Fisheries monitoring and assessment: 5

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5 FISHERIES MONITORING AND ASSESSMENT

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The purposes of this chapter are (i) to review the monitoring programs dedicated to or simply taking into account shads and lampreys in Europe and to determine strategies to improve methodologies into the future and (ii) to review stock assessment methodologies and population dynamics models for these two fish groups.

Of the fish species being examined here, sea lamprey is the most frequent species recorded in Spain, Portugal, France, Great Britain and Ireland. Rivers with river lamprey seem to be more numerous in the north than in the south. Allis shad is more frequent in France. Rivers with presence of twaite shad seem equally distributed. Shad representation in GB is biased since monitoring is only implemented in 3 rivers (Figure 5.1).

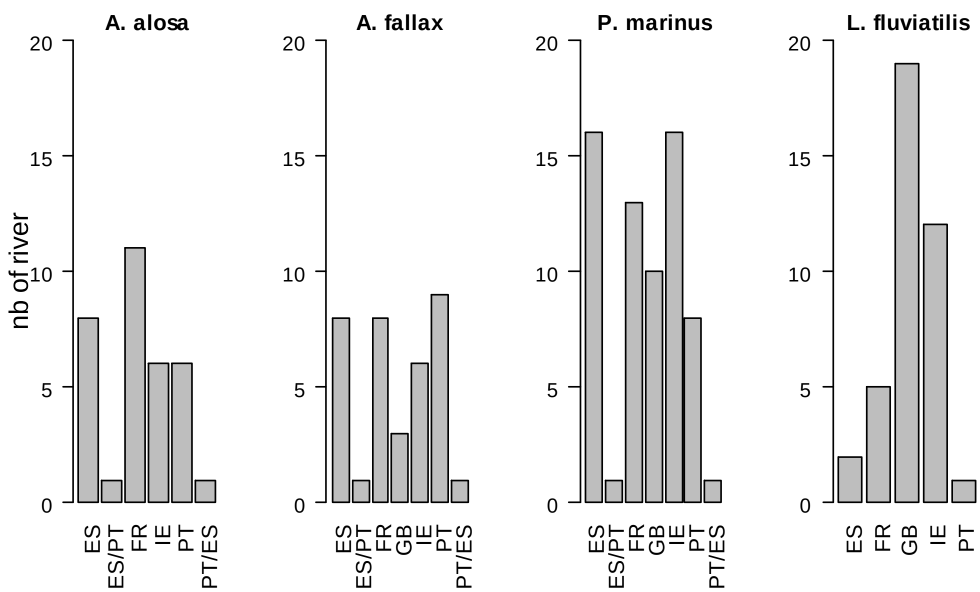

Figure 5.1. Number of rivers with species presence (based on expert group knowledge) in the different countries for the two species of shad and two species of lamprey.

5.1 MONITORING

5.1.1 Review

The four tables reviewed monitoring in Europe for the two species of anadromous shad and the two species of anadromous lamprey (see Annex A). The information was gathered at the catchment scale. It was filled in with the expert knowledge of the ICES Working Group and therefore this review does not claim to be exhaustive but rather to give a first impression of what exists in Europe. It needs to be expanded especially with information from northern European and Baltic countries, where *Lampetra fluviatilis* is commercially fished, and possibly from North America.

The first item addressed was the aim of the monitoring - to know whether the monitoring was implemented with

- a conservation objective,
- a commercial fishery objective
- both objectives.

Lamprey monitoring focused more frequently on the conservation objective than for the shad monitoring (Figure 5.2).

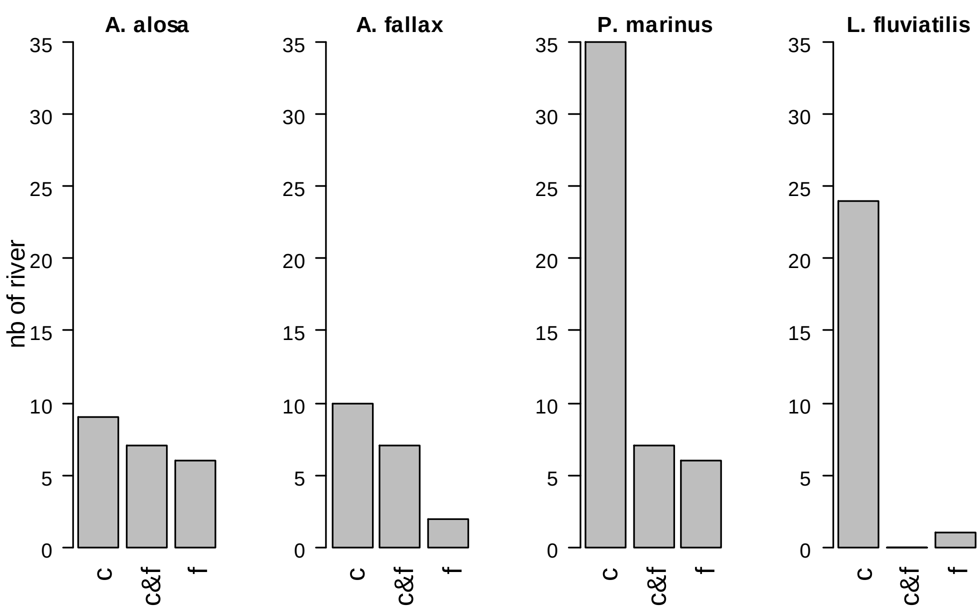

Figure 5.2. Monitoring objectives for each species.

Then methodologies were listed for each catchment, drawing a distinction between fishery–dependent and fishery-independent methods.

For fishery-dependent methods, we identified

- Official fishery declaration
- Unofficial fishery declaration sampling
- Mark-recapture

Official fishery declaration is the most common methodology for the 4 species (Figure 5.3).

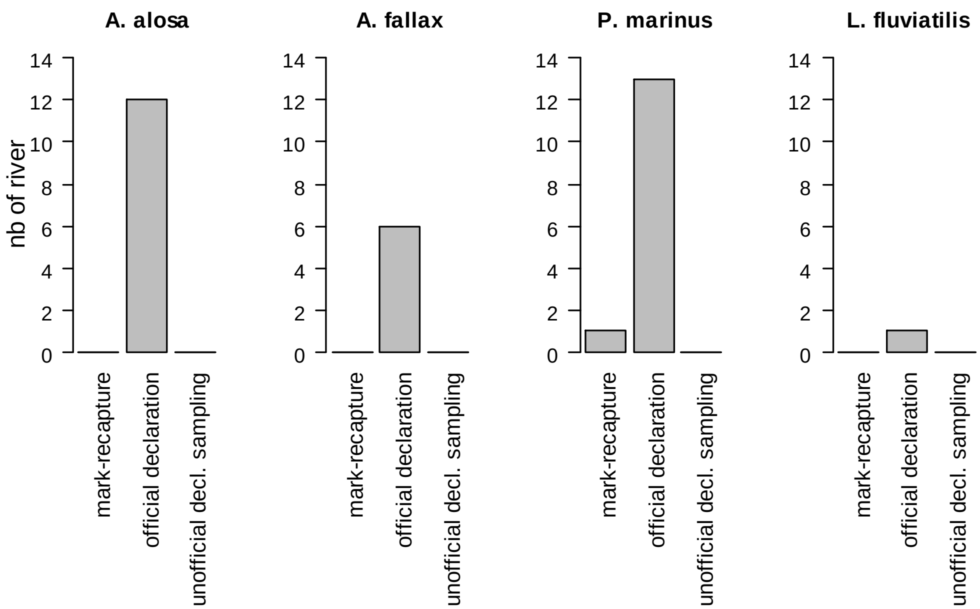

Figure 5.3. Fishery-dependant methodologies used in shad and lamprey monitoring.

For fishery-independent methods, we identified

- Fish pass survey
- Bottom sampler, egg traps, bongo netting (horizontal haul zooplankton net) for post-larval shads
- Trapping, smolt trapping
- Redd survey (for lamprey)
- Beach seine survey
- Survey via electric fishing for lamprey ammocoete presence/absence, density, biomass, population structure
- Spawning events survey (for shad)

The profile of fishery-independent methodologies varies between species (Figure 5.4) according to their ecology. Shad monitoring is mainly based on fish pass surveys, spawning events and juvenile surveys. Sea lamprey monitoring uses redd count surveys and electro-fishing surveys for ammocoetes. River lamprey monitorings are mainly based on electro-fishing campaigns.

For example, in Ireland, there are no commercial fisheries for the anadromous shad or lamprey species. Monitoring is undertaken in the context of the Habitats Directive and the Article 17 requirement to report on the status of species within national territories. The monitoring effort is focussed in the freshwater phase of the various species life cycles. Monitoring of lamprey is focussed on the larval or ammocoete stage, as this is most available for investigation over an extended period of the year. A limited degree of targeted monitoring of sea lamprey spawning, via redd counting, is undertaken. For the shads, a standardised sampling effort using bongo netting to collect post-larval and early-swimming fish is undertaken annually in the listed SAC waters. The low population levels of the shads, and low level of production, are considered a reason for the low density values obtained. Zero values are common from many sampling stations.

In the UK, the extent of shad spawning in each of the three designated SAC rivers should be monitored each year by kick sampling for eggs at a proportion of known spawning sites. A standard macro invertebrate hand net (250 m mesh) should be used to collect material dislodged by kicking upstream of the net for 15 seconds. The net should be checked after each kicking interval. If eggs are present, the extent of the spawning area should be determined by progressively kick sampling (about10 m) upstream and downstream (Caswell and Aprahamian 2001). To confirm the limit of a spawning area, sampling should be continued for at least another five intervals after the last egg is recorded. The identification of shad eggs is crucial to this method of monitoring. Eggs are clear, non-adhesive, semi-buoyant and between 1.5 and 5.0 mm in diameter (typically 2.5 mm). It is not possible to differentiate between the eggs of allis and twaite shad. If shad eggs are identified, the likely shad species to have spawned should be inferred from the species recorded in the catchment; in the Usk, Wye and Tywi this will almost certainly be twaite shad.

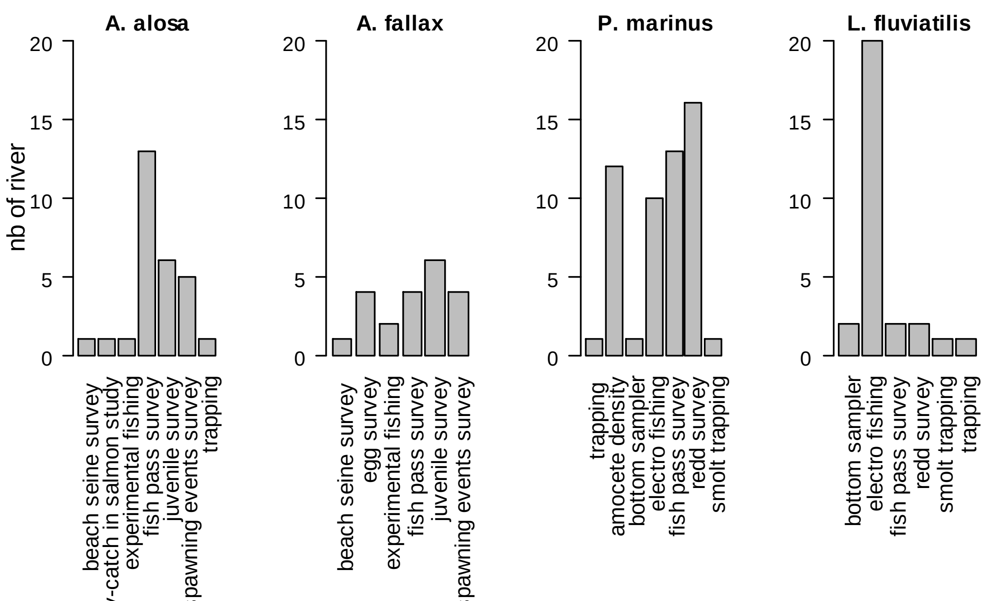

Figure 5.4. Fishery-independent methodologies used in shad and lamprey monitoring.

For each method the targeted biological stage (spawners in reproduction, juvenile in river, juvenile at sea, adult at sea) and the duration of the survey time series (years of beginning and end) were mentioned.

The last item summarized the framework used to fund the monitoring. We identified

- Local or regional funding
- National funding
- European funding (INTERREG, SUDOE, special areas of conservation (SAC), Water framework directive (WFD), data collection framework (DCF))
- Research and development program from private or public institute (RandD)
- Unknown

National and local or regional funding are the most frequent for the 4 species (Figure 5.5). Few programs are funded by Europe. Research and development programs are rare.

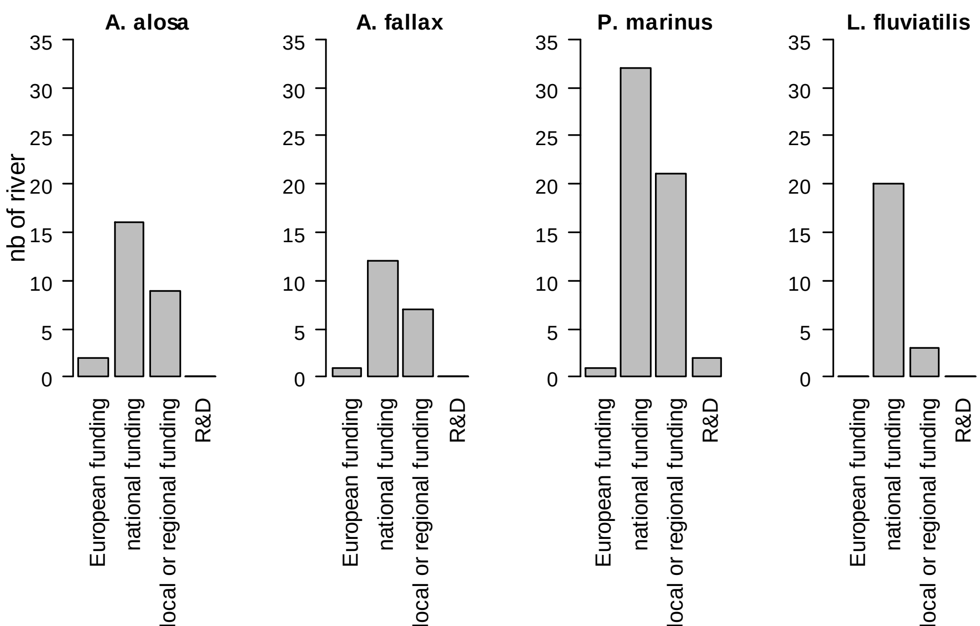

Figure 5.5. Source of funding for the 4 species monitoring.

5.1.2 Recommendations for a better monitoring

After this first attempt to review the monitoring programs in Portugal, Spain, France, United Kingdom and Ireland focusing to shads and lampreys, the group recommends to:

- Extend the review to the northern countries, to correct possible inconsistencies in the information presently gathered,
- Harmonize the protocols in countries in order to permit comparisons or, failing this, to inter-calibrate methods between countries in the near future,

- Try to merge fisheries management and conservation management in a more comprehensive program of monitoring.

5.2 POPULATION DYNAMICS MODELS, STOCK STATUS AND STOCK ASSESSMENT

5.2.1 IUCN stock status

The IUCN lists the two species of lamprey and the two species of shad as Least Concern (IUCN 2014). However, an examination of national red data books would indicate a different situation at the more local scale. The 'Least Concern' status for sea lamprey reflects the large extent of occurrence, large number of subpopulations, large population sizes, and perceived lack of major threats. The trend over the past 10 years or three generations is uncertain but likely relatively stable, or the species may be declining but not fast enough to qualify for any of the threatened categories (reduction in population size) (IUCN 2014). In Ireland, the sea lamprey is listed as Near Threatened (A2c, B1ab(ii)) (King *et al.* 2011). The river lamprey is still rare in some areas, but populations have markedly recovered following earlier pollution problems in central and Western Europe (IUCN 2014). The brook lamprey is still rare in some areas, but populations have markedly recovered following earlier pollution problems in central Europe (IUCN 2014). In Ireland, the river and brook lamprey are combined for status assessment and this entity is considered as Least Concern (King *et al.* 2011). Presently, allis shad has only a very localised distributed outside France and north-western Iberian Peninsula. In the past it has been a victim of pollution, impoundment of large rivers and overfishing throughout Europe. However, most populations declined during first decades of 20th century and the species now seems to have stabilised at a low or medium level in recent times (IUCN 2014). It is rated as Data Deficient in the Irish Red Data Book (King *et al.* 2011). It occurs in low numbers in the Irish SACs and is found to hybridize with Twaite shad (King and Roche 2008). Twaite shad is now only very locally distributed (large estuaries), a victim of pollution and impoundment of large rivers throughout Europe. It is rated as Vulnerable (D2) in Ireland, with one population on the R. Barrow that provides a leisure angling fishery annually. Most populations declined during the first decades of 20th century. Current status of the species is good and is increasing in the North Sea and Baltic (IUCN 2014).

However, these findings should not obscure more alarming local situations. Mateus *et al.* (2012) reviewed the lamprey species status in different European countries, in most cases, as threatened (i.e. critically endangered, endangered or vulnerable). The same conclusions were achieved for allis and twaite shad (Aprahamian *et al.* 2003; Baglinière *et al.* 2003).

5.2.2 Lamprey population dynamics

5.2.2.1 ***Petromyzon marinus***

European populations of sea lamprey are considered to have declined dramatically over the last 25 years. Several authors have pointed out a reduction in sea lamprey abundance in Iberian rivers (e.g. Almeida *et al.* 2002). River impoundments, pollution, dredging and habitat destruction, commercial exploitation, climate change and water availability possibly have contributed to this reduction (Mateus, *et al.* 2012).

However, the larval density and biomass of *P. marinus* showed a significant increase in Galician rivers (North of Spain) between 2007 and 2011 (Silva *et al.* unpublished data) (Figure 5.6). Population status of this species in Galicia could be considered good in the accessible habitat, which is significantly reduced. Problems – widespread, such as poor longitudinal connectivity and habitat fragmentation, or locally, in the case of pollution - may limit or prevent *P. marinus* presence. Larval densities for *P. marinus* are very low in data sets from Ireland. This may be due to major loss of eggs during spawning activity and summer floods, to ammocoete use of cryptic habitat not presently surveyed by investigators or to, simply, a very low level of spawning effort due to small adult population size. Data from more regions and related to longer time series are needed to corroborate a possible general trend of increasing for European populations of *P. marinus* (Silva 2014).

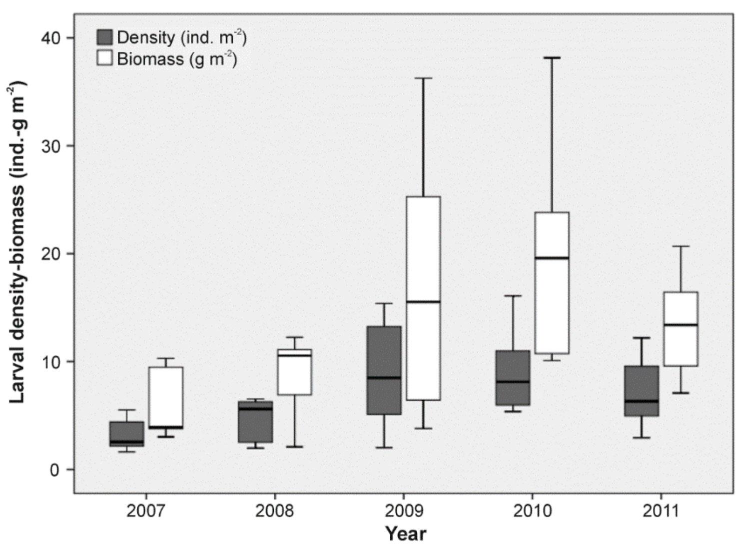

Figure 5.6. Larval density and biomass of *P. marinus* in Galician rivers between 2007 and 2011 (Silva *et al.* unpublished data).

The abundance of sea lamprey during the spawning run in the Gironde (South West of France) estuary reached a strong peak between 1952 and 1970, with a maximum that extends from 1957 to 1965. From 1973 to the end of the 1990s, the trend appeared to be stable at a level of abundance of 35–40% of the maximum encountered from 1957 to1965. Since the end of the 1990s to mid-2000s, sea lamprey abundance showed an upward trend approaching the CPUE of the 1960s (Beaulaton *et al.* 2008). The trend continued afterwards until the end of the 2000s. Fluctuations around a high level were recorded more recently (Girardin and Castelnaud 2013).

Official landings of Portuguese commercial vessels for sea lamprey in the River Minho (international river at the northern border between Portugal and Spain) offer one of the longest series of fishery records for the species (Figure 5.7). Although under-reporting and variation in fishing effort among years is likely to influence the time series, it provides no evidence of decline for sea lamprey in Minho along the reported time (unlike the series for Allis shad obtained by the same authority over the same period in the same system – see Figure 5.9 below).

In the different context of pest management of sea lampreys in the Laurentian Great Lakes, North Americans scientists developed a stock assessment tool to inform decision making in regard to which controls to use and when to apply them (Jones 2007 ; Robinson *et al.* 2013). In addition to research to address uncertainties about a particular life stage, there is a great need to develop and use models that integrate the entire lamprey life cycle. These models require updating and refinement, taking advantage of the abundance of new information about sea lamprey population dynamics that can be extracted from quantitative assessments. They also need to incorporate uncertainty and variability, aspects of system dynamics that are now widely recognized as being key to the use of systems models to evaluate policy (Jones 2007). Recently, Robinson *et al.* (2013) proposed a model that accounts for spatial population dynamics of sea lamprey. This age-structured model integrates a stock-recruitment relationship, natural mortality, treatment mortality and plot-specific larval and transformer (i.e. lamprey after transformation into parasitic phase) abundance. This work was possible thanks to a unique long-term data set for the St. Marys River to describe the dynamics of a lamprey population at a fine spatial scale.

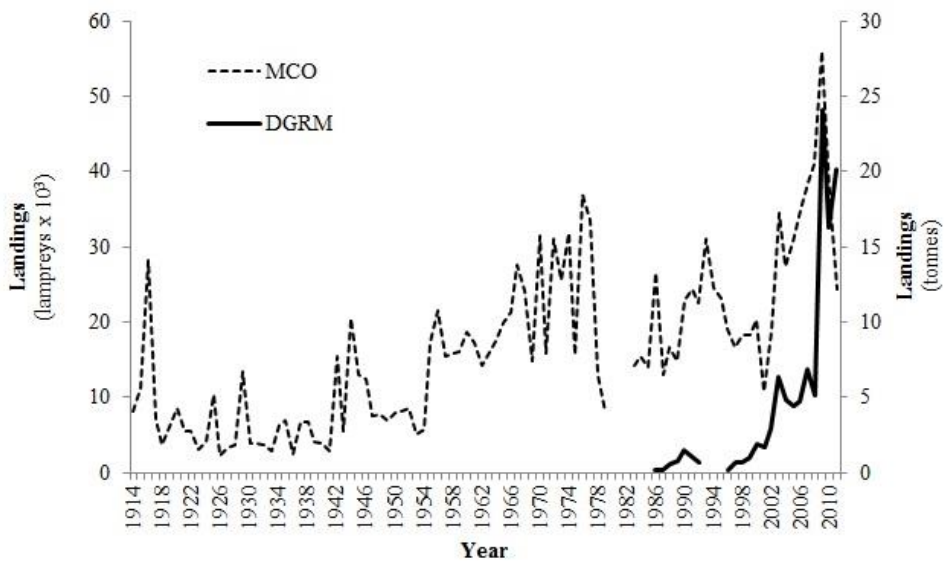

Figure 5.7. Commercial fishery declaration (landings) for sea lamprey in river Minho (Portuguese vessels only) as reported to a local (long series, broken line) and a national authority (short series, solid line). From Araujo *et al.* (*in press*).

5.2.2.2 *Lampetra fluviatilis*

Annual catches of lamprey (largely river lamprey but may include some sea lamprey as species were not distinguished in the past) showed high variations in the territorial waters and in the southern parts the Baltic Sea (Figure 5.8). The highest catches were obtained during the three 10 yr periods from 1890 to 1919, when 44430, 38250 and 32794 kg of lampreys were caught annually. Annual lamprey catches decreased significantly in subsequent years. The mean annual catch of river lamprey ranged between 400 and 14814 kg within the 10 yr periods between 1950 and 1999, with the highest mean annual lamprey yield (14814 kg) obtained in the 1970 to 1979 period. No, or very minor, catches of lampreys were registered during the time periods 1919–1929, 1940–1954 and 1980–1984 (Thiel *et al.* 2009).

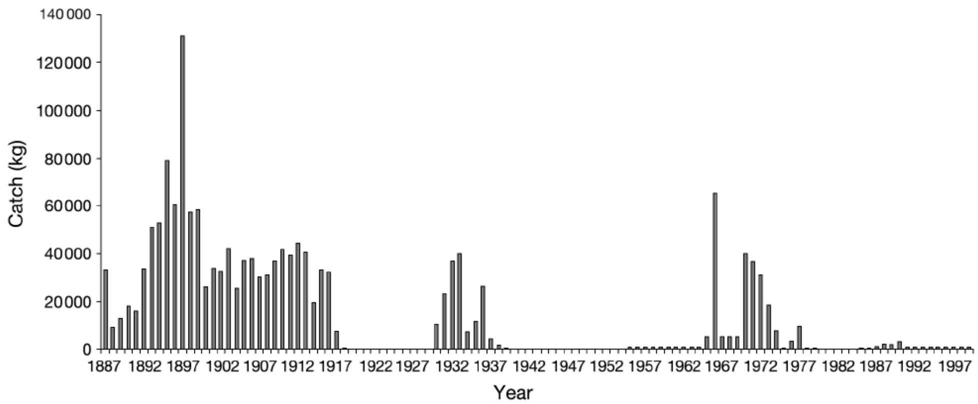

Figure 5.8. *Petromyzon marinus* and *Lampetra fluviatilis* total landings in the southern coastal parts of ICES Subdivisions 24–26 of the Baltic Sea from 1887 to 1999. (Data largely for the river lamprey, *Lampetra fluviatilis,* but may include some sea lamprey, *Petromyzon marinus,* as species were not distinguished in the past) (from Thiel *et al.* 2009).

5.2.3 Shad population dynamics

5.2.3.1 *Alosa alosa*

Portuguese official statistics of the small-scale fishery in the Minho River confirmed mean catches of 200 tonnes during the first half of the 20th century, with peaks of 300 tonnes (Figure 5.9). After the 1950s, catches decreased by about 90%, coinciding with the construction of the first dam on the river system (Baglinière *et al.* 2003). In the last 20 years, mean annual catches reached about four tonnes, while in 1980 the catch peaked with about 18 tonnes. However, these values seem to be underestimates due to the lack of good official statistics. Unofficial Portuguese and Spanish data over the last eight years indicates that yields may have been twice as high, pointing to the existence of a noticeable population worth studying to develop conservation and restoration strategies (Mota *et al.* 2015).

Until the end of the 20th century, the Gironde-Garonne-Dordogne (France) population was the largest allis shad population in Europe (Baglinière *et al.* 2000) and was still considered as a reference population (Martin-Vandembulcke 1999). A dramatic drop in landings and in estuarine juvenile abundances (Figure

5.10) led to the Gironde basin's diadromous fish management committee implementing a total moratorium in 2008.

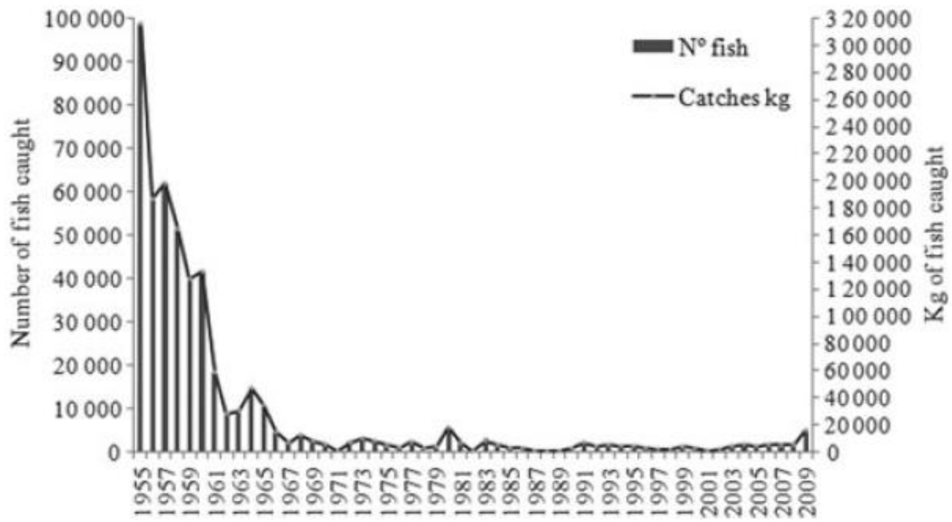

Figure 5.9. Time series data for half a century of *A. alosa* catches (kg and numbers) in the Minho River reported by Portuguese fishermen to the local Maritime Authorities of the Fishing Port of Caminha (Mota and Antunes 2011).

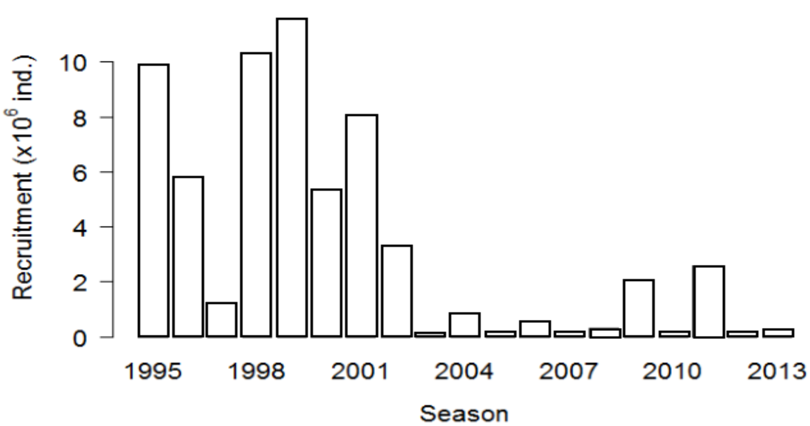

Figure 5.10. Evolution of abundance of allis shad juveniles in the Gironde estuary (Stock was estimated from monthly trawl surveys (Pronier and Rochard 1998). Size of the juvenile population in the whole estuary was calculated according to densities and estuarine volumes associated with each of the 4 transects (Lambert *et al.* 2001) for each month. For each cohort y, the estimate of abundance was calculated as the sum of the abundance data between July of year y and June of year y +1 (Rougier *et al.* 2012).

The relationship between stock and recruitment from the Gironde-Garonne-Dordogne (France) was found to fit a Ricker curve (Martin-Vandembulcke 1999). Recent reanalysis by Rougier *et al.* (2012) identified that this relationship gave rise to a demographic Allee effect in the reproduction dynamics which, combined with high estuarine mortalities, could explain the population collapse. However, they were not able to prove the presence of density-dependant mechanisms necessarily associated with a demographic Allee effect. In a stock-recruitment relationship, Allee effect (Allee 1931), also known in the fishery literature as the depensation in fish stock productivity (Hilborn and Walters 1992; Myers 1995; Gascoigne and Lipcius 2004), can seriously accelerate population decline and drive a population to extinction, or at least heavily hamper its recovery (Walters and Kitchell 2001).

Based on these data, Lambert and Rougier (in prep) proposed a precautionary diagram (ICES 2004) adapted from developments realized for the European eel population (ICES 2010). A dark red zone was added to the left corresponding to the depensatory trap. Since the 1991 cohort, the population has never been in the orange and the green zone (Figure 5.11). It entered the dark red zone without escaping in 2002 while a fishery moratorium was only introduced in 2008. With the hindsight knowledge of 2014, a massive reduction of the anthropogenic mortalities should have been decided more than six years before. Even with a very low fishing mortality in the estuary the total anthropogenic mortality has increased since the last 3 years. A deeper analysis of the recent dynamics is needed to confirm this increase that risks hampering the population restoration.

On the Loire River (France), Mennesson-Boisneau *et al.* (1999) found that recruitment of the 1980-1992 year-classes was significantly correlated with flow during the period of upstream migration (March 15th to June 15th), though the relationship is heavily influenced by the flow in one year. The resultant implication is that in the Loire the population is regulated by the amount of spawning and/or nursery area available. High flows allow the fish to penetrate further up the river system and increase the amount of rearing area available, reducing the level of density dependent mortality. However, a more recent study of the 1995-2004 year-classes found no relationship between juvenile (age 0+) abundance and adult abundance, temperature or flow (Boisneau *et al.* 2008).

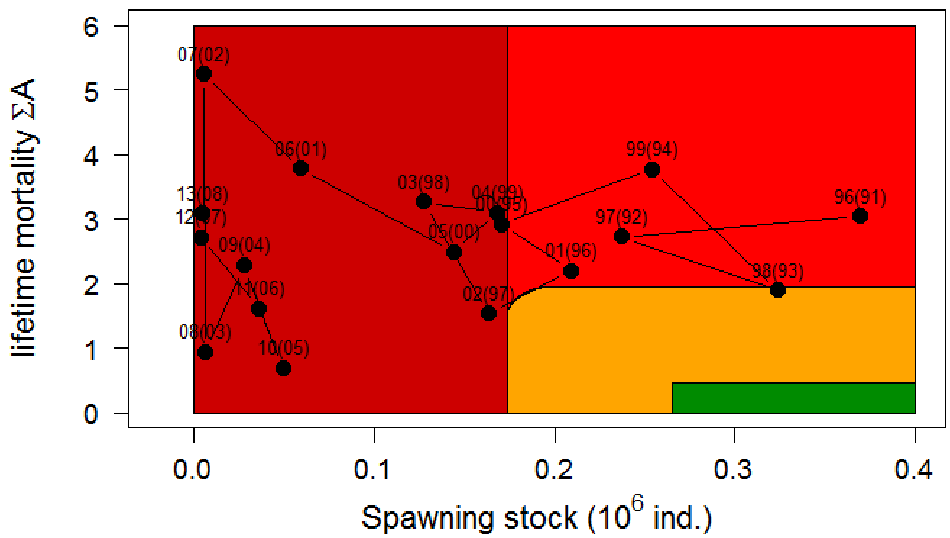

Figure 5.11. Precautionary diagram for allis shad population in the Gironde system (Two-digit label indicate the years of anadromous migration in bracket the year of birth).

5.2.3.2 ***Alosa fallax***

The population entering the Severn Estuary at the start of the freshwater phase of their spawning migration has been sampled between 1979-1996 by Aprahamian (personal communication) (Figure 5.12). Counts of shad caught were obtained from the putcher net fishermen, from April 15 (start of the salmon net season) for various periods, until the middle of June. Samples of shad were taken at intervals throughout the migration.

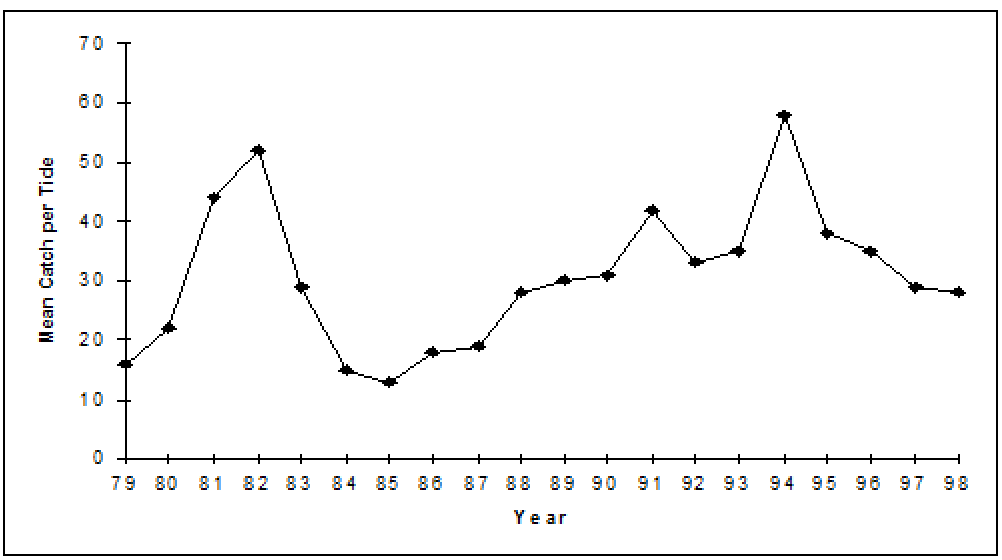

Figure 5.12. Catch per unit effort of female *Alosa fallax fallax* in the Severn Estuary.

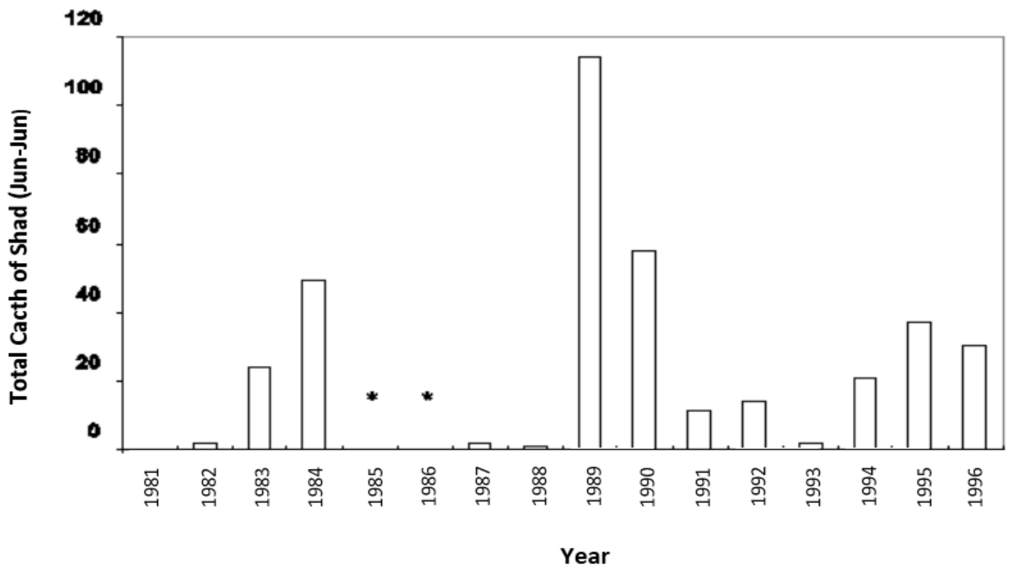

Figure 5.13. Number of twaite shad caught at Hinkley Point 'B' Nuclear Power Station between June 1 of year n and May 31 of year n+1, from 1981 - 1996, Henderson personal communication (* counts excluded as data in 1986 were not recorded monthly).

Quantitative, monthly sampling of fish and crustaceans at Hinkley Point 'B' Nuclear Power Station has been carried out by P. Henderson (personal communication) since October 1980 (Figure 5.13). The method is selective towards juvenile shad with the majority of the catch consisting of the 0+ age group (Holmes and Henderson 1990).

Part of the variation in recruitment can be associated with variation in temperature. For example, Aprahamian and Aprahamian (2001) found that mean July temperature explained the greatest proportion of the variance (67.1%) in year class strength, followed by August (50.9%) and June (30.9%). Taking the mean temperature for the three month period improved the proportion of variability explained to 77.1% (Figure 5.14).

River flow was found to be inversely related to year-class strength, though flow and temperature were significantly inversely related ($P<0.05$) during the summer months (June to August). The greatest proportion of the variability (42.3%) was explained by August flows, followed by July flows (36.8%) and June (27.7%) flows. Flows during the main upstream migration period in May were not significantly correlated ($P>0.05$) with year-class strength.

The relationship between stock (measured as the number of eggs deposited in a given year) and the number of recruits (measured as the number of eggs produced by females age 6 years later, standardised using temperature as an explanatory variable) for the Severn population of twaite shad led to a weak density-dependent Ricker relationship. In that case, the parental stock fluctuations explained only a small proportion of the variability in recruitment measured 6 years later (Aprahamian *et al.* 2010).

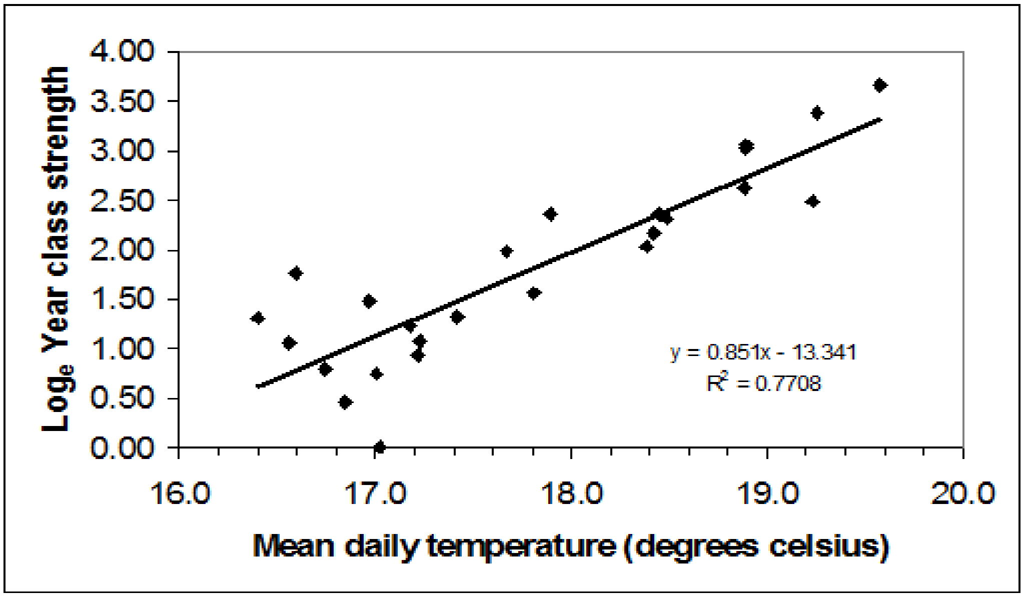

Figure 5.14. The relationship between year class strength of *Alosa fallax fallax* from the Severn Estuary, England between 1972 and 1996 and mean water temperature between June and August inclusive (Aprahamian and Aprahamian 2001).

Information on Twaite shad status in Ireland has largely derived from by-catch of commercial salmon netsmen operating in estuarine waters (King and Roche 2008). An additional, and interesting, barometer has also come from data of the Irish Specimen Fish Committee (ISFC) (www.irish-trophy-fish.com). This voluntary group sets 'specimen' weights for a range of fish species of interest to anglers. If an angler catches a fish exceeding the 'specimen' weight for that species the angler receives a certificate. Such certificates, and other awards, are prized among Irish anglers. The spawning run of Twaite shad has been targeted for over thirty years by anglers coming to the River Barrow estuary in May each year. The modal peaks (Figure 5.15) correspond to 'angler effort' and may not solely reflect numbers of shad actually present. However, it is considered that the data indicate a fluctuating size of spawning shad population. The anglers use social media to reflect the size of the run of fish – if the run is good more anglers come and more fish are caught and released. If the run is poor there is a smaller angler effort. Where a large number of specimen fish were listed over a period of two or more years, the ISFC increased the 'specimen' weight, making the challenge greater for the angler. Even with these increases, strong year classes are considered to be reflected in angler effort. For some years, anglers are encouraged to minimise handling of the shads and to operate a catch-and-release approach. In early years, anglers were required to provide the body of the fish for confirmation (i.e. Twaite and not Allis shad). Since 2009, anglers are required to return all fish and to take a small sample of scales for genetic confirmation of species.

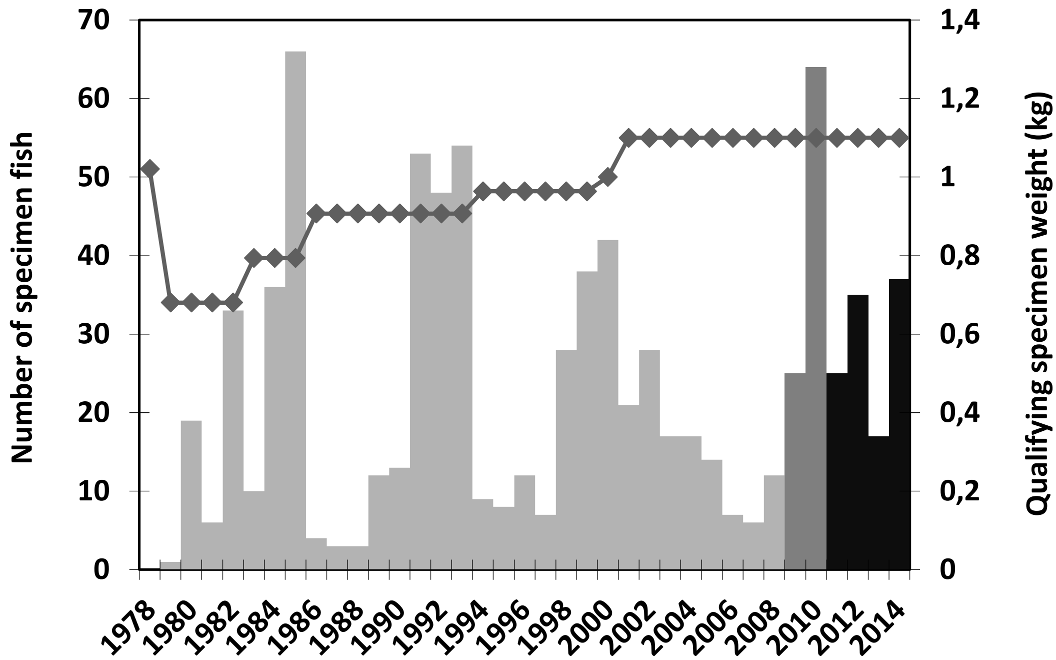

Figure 5.15. Numbers of rod caught specimen twaite shad ratified by ISFC 1978 and 2010. Solid line represents annual qualifying specimen weight. 2009 and 2010 includes confirmed shad hybrids.

5.3 CONCLUSIONS AND RECOMMENDATIONS

The decrease observed so-often lead to the conclusion that the most of the populations for the four species are in bad status. But most of the countries were blindly reporting against targets. A first attempt to define biological reference points was performed for allis shad in the Gironde system without being exempt from criticism.

The group recommends to

- Develop methodologies and collect data to calculate management targets and limits with coordination between conservation and fisheries objectives. The cost of such programs should be in accordance with the commercial and heritage value of the species
- Assess the possibility of using these species as metrics of habitat continuity or quality..

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