Atrina fragilis (Pennant 1777): A Species of Conservation Concern

Dr. Jean-Luc Solandt, Marine Conservation Society

Figure 1. *Atrina fragilis*, at 10m depth in Loch Carron, Western Scotland. © Sue Scott

The UK Biodiversity Action Plan (UK BAP) was written in 1994 by the (then) Department for The Environment, Trade and The Regions (now DEFRA) in order to protect species and habitats important to the integrity of UK biodiversity. The BAP highlights species and habitats requiring immediate conservation action, and was initially recommended to government by a consortium of marine biologists, conservationists, government agencies and departments. For some plans it also provides targets for conservation action and for stable population numbers in the field. There are 38 BAPs for marine species and habitats, and amongst them three for marine molluscs, including a pinnid bivalve mollusc, The Fan Shell (*Atrina fragilis*). *Atrina fragilis* naturally occurs in all UK and Eire waters between the surface and down to at least 400m. It can grow up to 40cm long, and is found in mud, sand and gravel habitats. They are commonly found with half to three quarters of their shell submerged in sediment (Fig. 1).

Growth

The growth rate of *A. fragilis* is around 3-4cm per year (Anon 1999), which suggests that larger specimens are at least 10-12 years old. A study of the growth of a related Mediterranean species (*Pinna nobilis*), indicated faster growth rates at a Yong life stage (1-3 years), followed by slower growth in later years (4+ years) (Richardson *et al.* 1999). In *P. nobilis*, the growth rate of the shell between 1 and 3 years of age also varied between sites, with some populations growing at 9cm per year, and others with a rate of growth of 6-7cm per year. Oceanographic differences between sites may have considerable bearing on the growth rates of populations of Pinnid bivalves. Particle capture by filter feeders differs considerably from site to site because of the velocity and organic content of water currents (Shimeta and Jumars 1991).

A factor that decreases the growth rate of the shell is the onset of sexual maturity. Putting energetic resources into gonad development reduces the rate of shell accretion. Therefore, age of maturity and speed of reaching reproductive size will have considerable impact on subsequent growth rate (Richardson *et al.* 1999).

A. fragilis is adapted to damage of the upper (exposed) portion of its shell, as most soft tissues of the mantle are withdrawn into the posterior margin of the shell upon contact with the outer surface. This may have had some impact on their ability to re-generate shell material after passage of scallop-fishing trawlers and dredges. Yong and Thompson (1976) suggested that after damaging the posterior (upper) portion of the shell, regrowth occurs at the rate of 1cm per year (Fig. 2).

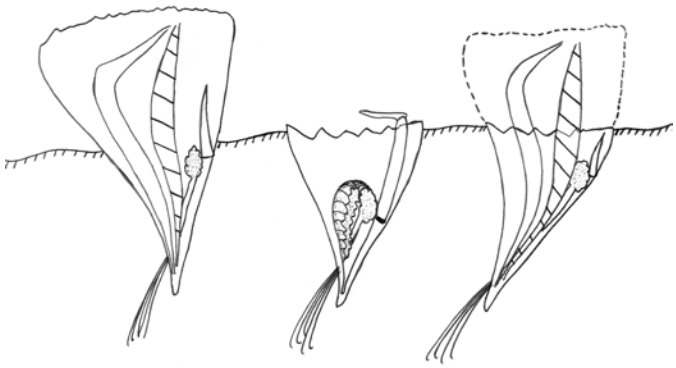

Figure 2. Diagram of damage and subsequent regrowth of *A. fragilis* shell after physical disturbance to the upper part of the shell (After Yong and Thompson 1976).

Reproduction

A feature of the biology of the Fan Mussel that hinders its distribution is the stochastic nature of its recruitment success. As with many external spawners, fecundity is likely to be considerable within the species – although we still don't know (from the scientific literature) anything about the egg and sperm abundance or ratios of *A. fragilis*. As with all marine broadcast spawners, currents, timing of spawning, and the proximity of other individuals will determine fertilization success (Marshall 2002). The same oceanographic effects, coupled with the availability of foods, and appropriate settlement habitat for larvae will also likely determine recruitment success. Unfortunately, many populations appear significantly dispersed, and the majority of reported live sightings of this species are for single specimens. However, records of occurrence of these species rely on anecdotal information, and there may still be areas of high population density in deeper waters that will be a considerable source of planktonic larvae. A clear national survey strategy to find these metapopulations would help set up a localized conservation programme for this species.

Historical record

"*The fine golden-brown byssal fibers of the Mediterranean Pinna were used to weave the legendary Cloth-of-Gold, a fabric that must have rivaled our finest synthetics, for a woman's scarf of this material was said to be so flexible it could be rolled into a ball the size of a walnut. So much work was involved to harvest enough of the Pinnas and to process the fiber for weaving, however, that the cloth could be afforded only by royalty*." – historical record of the value of the byssus threads from the Mediterranean species, *Pinna nobilis* (as recounted by Keene 1958).

The historical record once showed considerable numbers of *A. fragilis* in the waters around the UK and Eire. They were commonly caught either in the dredges and trawls of expedition ships, or in the nets of scallop and demersal fish trawlers. Sometimes, they were even caught in aggregations, showing evidence for considerable metapopulation centers. Jeffreys (1863) described the species as

being ‘gregarious’ from ship records around the middle of the 19th century. This appears not to be the case in the 20th century, as almost every reported record is of individuals (ERCCIS 2002).

Present day populations

Population levels from UK waters are described as ‘scarce’ (Anon 1999). Recordings of *A. fragilis* are predominantly made by scallop trawler boats, or scallop divers. However, there is no strategic programme for reporting sightings. Reports may increase with greater awareness, but it can be assumed that there will always be inadequate data available unless a dedicated survey programme is carried out, and this is unlikely unless a considerable programme is undertaken that surveys comprehensive sections of the UK seabed. Unfortunately, ship-based survey techniques can be destructive (MAFF survey of the English Channel within the ERCCIS database brought up only dead specimens), and is difficult to justify in terms of financial and biological expense.

Population ‘hotspots’ appear to be in Scotland, and the southwest coast of Cornwall. Two different sources of information exist – The Marine Life Information Network (www.marlin.ac.uk/index2.htm?demo/Atrfra.htm) appears to highlight considerable populations in the areas between the Western Isles, and the Scottish mainland within deeper tidal waters of the sound of The Minch, and the Sound of Skye. There appears to be another ‘pocket’ of abundance within the waters between John O’ Groats and The Shetland Isles. However, the populations in this map are for coastal waters, and don’t take into account offshore records (between 12nm and the outer edge of the European Economic Zone 200nm limit).

Woodward (1985) showed greater numbers of observations around the northeast of Scotland, with a center of concentration in Shetland. There are approximately six records from the Western Isles within this reference. Differences in distributions and the number of records within these two reference sources indicate the difficulties in getting true representative samples of populations. Woodward’s records come from over one hundred years of observations, which would include many gaps in recording years. By example, Figure 4 shows the dates of the records taken from Wooward (1985). This figure also shows environmental records data for the whole of Cornwall and The Scilly Isles from 1841 to the present day (ERCCIS 2002). The abundance record from 1950-2000 is considerably increased by a single MAFF cruise to survey scallops between the sixth and 20th July 1991. In this survey period, undertaken in the western approaches of the English Channel, 14 specimens of *A. fragilis* were collected from 14 different trawls. These trawls were carried out in waters with an average depth of over 100m, at least 50km offshore, representing an entirely different dataset than that contained within the MarLIN database. This emphasizes that there is considerable need for dedicated *A. fragilis* surveys to establish a definitive dataset of *A. fragilis* records around the UK, both in coastal, and offshore waters.

Figure 3. Records for UK coastal (within 12nm) observations of *Atrina fragilis* (adapted from MarLIN, www.MarLIN.ac.uk).

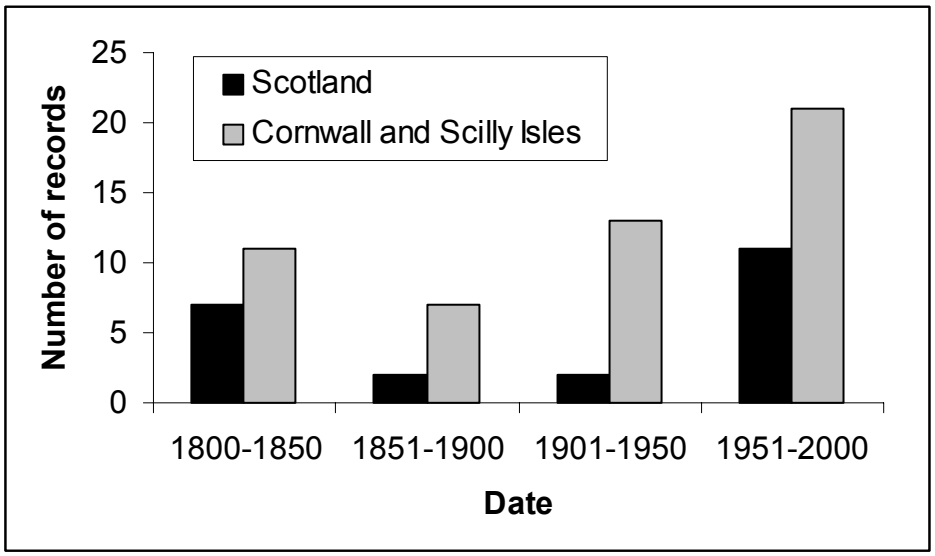

Figure 4. *Atrina fragilis* observations by half century from Scottish (from Woodward, 1985), and Cornwall and the Scilly Isles (ERCCIS 2002).

Carrying out dedicated surveys could reveal accurate densities of Pinnid bivalves. By way of example, surveys of deep-water habitats were undertaken in the Adriatic from 1982 to 1994 over 59000 km^2 of continental shelf (Simunovic *et al.* 2001). During this survey period, *A. fragilis* were collected in 20% of trawls. The authors concluded that population numbers were stable, if not slightly recovering from intensive commercial trawling activity. They found that the species was most abundant between 25

and 50m of water on clay-sand habitat. Deeper specimens were collected from around 250m. However, the negative effects of this sample technique on the population were not discussed!

Causes of UK population decline

Atrina fragilis, though adapted to limited damage to its upper surface from minor disturbance, will be destroyed by heavy beam trawls, and dredges. Many of these types of gear dig into the sediment in order to disturb fish and scallops and move them into water column, where they can be captured in the following net. This physical disturbance to the substrate damages much of the soft tissue of *A. fragilis* that constricts into the inner (anterior) part of the shell (Fig. 2). Considerable fragments of *A. fragilis* shells are collected on scallop trawler boats as evidence of the damage incurred.

Considerable anecdotal information also confirms trawler damage as a probable cause of decline in the more exposed open seas. Observations from fisheries observers on trawler boats have seen considerable declines in populations from areas as widespread as the Nymphe Bank off County Cork in Eire to The Irish Sea (Cardigan Bay, Bristol Channel and the Lundy's). These trawlers regularly encountered shells of *A. fragilis* within their trawls, which they would sell on to shell collectors. Large individuals were caught in the Celtic Sea in the 1970's and one comment was of "decks being covered with the broken fragments of this species" (Francis Kerkhof, personal communication).

Using the expansive dataset from the Environmental Records center of Cornwall and The Scilly Isles (ERCCIS 2002), it can be seen that records of *A. fragilis* come from shallower waters in earlier years, to progressively deeper areas in more recent years (Fig. 5). This could be a result of two factors; the first could be that today there is a greater need for commercial fishing to visit offshore areas to reach the last of our fish and shellfish stocks, as inshore areas may be fished out. It also highlights another possible reason that deeper waters now have greater densities of *A. fragilis*, as in earlier times, fishing was more likely to occur further inshore. Indeed, demersal fishing was concentrated within 12nm miles of the coast at the beginning of the 20th century and in the middle to latter part of the 19th century. With the onset of the industrial age, and the development of more powerful combustion diesel engines in fishing boats from around 1930-1970, there was a shift in the ability of fishers to trawl greater areas, and go further offshore. Therefore, it is likely that the early ship records of *A. fragilis* were taken from inshore waters. Indeed, 50% of 18th century records of Cornish *A. fragilis* come from inshore waters (ERCCIS 2002). The Fal estuary, Falmouth Harbour and Mounts Bay are all examples of mid 19th century *A. fragilis* records. Later on in the Cornish record, higher *A. fragilis* populations were taken farther out to sea, especially during the MAFF scallop survey of 1991. During this survey, it appears that 'Melville Knoll' and 'Haddock Bank' sea mounts were surveyed, indicating the importance of not only associating *A. fragilis* with inshore waters as these pinnacles and banks are some 50 miles SW of The Scilly Isles in water depths between 50 and 200m.

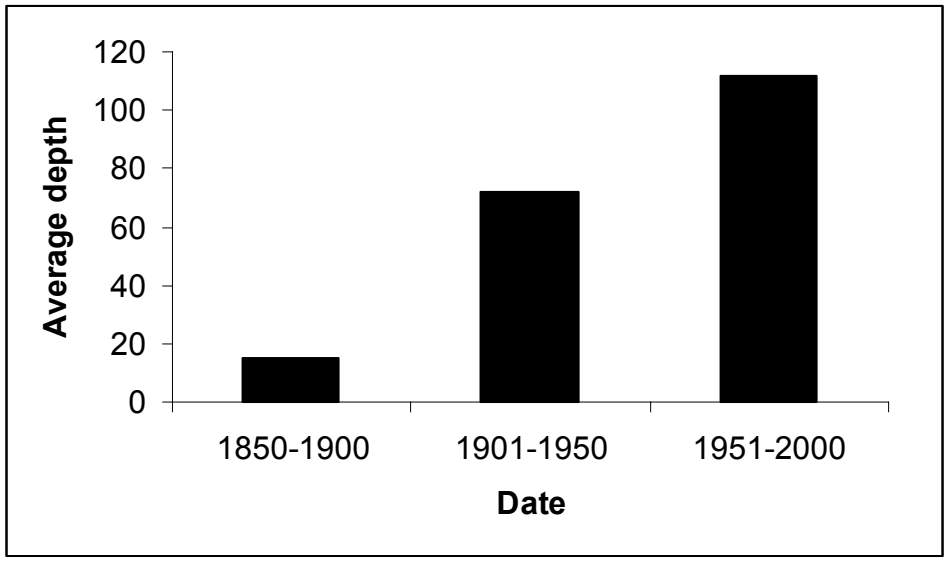

Figure 5. Average depth of *A. fragilis* records from Cornwall and the Scilly Isles (ERCCIS 2002) between 1850 and the present day.

Anecdotal records from the diving community suggest that considerable numbers of *A. fragilis* may be found in areas where scallop trawlers and dredgers cannot set their gear. This could potentially be in waters of higher current, where the seabed is more steeply sloping, or where there is such a narrow, yet deep stretch of water, where trawlers cannot sufficiently run a trawl before having to turn. This type of seascape is typical of that found in the Western Isles of Scotland, where considerable numbers of *A. fragilis* are still being found.

Unfortunately, at other areas of our coast, *A. fragilis* numbers have decreased over the last 100 years, and that their description as 'scarce' from MarLIN, and from BAP, appears to be an accurate description.

Potential for restoration of populations?

The lack of scientific data on the biology *A. fragilis* makes it difficult to suggest practical restoration methods for this species. However, if certain assumptions are made, there could be considerable scope for developing a strategy to restore populations in areas of seabed where a habitat suited to *A. fragilis* is completely undisturbed. We already know that individuals can be manhandled and moved from one location to another and survive. Two mature *A. fragilis* were given to Sue Scott in Loch Carron in North West Scotland, and survived being 'planted' back into the sediment in an area of high current in 10m of water (Fig. 1). This has also been achieved on a commercial scale for another species fan mussel, *Pinna bicolor* in Hong Kong as part of an aquaculture project (Wu and Shin 1998). Loch Carron (or other such suitable locations) could be used as a source population for *Atrina fragilis*, and enhanced with individuals donated from scallop fishermen (live *A. fragilis* are caught as bye-catch on scallop trawls). These could then be 'planted' within close proximity to the existing pair in Loch Carron, which may eventually result in a considerable source of larvae for this section of coast. It is understood that the planktonic phase of *A. fragilis* larvae is between five and ten days (Anon 1999), which could result in considerable dispersal of the population. It is likely that the closer an individual is to another conspecific, the greater the likelihood of gamete fertilization success, and therefore, the greater chance of successful recruitment. Evidence for this is seen in other sessile broadcast spawning organisms such as ascidians (Marshall 2002). These assumptions of spawning biology, fertilization success, and propensity for greater recruitment have yet to be researched for *A. fragilis*, but could provide the basis for future restoration of *A. fragilis* populations in protected waters. Another factor that allows practical application of protecting known *A. fragilis* source populations, is that they are a

benthic, attached species. Therefore, it will be simple to designate protected areas where artificial source populations are known to occur.

Figure 6. *A. fragilis* collected by Scottish scallop fishermen, and transplanted at a site at the mouth of Loch Carron by Sue Scott. One of two individuals in this area that could potentially be the start of a nursery area if further *A. fragilis* were collected and transplanted here. © Rohan Holt.

Figure 7. *Atrina fragilis* specimen collected from Falmouth in 1953 (called *Pinna fragilis* on ID label). This specimen is approximately 30cm long. This specimen resides at the Natural History Museum, London. © J-L. Solandt.

Acknowledgments
MCS would like to thank Sue Scott for providing photographs, the Esmee Fairbairn Foundation, for providing generous support for this work. MCS would also like to thank the Environmental Records Centre of Cornwall and the Scilly Isles for contributing extensive data for this work.

References

Anon, 1999 *Atrina fragilis* (a fan shell). Species Action Plan. In *UK Biodiversity Group. Tranche 2 Action Plans. English Nature for the UK Biodiversity Group, Peterborough*

Jeffreys J G 1863 *British Conchology, (vol. 2 – Marine Shells)* London

Keen, A M 1958 *Sea Shells of Tropical West America*. Stanford Univ. Press, Stanford, California

Marshall, D J 2002 In situ measures of spawning synchrony and fertilization success in an intertidal, free-spawning invertebrate. *Mar. Ecol. Prog. Ser.* 236:113-119

Richardson, C A, Kennedy, H, Duarte, C M, Kennedy, D P, and Proud S V 1999 Age and growth of the fan mussel (*Pinna nobilis*) from south east Spanish Medierranean seagrass (*Posidonia oceanica*) meadows. *Mar. Biol*. 133:205-212

Shimeta, J, and Jumars, PA 1991 Physical-mechanisms and rates of particle capture by suspension-feeders. *Oceanography and Marine Biology* 29: 191-257

Simunovic, A, Piccinetti, C., Bartulovic, M, and Grubelic, I 2001 Distribution of *Atrina fragilis* (PENNANT, 1777) (Pinnidae, Mollusca Bivalvia) in the Adriatic Sea. *Acta Adriatica* 42(1): 49-59

Woodward F R 1985. The Fan-mussel, *Pinna fragilis* Pennant in Scotland. *Glasgow Naturalist* 21: 63-69.

Wu, R S S and Shin P K S 1998 Transplant experiments on growth and mortality of the fan mussel *Pinna bicolor*. *Aquaculture* 163:47-62

Yong, C M and Thompson T E 1976 *Living Marine Molluscs*. William Collins and Sons and Co