of 0.5 m – 2.5 m, with dives down to 30 m within a Norwegian fjord. A recent study by Godfrey et al (2014) provides the most extensive survey to date of adult Atlantic salmon behaviour in the coastal zone, reporting information from 34 fish fitted with pop-up satellite transmitters off the coast of Scotland. They found salmon spent a median of 72-86 percent of their time at 0–5 m, 79–90 percent at 0–10 m, and 6–9 percent of time at >20 m depth. Dives were recorded down to 118 m depth. Whilst these general trends exist, there is evidence that behaviour varies extensively between individuals (Holm et al, 2006; Godfrey et al, 2014), potentially between groups of individuals (Godfrey et al, 2014) and between night and day (Potter, 1985; Godfrey et al, 2014).

There is evidence to support that Atlantic salmon kelts (post-spawning adults) are also largely surface orientated. Reddin et al (2011) observed that fish spent the majority of their time in the upper 5 m during the day, spending over 50 percent of their time within 2 m of the surface, and were even closer to the surface at night. Deeper dives up to 30 m were recorded with dives more frequent during the day. Halttuen et al (2009) observed that Atlantic salmon kelts within a Norwegian Fjord remained predominantly in the upper water column spending 94 percent of their time within 5 m of the surface. Again, deeper dives to 83 m were recorded with the authors hypothesising this was for the purpose of orientation. Hubley et al (2008) suggest an even shallower depth range with 90 percent of detections within just 1 m of the surface for Atlantic salmon kelts migrating in the inner estuary of the LaHarve River in Canada, and 99 percent within 5 m (80.7 percent and 96.8 percent at 1 m and 5 m respectively in the outer estuary).

There is less information available on the vertical distribution of sea trout but what data is available supports behaviour similar to that of Atlantic salmon. Rikardsen et al (2007) tracked sea trout within a Norwegian Fjord and found they spent 93% of their time in water no deeper than 3 m with irregular, short-duration dives down to 28 m. Data storage tags revealed that sea trout migrating from a river in south east Iceland spent the majority of the time in water less than 5 m, with deeper dives down to 26 m (Sturlaugsson & Johannsson, 1996). As with the majority of studies of salmon, sea trout are believed to be located closer to the surface at night than during the day (Sturlaugsson & Johannsson, 1996).

Whilst existing protection measures recognise the importance of protecting returning adult fish, similar measures could be considered necessary for emigrating smolt (although see section 4.2.1). There is evidence to support that like adult salmonids, smolts and post-smolts are also found in the upper 0-5 m of the water column (Holm et al, 2000; Reddin et al, 2006; Renkawitz et al, 2012; Thorstad et al, 2012), undertaking irregular deeper dives to 6-7 m (Davidsen et al, 2008), or potentially deeper (25-50 m suggested in Reddin et al, 2006). Data suggests that they are found closer to the surface at night than during the day (Reddin et al., 2006; Davidsen et al., 2008), a behaviour possibly associated with predator avoidance (Thorstad, 2012).

A **5 m depth restriction** below which the headline of all nets must be set would offer the greatest level of protection for salmon and sea trout. Where this would result in unacceptable impacts to local fisheries interests, for example in locations where total water depth is low for an extended distance offshore, this could be reduced. Where this is the case, consideration should be given to increasing protection offered through other measures (e.g. extending temporal and/or spatial coverage) to compensate for the reduction in depth protection measures below the optimum.

4.2 Temporal protective measures

A number of IFCA regions place temporal restrictions on netting activity recognising that salmonids may not be equally abundant in the area all year round. Existing temporal restrictions vary between IFCA regions but generally begin between March to May and end/are reduced between September to November. This section reviews the best available data on the temporal distribution of salmon and sea trout in inshore areas to help inform appropriate temporal restrictions.

4.2.1 Smolt

Salmon smolts leaving English rivers to begin their ocean migration are between 1-2 years (mean smolt age is 1.61, 1.85 and 1.92 for the Lune, Tyne and Tamar respectively; Davidson, 2008) and are generally between 10 and 20 cm in size when leaving freshwater. Sea trout migrate at a slightly greater average age than Atlantic salmon (mean smolt age is 1.95, 2.00 and 2.33 for the Lune, Tyne and Tamar respectively; Davidson, 2008) and at a slightly larger size (15 – 22 cm).

The timing of smolt runs for salmon and sea trout from the main rivers in England are presented in Appendix 1. These represent approximate timings based on local knowledge and should be considered as indicative only. Exact timings will vary by year depending on environmental conditions. The sea trout smolt run generally precedes that of salmon smolts in most rivers. There is also a smaller run of salmon smolts on most rivers in autumn (Pinder et al, 2007). The key migratory months for sea trout are **March**, **April** and **May** and for salmon are **April**, **May** and **June** with smolts being present in the estuaries and inshore areas from this period.

The key months for mackerel and herring capture in UK waters, the fisheries most likely to intercept smolt, are January/February/September/October (mackerel) and June-September (herring) (Radford, 2014). These fisheries are therefore considered to be largely self-regulating assuming that capture data reflects fishery activity. There is a risk of overlap with the tail end of the salmon smolt migration from some rivers that may warrant further investigation but no information about bycatch is available.

No temporal protective measures are considered necessary for smolt protection in inshore waters based on the available evidence. Temporal protective measures could be considered where there is evidence of a specific local issue.

4.2.2 Adults

The length of time spent in inshore areas will generally be greater for adult sea trout than for salmon. After migrating to sea as smolt, salmon post-smolts migrate out of inshore waters relatively quickly (Halfyard et al, 2012) to feed in distant waters (off Greenland and the Faroe Islands), only returning to inshore waters to undertake their spawning migrations. Peak periods of migration can therefore be identified where the presence of returning adult salmon in inshore waters is more likely and thus control measures can be targeted.

Appendix 2 provides information on the run timings for returning adult salmon for the principle salmon rivers in England. These represent approximate timings based on local knowledge and should be considered indicative only. Figure 4.1 presents the average (1997-2006) run timings of salmon from three index rivers in the UK (Davidson, 2008). It should be noted that timings generally reflect river entry (i.e. date of entry to freshwater). In most cases, fish will return to coastal areas earlier than indicated by freshwater entry alone; Atlantic salmon typically begin entering coastal waters and rivers from the sea several months prior to spawning (Thorstad et al, 2008). Salmon will spend longer in coastal areas and estuaries when river conditions (such as low flows/DO and high temp) are unfavourable for river entry (Solomon and Sambrook, 2004). Consequently, coastal or estuarine residence time, and therefore vulnerability to inshore fisheries, is likely to vary by year and location depending on environmental conditions. The key period when salmon are most likely to be present in inshore areas is between **April/May** and **October/November**.

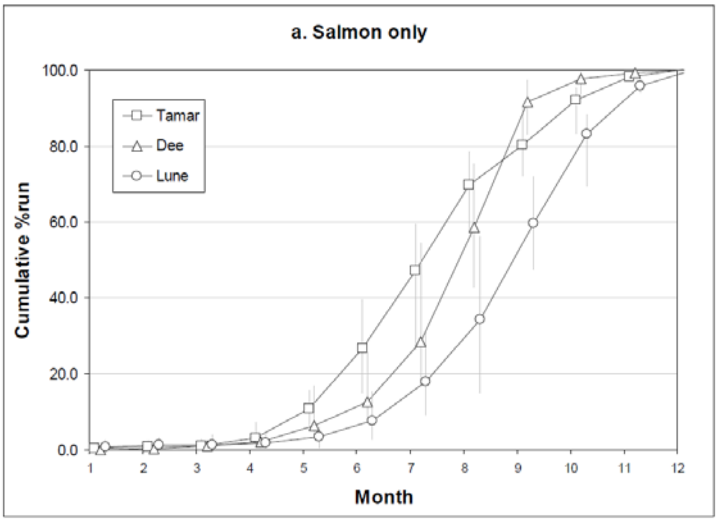

Figure 4.1: Average run timings (1997-2006) for salmon on 3 UK index rivers (R. Tamar, Dee and Lune; Davidson, 2008)

Whilst Atlantic salmon are considered iteroparous (able to spawn multiple times) repeat spawners are relatively rare (3-6%; Hendry & Cragg-Hine, 2003). Data on migration timing and behaviour of post-spawning salmon kelts is largely absent for English rivers though kelt from other countries are known to either emigrate directly to sea after spawning or overwinter in freshwater migrating in the spring (Fleming, 1996).

Sea trout have a much more variable life cycle undertaking migrations of varying duration (from a few months to several years) and distance (those at sea for only a few months undertaking more local migrations), and will commonly spawn multiple times. There remains a lack of knowledge on the ecology, distribution and behaviour of sea trout in the sea. However, recent research projects (namely the Celtic Sea Trout Project and the Living North Sea project), and historical tagging studies (reviewed in Solomon, 1995), provide evidence to support that sea trout undertake migrations along UK coasts, and are commonly, though not exclusively, found in inshore areas (see also Section 4.3). Sea trout may therefore be found in coastal and estuarine areas out with recognised peak migratory periods for the river in question; the sea trout present often being of mixed stocked origin. The presence of a high number of repeat spawners also means that sea trout exit and enter estuaries and coastal areas multiple times throughout the year. Consequently sea trout are considered to be at greater risk of capture by non-target fisheries in inshore waters and temporal restrictions may be harder to identify for most stocks.

As with Atlantic salmon, adult sea trout entry can occur in virtually any month of the year but peak periods are generally seen, often associated with different ages of sea trout. Appendix 3 provides information on run timings for sea trout in principle sea trout rivers in England. These represent approximate timings only based on local knowledge and should be considered indicative only. Figure 4.1 presents the average (1997-2006) run timings of salmon from three index rivers in the UK (Davidson, 2008). As with salmon, timings generally reflect river entry (i.e. date of entry to freshwater) and sea trout may indeed be present all year round in some locations due to their more variable life history. For sea trout, there are also a number of smaller rivers around the coast which produce good runs of sea trout for which little information is available. The key period of movement into freshwater occurs between **June and August**. However, as previously stated, evidence suggests that sea trout of various ages and from a variety of stocks are likely to be present in inshore areas through the year (see also Section 4.3).

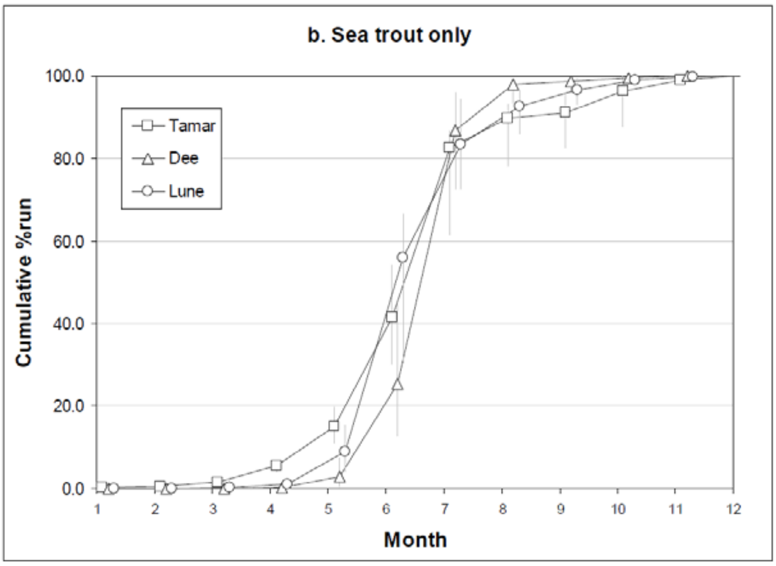

Figure 4.2: Average run timings (1997-2006) for sea trout on 3 UK index rivers (R. Tamar, Dee and Lune; Davidson, 2008)

An exception to this may be the North East coast of England. Historical tagging work on the East coast rivers (Tweed, Coquet, Tyne, Wear, Yorkshire Esk) has shown a rapid migration south, where some are captured in the East Anglian fishery, then continuing south and out into the central north sea along the coast of the Netherlands and Norway (Solomon, 1995) (see also Section 4.3). Analysis from Index River Monitoring also suggests a later run (of both salmon and sea trout) for the River Tyne (Figure 4.3).

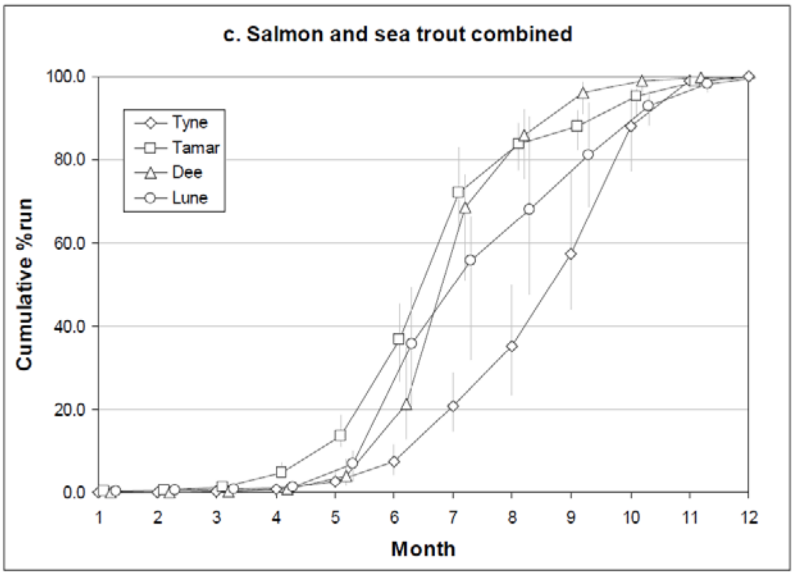

Figure 4.3: Average run timings (1997-2006) for salmon and sea trout on 4 UK index rivers (R. Tamar, Dee, Lune and Tyne; Davidson, 2008)

Unlike salmon, it is common for sea trout from English populations to survive and spawn multiple times. Information on the behaviour of sea trout post-spawning kelts in England is limited to a single study on the River Fowey, south-west England (Bendall et al, 2005). The authors found freshwater residence time to be between 4 and 70 days, with fish moving out into the estuary and quickly into coastal waters between **December and February**. A small number (5) fish tagged on their first river entry returned to spawn between **mid-April and early-June** having spent between 89 and 145 days at sea.

For **Atlantic salmon** – restrictions (combined with depth and/or geographical measures) during key migratory periods (**April/May through to October/November)** would be most effective recognising that fish are only likely to be present in inshore areas in the months prior to river entry. This could be extended or reduced based on local knowledge and known local fisheries characteristics (i.e. on a risk-based approach).

For **sea trout** – an **all year restriction** (combined with depth and/or geographical measures) offers the greatest level of protection as recognition should be given to the likely presence of sea trout, potentially from other rivers, over extended periods due to their more variable life history, including their outward migration as kelts. An exception to this may be the North East coast where sea trout may undertake longer, more distant migrations.

4.3 Spatial protective measures

A number of IFCA regions attach spatial conditions to netting activity recognising that salmonids home to their natal rivers. Existing restrictions, which are often seasonal, are in place in the estuaries of many principle salmon and sea trout rivers but in some areas may not extend far enough to be sufficiently protective (K. Sims, *personal communication*). Other coastal areas, such as those off East Anglia, have no recognised/principle salmon or sea trout rivers but salmonids are frequently caught in these waters. This section reviews the best available data on the spatial distribution of salmon and sea trout in inshore areas.

Appendix 1 presents a map showing the location of all English principle salmon and sea trout rivers. There are 49 rivers in England that regularly support runs of salmon exploited by rod fisheries and 46 rivers that support sea trout, although catches in some of these rivers are minimal.

Where salmon and sea trout go once they have left their natal rivers is an area of continued investigation. As detailed in Section 4.2.2, Atlantic salmon undertake long migrations to known distant feeding areas. There is a paucity of information on specific migration routes and timing once smolts from English rivers enter open water. Malcolm et al. (2010), states that post-smolts originating from Scottish rivers inevitably use near-shore areas at the start of their marine migration, but no data is provided in support of this statement. In the absence of direct tracking information, particle-tracking models have been applied to identify likely migration routes of post-smolts (Mork et al, 2012). The models (validated by capture data) demonstrate that migration routes are influenced by the direction and strength of surface currents which may influence the distance from shore the post-smolts are travelling (Mork et al, 2012). However, by the time out migrating post-smolts are of sufficient size to be vulnerable to other fisheries they are likely to be in offshore waters.

The risk to salmon is therefore likely to be concentrated on returning adults. The exact migratory routes that Atlantic salmon take when returning to their natal rivers remains unclear (Davidsen et al, 2013; Godfrey et al, 2014), and may vary by river, year, and potentially by individual fish. Tracking and tagging work on the North East coast fishery (Potter, 1985; reviewed in Malcolm et al, 2010) indicates that salmon from rivers in north east England and Scotland arrive to inshore areas around Whitby and then migrate up the coast towards their natal rivers, with few fish heading south. This is further supported by recent genetic mixed stock fishery analysis of the north east England net fisheries which showed high catches of salmon from rivers in north east England and Scotland and low catches of salmon from southern England or Europe (Gilbey et al, 2012). Recapture data from different fisheries suggests that salmon spend more time in foreign estuaries and inshore areas as they get closer to their natal river (Potter, 1985).

Salmon from west coast and southern rivers appear to follow a different migration route. Historical tagging data from the (now closed) Irish drift net fishery shows high levels of capture of fish from Welsh and Southern English rivers (1991-1996 average of 15%, 22% and 28% for the Dee, Taff and Test respectively) (Potter & Maoiléidigh, 2006). Data on other individual stocks is not presented but the authors' state that the overall pattern of tag recapture rates for stocks around England and Wales is consistent with this regional pattern of exploitation. The exact route and distance from shore of salmon migrating down the west coast is not known.

The more variable life-history of sea trout and increased inshore residence time means that they are more likely to be vulnerable to capture by inshore fisheries targeting other species (see Section 4.2.2). Although still an area of uncertainty, the evidence on the distribution of sea trout at sea suggests high levels of variability between stocks, with stocks from multiple rivers (mixed stocks) being found in coastal and estuarine waters.

Historical tagging suggests that most English east coast sea trout populations (Tweed, Coquet, Tyne, Wear, Yorkshire Esk) undertake rapid migrations south then continue south and out in to the central North Sea (Solomon, 1995). The fish returning to these rivers are also thought to return from a southerly direction as fish have not been reported from north of the river of origin (Solomon, 1995). This is supported by genetic mixed stock analysis undertaken for the Living North Sea (LNS) project. This found that sea trout caught in coastal fisheries operating along the east coast of England were from rivers throughout north east England and Scotland but also from rivers further afield in the English Channel and Denmark (LNS, *unknown*).

Targeted scientific netting and subsequent genetic mixed stock analysis undertaken as part of the Celtic Sea Trout Project (CSTP) revealed a mixed pattern of migration for sea trout stocks from Ireland, Wales and north west England around the Irish Sea (McGinnity,P, *unpublished data*). Fish from local stocks were generally most abundant in inshore areas nearest to their natal rivers but most populations showed extensive migrations across the Irish Sea area, often undertaking migrations of more than 400km.

Evidence from historical tagging work suggests that some populations from the southern coast of England may have more limited migration ranges (Solomon, 1995). Fish tagged leaving the River Axe were generally recaptured between the Isle of Wight and the Lizard, although a small number of longer distance recaptures were noted including from the River Tweed and rivers on the north Devon coast (Solomon, 1995). Recaptures from tagging on the Fowey were also reported to be within a short distance (30km), although numbers are small and may continue to reflect a pattern of mainly short migration with a minority of individuals travelling further afield (Solomon, 1995).

The existence of net fisheries off East Anglia and Kent and Essex where no (or limited) sea trout production in local rivers occurs provides additional support for the need to consider protection measures for sea trout beyond estuaries of rivers known to support sea trout. These fisheries operate from beaches and in inshore areas, rarely extending further than 1 mile offshore (fisheries enforcement, personal communication), and historically catch large numbers sea trout. Catches tend to increase through the licensed fishing season (April – September) from June onwards (Pawson, 2008). A reducing Net Limitation Order (NLO) exists for the fishery to reduce pressure on the recognised mixed stock fishery.

For **salmon** - **total net ban in all estuaries of principle salmon rivers** (with or without physical and/or temporal restrictions).

For **sea trout** – **total net ban** (with or without physical and/or temporal restrictions) **in all inshore areas** (potentially defined by a depth contour or distance from shore measurement; see Section 4.4), unless there is evidence that sea trout are not present/vulnerable to local fisheries.

4.4 Additional protective measures

4.4.1 Drift nets

The existing protection measures identified in Table 3.1 refer largely to fixed nets, with only a few IFCA districts also restricting the use of drift nets. Fixed nets have a heavily weighted footrope to “fix” the nets to the sea bed. Conversely, drift nets are only lightly weighted on the footrope and hang loosely from the surface via a floated headrope (Potter & Pawson, 1991). Nets hung more loosely may offer less opportunity for escape, unharmed release and capture a greater range of sizes of fish (Potter & Pawson, 1991). The recommendations in the above sections are therefore equally relevant to drift nets and they should be subject to the same restrictions.

4.4.2 Net mesh size

Consideration could be given to using mesh size restrictions to reduce the likelihood of capturing salmonids, though this is seen as challenging. Protection for larger species such as salmonids can be achieved by specifying maximum mesh sizes for fisheries targeting smaller species such as mullet and sole (Potter & Pawson, 1991). However, given the recent increase in minimum conservation size for bass (42 cm), such measures are unlikely to be appropriate everywhere. There is also considerable variation in salmon and sea trout size by season and location which could require variations in recommendations. Such measures could be considered locally where appropriate and informed by area specific size data from rod catches.

4.4.3 Distance to shore

Setting a distance from shore within which gillnetting is not permitted offers an alternative to specific spatial restrictions. In Denmark, gillnetting is not permitted within 100 m of the watermark any time of the year (ICES, 2014). This is combined with 500 m closed areas around any salmon or sea trout stream with outlets greater than 2 m, with shorter 4 month seasonal closures around smaller water bodies, and generally larger areas of protection in estuaries (ICES, 2014).

4.5 Conclusions and recommendations

The recommendations within this report identify the most appropriate protection measures for salmon and sea trout considered in isolation. The information provided on what is known about the behaviour and distribution of salmon and sea trout within inshore areas should be considered alongside local knowledge on fisheries character, intensity and distribution in order to make appropriate risk-based decisions taking socio-economic impacts in to account.

The review presents evidence to suggest that current protection measures are unlikely to be sufficiently protective for salmon, and to a greater extent for sea trout, and are lacking completely in some areas.

The evidence supports the following best practice protective measures;

- For salmon - temporal restriction between April and October with a 5 m headline depth restriction in the estuaries of all principle salmon rivers, for fixed and drift nets. This would allow the majority of salmon present in inshore waters to be protected the majority of the time, recognising that there are identified periods of low risk.

- For sea trout - an all year restriction with a 5 m headline depth restriction (potentially shallower if all other criteria are adopted) in all inshore areas or seaward of a given contour line/distance from shore (to be determined locally), for fixed and drift nets. These recommendations recognise that the more variable life-history of sea trout, combined with their increased residence time in inshore areas, means they are likely to be more vulnerable to capture by fisheries targeting other species.

The review has identified that there remains a paucity of information regarding the movement and distribution of sea trout in particular. Further research involving tracking, or the implementation of catch reporting by recreational anglers, would help improve knowledge about the species and inform future management actions.

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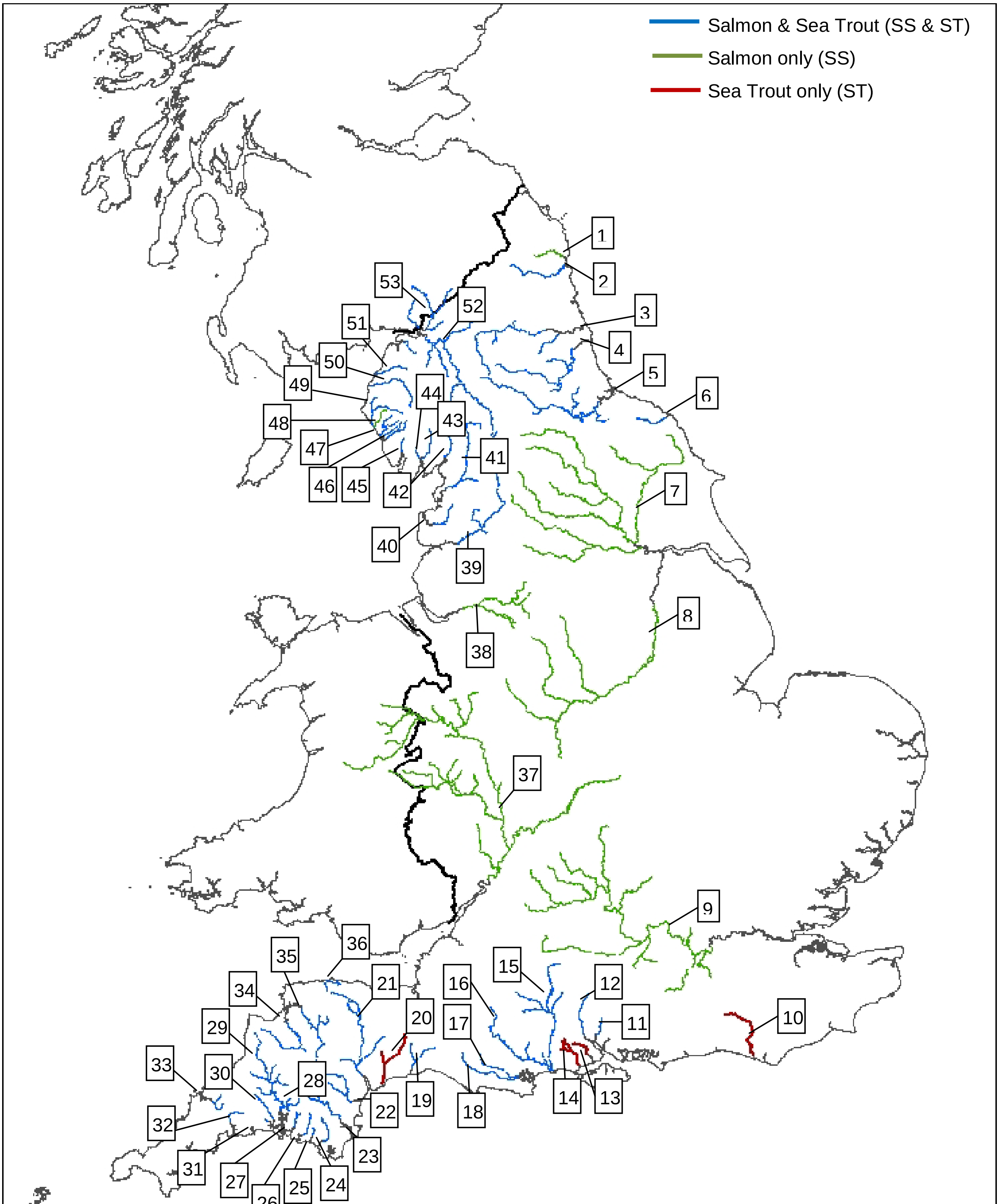
Appendix 1: Map of salmon and sea trout rivers in England



1 Aln (**SS**)
2 Coquet (**SS&ST**)
3 Tyne (**SS&ST**)
4 Wear (**SS&ST**)
5 Tees (**SS&ST**)
6 Esk (Yorkshire) (**SS&ST**)
7 Ouse (Yorkshire) (**SS**)
8 Trent (**SS**)
9 Thames (**SS**)
10 Sussex Ouse (**ST**)
11 Itchen (**SS&ST**)
12 Test (**SS&ST**)
13 Beaulieu (**ST**)
14 Lymington (**ST**)
15 Avon (Hampshire) (**SS&ST**)
16 Stour (Dorset) (**SS&ST**)
17 Piddle (**SS&ST**)
18 Frome (**SS&ST**)
19 Axe (**SS&ST**)
20 Otter (**ST**)
21 Exe (**SS&ST**)
22 Teign (**SS&ST**)
23 Dart (**SS&ST**)
24 Avon (Devon) (**SS&ST**)
25 Erme (**SS&ST**)
26 Yealm (**SS&ST**)
27 Plym (**SS&ST**)
28 Tavy (**SS&ST**)
29 Tamar (**SS&ST**)
30 Lynher (**SS&ST**)
31 Looe (**SS&ST**)
32 Fowey (**SS&ST**)
33 Camel (**SS&ST**)
34 Torridge (**SS&ST**)
35 Taw (**SS&ST**)
36 Lyn (**SS&ST**)
37 Severn (**SS**)
38 Mersey (**SS**)
39 Ribble (**SS&ST**)
40 Wyre (**SS&ST**)
41 Lune (**SS&ST**)
42 Kent (**SS&ST**)
43 Leven (**SS&ST**)
44 Crake (**SS&ST**)
45 Duddon (**SS&ST**)
46 Esk (Cumbria) (**SS&ST**)
47 Irt (**SS&ST**)
48 Calder (**SS**)
49 Ehen (**SS&ST**)
50 Derwent (**SS&ST**)
51 Ellen (**SS&ST**)
52 Eden (**SS&ST**)
53 Esk (Border) (**SS&ST**)

Appendix 2: Smolt run timings from the main salmon rivers in England

Map no.	River system	IFCA district	Atlantic salmon	Sea trout
1	Aln	Northumberland	March to early July	n/a
2	Coquet	Northumberland	March to early July	March to early July
3	Tyne	Northumberland / North East	March to early July	March to early July
4	Wear	North East	March to early July	March to early July
5	Tees	North East	March to early July	March to early July
6	Esk (Yorkshire)	North East	May to June	May to June
7	Ouse (Yorkshire)	North East	May to June	n/a
8	Trent	North East	Mar to June	n/a
9	Thames	Kent & Essex	May to June	Not known
10	Sussex Ouse	Sussex	n/a	March to April
11	Itchen	Southern	April to mid May	mid March-early May
12	Test	Southern	April to mid May	mid March-early May
13	Beaulieu	Southern	n/a	mid March-early May
14	Lymington	Southern	n/a	mid March-early May
15	Avon (Hampshire)	Southern	April to May	April/May
16	Stour (Dorset)	Southern	April to May	April/May
17	Piddle	Southern	April to May	April/May
18	Frome	Southern	April to May	April/May
19	Axe	Devon & Severn	April to May	March to April
20	Otter	Devon & Severn	n/a	March to April
21	Exe	Devon & Severn	April to May	March to April
22	Teign	Devon & Severn	April to May	March to April
23	Dart	Devon & Severn	April to May	March to April
24	Avon (Devon)	Devon & Severn	April to May	March to April
25	Erme	Devon & Severn	April to May	March to April
26	Yealm	Devon & Severn	April to May	March to April
27	Plym	Devon & Severn	April to May	March to April
28	Tavy	Devon & Severn	April to May	March to April
29	Tamar	Devon & Severn / Cornwall	April to May	March to April
30	Lyhner	Cornwall	April to May	March to April
31	Looe	Cornwall	April to May	March to April
32	Fowey	Cornwall	April to May	March to April
33	Camel	Cornwall	April to May	March to April
34	Torridge	Devon & Severn	April to May	March to April

Map no.	River system	IFCA district	Atlantic salmon	Sea trout
35	Taw	Devon & Severn	April to May	March to April
36	Lyn	Devon & Severn	April to May	March to April
37	Severn	Devon & Severn	Mar to June & Sept to Oct	n/a
38	Mersey	North West	Unknown/insignificant	n/a
39	Ribble	North West	April to June	Feb to March/April
40	Wyre	North West	April to June	Feb to March/April
41	Lune	North West	April to June	Feb to March/April
42	Kent	North West	early May to mid-June	April to May
43	Leven	North West	mid-May to mid-June	April to May
44	Crake	North West	mid-May to mid-June	April to May
45	Duddon	North West	mid-May to mid-June	April to May
46	Esk (Cumbria)	North West	mid-May to mid-June	late April to end May
47	Irt	North West	mid-May to mid-June	late April to end May
48	Calder	North West	mid-May to mid-June	n/a
49	Ehen	North West	mid-May to mid-June	late April to end May
50	Derwent	North West	mid-May to mid-June	late April to end May
51	Ellen	North West	mid-May to mid-June	late April to end May
52	Eden	North West	mid-May to mid-June	late April to end May
53	Esk (Border)	North West	mid-May to mid-June	late April to end May

Appendix 3: Returning adult salmon migration timings for principle rivers in England

Map no.	River system	Adult return	Additional information
1	Aln	April to December	
2	Coquet	March to December	
3	Tyne	February to December	
4	Wear	June to December	
5	Tees	April to November	
6	Esk (Yorkshire)	July to September	
7	Ouse (Yorkshire)	March to October	
8	Trent	October to December**	
9	Thames	July to September	
11	Itchen	April to December	
12	Test	April to December	
15	Avon (Hampshire)	February to December	Fish known to be present in the Christchurch harbour throughout this period
16	Stour (Dorset)	February to December	Fish known to be present in the Christchurch harbour throughout this period
17	Piddle	February to December	Fish known to be present in the Christchurch harbour throughout this period
18	Frome	February to December	Fish known to be present in the Christchurch harbour throughout this period
19	Axe	February to November	
21	Exe	March to January	
22	Teign	March to January	
23	Dart	March to January	
24	Avon (Devon)	March to January	
25	Erme	March to January	
26	Yealm	March to January	
27	Plym	March to February	
28	Tavy	March to January	
29	Tamar	March to January	
30	Lyhner	March to January	
31	Looe	March to January	
32	Fowey	March to January	
33	Camel	March to January	
34	Torridge	March to January	
35	Taw	March to January	
36	Lyn	March to January	
37	Severn	March to October	Migration all year but peak period March to June for MSW fish, June to October for Grilse
38	Mersey	September to November	

Map no.	River system	Adult return	Additional information
39	Ribble	April to December	Peak period August to October with a few spring salmon in April / May
40	Wyre	April to December	Peak period August to October with a few spring salmon in April / May
41	Lune	April to December	Peak period August to October with a few spring salmon in April / May
42	Kent	May to December	Peak period July to August
43	Leven	May to December	Peak period July to August
44	Crake	May to December	Peak period July to August
45	Duddon	May to December	Peak period July to August
46	Esk (Cumbria)	Mid July to December	Peak period mid-August to September
47	Irt	Mid July to December	Peak period mid-August to September
48	Calder	Mid July to December	Peak period mid-August to September
49	Ehen	Mid July to December	Peak period mid-August to September
50	Derwent	April to December	Peak period mid-August to September with occasional spring fish April onwards
51	Ellen	Mid July to December	Peak period mid-August to September
52	Eden	Mid March to end May and mid July to December	Migration all year but concentrated in Spring and Autumn as indicated
53	Esk (Border)	Mid July to December	Peak period mid-August to September with occasional spring fish April onwards

Appendix 4: Returning adult sea trout migration timings for principle rivers in England

Map no.	River system	Adult return	Additional information
2	Coquet	June to December	
3	Tyne	May to December	
4	Wear	June to December	
5	Tees	June to December	
6	Esk (Yorkshire)	July to September	
10	Sussex Ouse	July to November	Early run in late summer/August then secondary run in late autumn with rain
11	Itchen	April to December	
12	Test	April to December	
13	Beaulieu	April to December	
14	Lymington	April to December	
15	Avon (Hampshire)	May to December	Peak period June to July then with Autumn rains
16	Stour (Dorset)	May to December	Peak period June to July then with Autumn rains
17	Piddle	May to December	Peak period June to July then with Autumn rains
18	Frome	May to December	Peak period June to July then with Autumn rains
19	Axe	March to November	
20	Otter	March to November	
21	Exe	March to November	
22	Teign	March to November	
23	Dart	March to November	
24	Avon (Devon)	March to November	
25	Erme	March to November	
26	Yealm	March to November	
27	Plym	March to November	
28	Tavy	March to November	
29	Tamar	March to November	
30	Lyhner	March to November	
31	Looe	March to November	
32	Fowey	March to November	
33	Camel	March to November	
34	Torridge	March to November	
35	Taw	March to November	
36	Lyn	March to November	
37	Ribble	May to August	Peak period June to July

Map no.	River system	Adult return	Additional information
40	Wyre	May to August	Peak period June to July
41	Lune	May to August	Peak period June to July
42	Kent	May to October	Peak period July to August, recent runs also in September and October
43	Leven	May to October	Peak period July to August, recent runs also in September and October
44	Crake	May to August	
45	Duddon	May to August	
46	Esk (Cumbria)	June to August	Peak period June
47	Irt	Mid May to August	Peak period mid May to June
49	Ehen	Mid May to August	Peak period mid May to June
50	Derwent	Mid April to August	
51	Ellen	June to August	Peak period June
52	Eden	Mid April to August	
53	Esk (Border)	Mid April to August	