

CHANGES IN THE FIRTH OF CLYDE  
MARINE ECOSYSTEM SINCE THE 1850S



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Introduction

*The need for long-term management of marine ecosystems*

The past often holds the key to understanding the present problems of ecosystems and, therefore, perhaps the key to their recovery<sup>1</sup>.

The history of fisheries management goes back a long way. Local regulatory boards existed in the harbours of France, Spain and England centuries ago in an attempt to protect resources, and many coastal communities over the world have long had traditional access rights established<sup>2</sup>. However, present catch and landings statistics do not have such a lengthy history, and we have little evidence of how marine ecosystems used to be. The past conditions of an area are recalled as reflections by fishers, and a few descriptions perhaps recorded by chance, described collectively as ‘anecdotes’. Past information needs to be incorporated into present day fisheries management to gain a fuller understanding of the changes that have occurred over time in populations and exploitation patterns. However, this is rarely done.

Long-term studies are slowly becoming used to determine how marine ecosystems used to be, and what has caused these changes over time. Jeremy Jackson and colleagues used ecological, historical, archaeological and paleoecological records to describe long-term changes to several major marine ecosystems caused by human disturbance<sup>3</sup>. John Pandolfi and co-workers also performed similar research into coral reef ecosystems, and found that substantial degradation had occurred before 1900<sup>4</sup>, something that would be missed by short-term datasets. The ‘Sea Around Us’ project is piecing together information to identify trends over time for the North Atlantic Ocean, in an attempt to establish data that can be used for future ecosystem based management<sup>1</sup>.

Traditional fisheries management has failed because we have not taken into account the effects of complex interactions between species, and the fact that fishing gear is rarely selective enough to capture just one target species<sup>5</sup>. The current emphasis is on ecosystem based management and the application of the precautionary approach<sup>2</sup>, but this is not being achieved quickly enough because of weak legislation, political stalemates and challenges to the quality of scientific advice<sup>6</sup>. However, by looking at long-term changes in an ecosystem, the stark contrasts between the past and the present should throw into light the failings that have occurred and the desperate situation that many marine species now face.

This project reports on the Firth of Clyde. By building up a picture of this region and the changes that have come about, it is hoped that some sense can be made of the scale of transformation that has occurred.

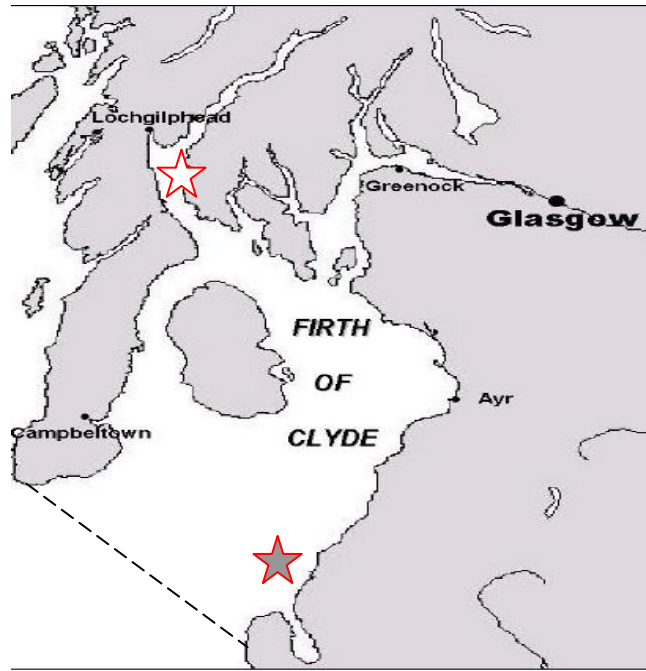
### *The Firth of Clyde*

The Firth of Clyde lies on the south-west coast of Scotland and is the most southerly fjord in the northern hemisphere<sup>7</sup>. Today the Clyde sea area is used for a range of activities including fishing, shipping and aquaculture, with a nuclear power station and oil terminal also situated on the Clyde<sup>8</sup>.

Historically, fishing has been the mainstay of the Firth of Clyde economy, with a growth in commercial fishing dating from medieval times<sup>9</sup>. The herring fishery was of importance for hundreds of years, with Loch Fyne on the inner Clyde famous for its high quality herring<sup>10</sup>. This fishery has since declined, and the focus has shifted towards *Nephrops norvegicus*, a crustacean that demands high prices on the continent and is popular as ‘scampi’ throughout the UK. Other fisheries for cod, hake, saithe and whiting have also been of importance within the Clyde area<sup>10</sup>.

The growth of human populations and increased movement to cities during the industrial era meant that pollution from sewage and industrial effluents drastically increased upriver of the Firth of Clyde, destroying the once productive salmon fishery<sup>11</sup>. Pollution problems were not properly addressed until the 1960s, after which environmental conditions began to slowly improve<sup>9</sup>.

The Firth of Clyde has been a focus for recreation for many years, with popular angling competitions taking place in the past. The Clyde boasts several National Scenic Areas whilst three European Special Protection Areas<sup>8</sup> recognise and protect internationally important seabird and wader populations, which use the Clyde as a winter feeding site<sup>12</sup>.



*Location of the Firth of Clyde: the limit of the Clyde sea area has traditionally been taken as a straight line from the Mull of Kintyre to Corsewall Point, as shown by the dashed line. Open star indicates Loch Fyne, traditionally a source of high quality herring, and the filled star shows the location of Ballantrae Banks, an important herring fishing ground. Source: Scottish Sustainable Marine Environment Initiative<sup>13</sup>.*

#### *Primary objectives and methods*

In writing this report, I hope to build up a picture of the changes to the Firth of Clyde marine ecosystem over the past century, in an attempt to determine the causes and magnitude of change.

Historical information was taken from the Annual Reports of the Fishery Board for Scotland, Scottish Home Department Reports, Scottish Fisheries Bulletins and the Department of Agriculture and Fisheries for Scotland. Contemporary literature was accessed from relevant journal reports and Clyde organisations through the internet. A skipper's past recollections were also published in a local paper, which was kindly sent to me by the narrator.

Contemporary datasets of disaggregated catches were requested from the Scottish Fisheries Protection Agency (SFPA). Earlier information on landings has been taken from the Scottish Sea Fisheries Statistical Tables, published by the Department of Agriculture and Fisheries for Scotland.

Information regarding a past Clyde fishing festival was donated by the Community of Arran Seabed Trust (COAST), with pictures also sent showing catches from the festival throughout the years. Questionnaires were carried out over the phone to fishers, to determine what changes they have seen over the course of their careers, and what they believe are the main causes of this (see Appendix 1).

## Results: a picture of the Firth of Clyde

### *Pre-1900*

#### *The herring fishery*

Before the onset of the 20<sup>th</sup> century and the rapid industrialisation that was to follow, fishing in the Firth of Clyde was performed mostly from small rowing and sailing skiffs. These sailed out to capture the huge shoals of herring that arrived every winter to spawn off the south coast of Arran and at Ballantrae Banks<sup>14</sup>. Other catches of fish were also taken in the Clyde, particularly in the summer months when herring did not congregate in shoals. Fisheries for mackerel, cod, haddock and whiting, turbot and flounders existed<sup>15</sup>, but none was as economically significant as the annual herring fishery.



*A Clyde skiff in c. 1904 using oars and sails. Source: Martin, A (2002). Herring fishermen of Kintyre and Ayrshire. House of Lochar, Isle of Colonsay, UK<sup>14</sup>.*

In the 1870s the Ballantrae winter herring fishery was the most important in Scotland<sup>16</sup>, with boats from as far away as the east coast coming to take part in the annual catch. Fishers were not the only ones to take advantage of the multitudes of herring, as P. Wilson describes in 1887,

The banks are at times the scene of lively interest when visited by a shoal of whales. On a recent occasion, as the sun was setting, a shoal of at least forty whales in pairs and a number of porpoises began to play, and went circling round the margin of the bank displaying their huge fins and arched backs, gracefully plunging and again reappearing a short distance off. The porpoises, in wild leaps went several feet sheer out of the water, and then dived apparently in search of their prey. In this manner the flock of whales and porpoises went circling round for at least a distance of ten miles<sup>16</sup>.

Wilson also depicts the activities of gannets in the area, as many seabirds were attracted to the rich resources of Ballantrae Banks to feed,

Overhead the air is often clouded with them [gannets]. Gathering their wings to their sides, they drop from the height of 200 to 300 yards like meteor showers, jets of spray rising on the surface, and indicating the spots where they have pierced the water. Sometimes they descend to a depth of several fathoms, and fish the herrings from the trammel-nets at the sea bottom, and occasionally get caught themselves in the meshes [...]. All authorities agree in the opinion that the quantity of herrings consumed by the gannets exceeds that captured by man.

The number of predators visible in the water and their ferocity when consuming the shoals of herring, led people to be amazed that there would be enough left at the end of the frenzy for the fishers, as P. Wilson states in 1887,

With so many agencies of destruction, the marvel is that so many herrings remain to become the food of man, who, with all his ingenuity and skill, cannot compete with the sea birds, cod, and other fishes<sup>16</sup>.

Plentiful catches were, however, still taken by people with entire boatfuls of fish regularly caught<sup>17, 18</sup>. The diversity of the Clyde was also apparent, with many species of skates, rays and sharks observed, including tope sharks, blue sharks and even a thresher shark witnessed in Loch Fyne in 1898<sup>19</sup>. The same author reports the finding of a seahorse (*Hippocampus spp.*) near Campbeltown in 1894, with news of these also found many years before in this area<sup>19</sup>. Dogfish could be so numerous during the herring fishery that they were perceived as serious pests. Their sharp

spines entangled them in fishers' nets<sup>20</sup>, tearing and rendering the nets useless, sometimes forcing the fishery to a halt until the dogfish moved from the area<sup>21</sup>.

### *Locating the herring*

Before the advent of echo sounders and fast moving trawlers, locating fish was a skilled and often frustrating activity. Whilst out on the boat, 'appearances' of herring would be constantly searched for upon the surface of the sea. These could take the form of gannets plummeting vertically into the sea, or bubbles present on the surface of the water as gas was released from the herrings' swim bladders. A phosphorescent glow on the surface of the sea at night, as microscopic dinoflagellates were disturbed by a shoal of fish was also a sign of herring<sup>14</sup>.

Once the presence of herring was suspected, nets were shot from the boat. Three main types of gear were in use in the Firth of Clyde in the 19<sup>th</sup> century, these were the drift, trammel and seine net<sup>16</sup>. Drift nets were set behind the boat<sup>14</sup>, while trammel nets were set upon the bottom of the sea bed and left to ensnare spawning herring<sup>16</sup>. Trammel nets were the major mode of fishing in the Firth of Clyde for centuries, but slowly the seine net began to be adopted. It was known as the 'ring-net', because fishers encircled the net around the shoal of herring, before drawing the net tight and ensnaring the fish.

### *Natural variation and conflict*

The herring fishery had always been subject to huge year-to-year fluctuations. Different areas around the coast would become productive, only to decrease a few years later. Loch Fyne in the inner Firth of Clyde was the site of a major spawning herring fishery in the mid-1800s, but by the 1880s few herring could be found there<sup>22</sup>. Even from year to year, changes in the numbers of herring caught could be enormous. In 1895 the herring fishery was a failure in the Rothesay district in the Firth of Clyde, yet in 1897 it is documented that a vast shoal, several miles wide, is seen<sup>23, 24</sup>. The spawning grounds of the Ballantrae Banks also had good years and bad years. P. Wilson, writing in 1887 stated,



The fishing has had its fluctuations, as there are years of scarcity and plenty in the sea as on the land, besides weather and other conditions which interfere with its prosecution. It is stated by [Mr William] Abercrombie [Minister of Maypole, written about 1686], when he wrote of Ballantrae as being greatly resorted to by reason of a herring fishery at Christmas, 'but that has ceased some thirty years past'<sup>16</sup>.

The use of different techniques to capture herring would sometimes lead to conflict, and in periods of drought when few herring could be caught, fishers were quick to blame the actions of others, as J.C Ewart and colleagues noted in 1887,

The fishermen, as a rule, seem to have made up their minds that certain modes of fishing are injurious, and although at times the opinions of the fishermen at one centre were in direct opposition to those prevailing at another, they were always firmly adhered to, the fishermen being unwilling to give weight to any considerations which failed to accord with their opinions. For example, the seine net fishermen of Campbeltown insist on the great injury done by the trammel net fishermen who work on the Ballantrae banks, while the Ballantrae fishermen believe that the use of seine nets on the banks is ruining the herring fishing<sup>25</sup>.

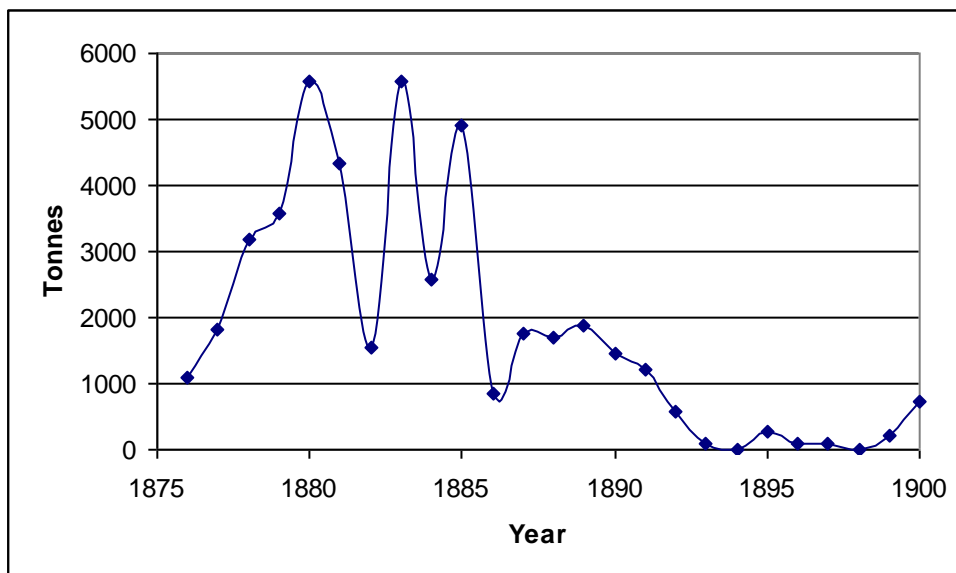
Technology was constantly being adapted and improved, but with new technology came additional conflict, as fishers became concerned that stocks may be depleted by the more efficient methods.

#### *Improved technology: the seine net at Ballantrae Banks*

The seine net was first used in Loch Fyne in 1838, but caused such conflict between the seine and drift netters that a law was passed in 1851 making seine netting illegal<sup>26</sup>. Conflicts still continued, with the result that one fisherman was wounded in 1853 and another shot dead in 1862 by those enforcing the law<sup>14</sup>. When shoals of fish found their way into Loch Fyne, it led to drift netters arming themselves to prevent the seine netters from entering the area. However, enforcement was little use, and seine netting continued almost unabated during the years it was made illegal<sup>26</sup>. A Royal Commission of Enquiry led by Thomas Huxley, resulted in the allowance of seine net fishing in 1867, along with the repeal of many other fishery regulations<sup>26</sup>.

An enquiry into whether the seine net was injurious to drift net fishing was launched by the Fishery Board for Scotland in 1899<sup>27</sup>. At this time the once important Ballantrae Banks fishing grounds had suffered a decline, and blame was being laid upon the seine netters, who had greatly increased in number in the 1880s shortly before the decline in catches occurred.

The Ballantrae Banks is a shallow area where herring were fished whilst spawning. This area had been closed to fishing in 1860 between January and May, as it was thought that these spawning fish were being caught before they could reach Loch Fyne, but this law was repealed and the fishery resumed in 1868<sup>26</sup>. Before 1878 the only gear used to capture herring was the trammel and drift net, but in 1878 the seine net began to be employed and was met with great success<sup>26</sup>.



*Changes of fortune at Ballantrae Banks: Landings of herring caught by trammel, drift and seine net from the Ballantrae Banks between 1876 and 1900. Source: Fulton, T.W (1900). Report of an enquiry on the action of the herring seine-net<sup>26</sup>.*

It was found that the relatively shallow banks of the Ballantrae fishing ground led to the larger seine nets dragging along the sea bed, as well as being more likely to entrap juvenile herring, as T.W. Fulton reported in 1900,

With regard to the capture of small or immature herrings, there is no doubt that the seine net takes far greater quantities than the trammel net does [...]. In seasons when small herrings abound very large quantities have been landed, and in some years have been found unsaleable and used for manure. Sometimes the catch of the seine boats consists of herrings as large and fine as those got by the trammels, but as a rule there is a considerable admixture of inferior fish. If the net is torn on the bottom, which is not an infrequent occurrence, or if a larger quantity is enclosed than the boats can well carry, and part is allowed to escape, the proportion of small herrings in the catch may be increased, inasmuch as large numbers of them are meshed<sup>26</sup>.

The dragging of the seine nets across the Ballantrae Banks was claimed to cause a great deal of destruction to deposited spawn. However, the trammel nets also destroyed spawn, and both the drift and trammel nets were by no means free of bycatch, especially if left standing for days due to stormy weather, as T.W. Fulton noted:

These nets are left in the water, and are usually visited in the morning by the fishermen, who remove the herrings and re-set the net; the boats do not stand by their nets. It often happens that, owing to bad weather, the nets cannot be visited for many days, and they become so weighted with fish as to lie flat on the bottom; and sometimes a gale sweeps them away or casts them into heaps, and in such cases putrefaction of the herrings contained in them causes pollution of the water<sup>26</sup>.

The investigation into the use of the seine net found that in certain conditions and deep water, the net would not be too much of a problem to fish stocks, but in shallow grounds such as the Ballantrae Banks more damage could possibly be done;

The seine net, when used at Ballantrae Bank, extends from the surface to the bottom and encloses everything that comes within its reach, and there is little doubt that it is in the power of seine-net fishermen to sweep this limited area almost clean of herrings for the time. The destruction of deposited spawn does not appear to be of much importance, but an excessive fishing on the Bank among the spawning shoals and constant sweeping of the bottom is not unlikely to prove injurious<sup>26</sup>.

Seine nets were difficult to work and required two boats to set and haul in the net<sup>14</sup>, but when shoals of herring were spotted, huge hauls of over 200,000 fish could be

taken<sup>26</sup>. Despite the continuing conflicts, the success of the seine net crews led other fishers to follow, until the seine was the most common method of fishing for herring in the Clyde by the 1890s<sup>26</sup>.

### *Demersal trawling*

Another type of fishing gear that was to increase in importance throughout the 19<sup>th</sup> century was the demersal beam trawl. To begin with the trawls were dragged by small local sailing vessels in the Clyde<sup>28</sup>, and were therefore restricted to 'clean' ground and favourable weather conditions. By the 1880's, the local sailing vessels worked almost everywhere in the lower reaches of the Clyde, where good catches of fish such as cod, dabs, flounder, lemon soles and turbot could be taken<sup>28</sup>. At this time, the advent of steam power brought larger steam trawlers into the area, mostly boats from England<sup>28</sup>.

By the late 19<sup>th</sup> century, declines were witnessed in many inshore areas around European coasts, with fishers forced to travel further to keep up the supplies of fish<sup>21</sup>. Within the Clyde area, numerous petitions were sent in favour of restricting trawling to certain areas, resulting in an enquiry by the Fishery Board as to whether trawling resulted in a decline in fish stocks<sup>25</sup>.

This was not the first enquiry to take place regarding beam trawling. A Royal Commission was established in 1866 in response to concerns about trawling and seine nets in fishing grounds, but no problems were proved at this point, and the Commission even repealed all regulations upon fishing in the open sea, saying,

Beam trawling in the open sea is not a wastefully destructive mode of fishing, but is one of the most copious and regular sources of the supply of eminently wholesome and nutritious fish. Any restriction upon this mode of fishing would be equivalent to a diminution of the supply of food to the people; while there is no reason to expect present or future benefit from that restriction<sup>25</sup>.

Further Royal Commissions in 1878 and 1885 failed to find any evidence of declines in fish because of a lack of statistics<sup>35</sup>. However, by 1887, the enquiry by the Fishery

Board of Scotland came to the conclusion that beam trawlers did damage other fishers' gear, and that the decrease of fish in territorial waters meant that restrictions would have to be imposed:

It is everywhere alleged that the territorial waters have been overfished, but in the absence of statistics it is impossible in the meantime to arrive at any definite conclusion on the subject. That there is no general exhaustion of the inshore and offshore waters around the coast may be inferred from the fact that nearly double the quantity of round fish (exclusive of herring) was landed in 1887 than in 1882, and that at Stonehaven and other centres, where trawling is not prohibited by the bye-laws, more fish were landed in 1887 than in former years [...]. It may afterwards be shown, however, that inshore grounds can be exhausted by either line or beam trawl fishermen, the rate and extent depending on the number and size of boats fishing<sup>25</sup>.

The enquiry conducted by the Fishery Board of Scotland was able to show the extent of ill-feeling about the more efficient and damaging methods of fishing that were increasing in extent. Yet to maintain a competitive edge, it was necessary that fishers continued to increase their efforts...

It appears that so long as one man fishes in the day-time all must follow, if only in self-defence<sup>22</sup>.

The mode of fishing adopted by the fishermen belonging to this district at the Ballantrae fishing is the circle net, and from repeated conversations I have had with them, they appear to be of opinion that this mode of fishing is injurious, especially during the spawning season, and in consequence of this they would willingly abstain from going to the Ballantrae fishing if fishermen from other districts would also abstain from going. They firmly believe that beam trawling in any part of the Firth of Clyde is injurious, and are desirous that this mode of fishing should be prohibited<sup>29</sup>.

Many fishers interviewed in 1887 were convinced that beam trawling was causing a decrease in the abundance and size of fish throughout the Firth of Clyde, because of the extent of fishing, the large bycatch of young fish and the disturbance of fishing grounds<sup>30</sup>. Some of the fishers had worked in the Clyde area for 40 years and more,

and witnessed the evolution of the trawler and seine net, and the consequent destruction of small fish. J. Wason was interviewed in 1887, stating,

Some fishermen present had seen the small fish shovelled overboard, and immense quantities of spawn also shovelled overboard<sup>30</sup>.

A. Campbell was a boat-owner, and was interviewed in the same year, saying,

...if beam trawling is allowed to go on unchecked, the chief fishing banks in the Clyde (already greatly exhausted) will soon be so destroyed that for many years the yield will not meet the working expenses<sup>31</sup>.

W. Hannah had been a fisher for 40 years by 1887, and when questioned about beam trawling he described the discarding practises he had seen, as well as the decrease in abundances of fish,

He had witnessed trawl being hauled, the catch consisting of dog-fish, skate, &c., and a great amount of small fish, rowds (gurnots), turbot, flounders, and others. There were more small than big fish, and they were usually thrown overboard<sup>17</sup>.

The supply of fish has been diminishing during the last 10 or 12 years, only 10 turbot being got now instead of from 40 to 80 got 15 years ago<sup>17</sup>.

A District Fishery Officer, W. Bain was also interviewed by J.C. Ewart and colleagues in 1887, and made it clear regarding his views about the destructiveness of beam trawling,

At the tail of the bank, in particular, the takes have fallen off very much of late, and the fish now got are generally very much smaller in size than formerly, and altogether the aspect of things appear to indicate that beam trawling has injured this fishery very considerably<sup>32</sup>.

By the 1880's fishing boats were undergoing a transformation. The small, undecked, uncomfortable boats were being replaced by larger decked boats that could travel further out to sea and carry larger amounts of fish<sup>33</sup>. Although the

beam trawl was viewed with much concern by many in the fishing community, its use continued to grow until the larger and more efficient otter trawl came into use in 1895<sup>33</sup>. The otter trawl with its broader sweep was able to capture more fish than the beam trawl, and despite being introduced only in 1895, within a year almost all trawlers in the Scottish fleet had adapted them<sup>34</sup>.

### *Scientific interest*

The Fishery Board of Scotland was established in 1882 to provide statistics on the Scottish fisheries<sup>35</sup>. As part of this research, experimental trawl surveys were performed in different areas around the coast, and the Firth of Forth and Firth of Clyde were compared in 1887:

It was found that, compared with the protected waters on the East Coast, the number of fish [in the Clyde] was very small; the average per trawl being 109, while in the Forth it was nearly double. Round fish, such as cod and haddock, were much more numerous in the Forth, while the paucity of flat-fish in the Clyde was most marked: plaice were thirteen times and soles over four times more abundant in the Forth. These facts seem to support the contention of the fishermen that a great diminution in the productiveness of the fisheries has occurred. The number of beam trawlers, many of them large and well equipped, which have been working in the Clyde in recent years is considerable, a large proportion of them coming from England and the East Coast. But it appears that this area is now so exhausted that most of them have been forced to seek more remunerative working grounds elsewhere<sup>36</sup>.

In 1887, the Firth of Forth had had an area closed to trawling for some years, and scientists from the Fishery Board started to think that this may be necessary for the Firth of Clyde,

From the enquiries carried on by the Garland into the present condition of the fishing grounds in the Firth of Clyde, it is obvious that the abundance of fish, and especially of the valuable flat fish in that area, is very much less than in the restricted waters on the East Coast. The evidence given in the special Report previously referred to shows the probable reason of this. The Firth of Clyde is rich in those animal forms which constitute the principal food of fish, and is naturally well adapted to support multitudes of edible fishes, provided that wasteful or destructive modes of fishing are not persistently carried on. But, from the scientific evidence obtained, and from the testimony given on the spot, it appears that the numbers of these fish have very seriously diminished in recent years; and it is scarcely possible to escape the conviction that this has been mainly due to excessive trawling, for a large number of English and other trawlers have habitually swept the grounds during successive seasons, and now this mode of fishing has become comparatively unremunerative; the East Coast trawlers having returned to Granton<sup>37</sup>.

In consequence of the state of matters thus revealed, it is extremely desirable to proceed to regulate as soon as possible beam trawling in the Clyde area, partly by way of protecting the spawning grounds, and partly in order to prevent the complete destruction of flat-fish. To admit of any real good being done, it will be necessary of the Board to have complete control over all the Firth, and not merely the upper reaches of the Clyde. There is reason to believe that were a period of quiescence bestowed upon some of these waters, opportunity would be given for undisturbed increase, especially of the smaller fish; and this would ultimately largely add to the yield, not only in the waters immediately protected, but in those which are contiguous. It is a noteworthy circumstance that recently an increase has occurred in the number of the smaller fish landed by line fishermen on the East Coast, especially from inshore waters, and this may be considered as an indication of more favourable conditions for natural reproduction<sup>36</sup>.

As a result of the interviews conducted in 1887, and the extensive trawl surveys performed, it became unlawful to trawl within three miles of the low-water mark anywhere in Scotland in 1889. However, a bye-law was granted at the request of fishers from the Clyde district, where small sailing vessels less than eight tonnes were still able to trawl within the three-mile limit<sup>38</sup>. In 1889 an area within the Firth of Clyde comprised of 600 square miles was also closed to trawling, in a straight line



from the Mull of Kintyre, Argyllshire, to Corsewall Point, Wigtownshire, and extending over part of the outer Firth of Clyde<sup>39</sup>.

Towards the end of the 19<sup>th</sup> century, the importance of the Firth of Clyde as a spawning area for many species of fish became known to fishery scientists<sup>40</sup>. The closed area also exhibited a gradual overall increase in the abundance of fish, with flatfish responding the most strongly<sup>41</sup>. These experiments were performed using demersal trawls at various stations throughout the Firth of Clyde<sup>41</sup>. Fishing methods were improving in efficiency, but also increasing the number of juvenile fish taken, many of which ended up thrown over the side of the boat or used as manure<sup>42</sup>.

Declines were reported from other countries bordering the North Sea, with the same pattern everywhere; a decrease in fish but improved catching technology as steam vessels became faster<sup>43</sup>, and an expansion in the fish trade<sup>44</sup>. Although it had become clear that trawling would supersede all other forms of fishing for whitefish<sup>45</sup>, the expansion of other techniques was also causing declines, as J.C. Ewart and colleagues reported in 1888,

The result appears to be a drain upon the supply of fish from the inshore waters sufficient, even without trawling, to cause diminution<sup>25</sup>.

It had been made clear that the coastal areas were no longer inexhaustible, and resources were in danger of becoming greatly diminished unless action was taken and regulations enforced<sup>46</sup>.



*Visiting east coast fishing boats in the Firth of Clyde to catch herring, c. 1888. By the end of the 19<sup>th</sup> century boats had become decked and larger than these skiffs, enabling them to carry greater quantities of fish. Source: Martin, A (2002). Herring fishermen of Kintyre and Ayrshire. House of Lochar, Isle of Colonsay, UK<sup>14</sup>.*

### ***1900-1950***

By the turn of the century the herring fishery had been a failure on Ballantrae Bank and Loch Fyne for a number of years, yet there were still signs that the herring were there, with spawn deposited on the banks<sup>47</sup>. Even with disappointing catches in parts of the Clyde, herring was still the mainstay of the Clyde fishing industry, although also of importance were line and net fishing for cod and flounder, shrimp trawling and crab and lobster fishing<sup>48</sup>. In 1913, herring accounted for 84% of the total landings in the Clyde area, and 81% of the total value<sup>48</sup>. By the first decade of the 20<sup>th</sup> century, line fishing was declining drastically as fishers came into increasing competition with trawlers<sup>48</sup>.

#### *Steam and diesel power*

At the end of the 19<sup>th</sup> century, steam had revolutionised the trawling industry, and quickly became an important part of the Firth of Clyde fishing industry. The ability of steam trawlers to work without being at the mercy of wind and tide meant that conflict with users of static gear still occurred, and probably increased as trawlers towed away set gear<sup>33</sup>. Diesel motorboats also quickly increased in use before the onset of the First World War, with the impact of motor power on the fishing industry as considerable and almost as rapid as the invention of the otter trawl. By the first

decade of the twentieth century, boats could travel further than ever offshore, with up to 240 miles travelled to fishing grounds, whereas 30-40 miles was considered a long distance just a few years before<sup>49</sup>. This innovation also meant that motor-powered boats could be back hours before the sailing boats, saving valuable time<sup>49</sup>.

In 1910 the Loch Fyne herring fishery was at its lowest ebb, and showed few signs of improvement from a state of depression that had become the longest on record<sup>50</sup>. Drift nets were gradually abandoned as more people turned to seine netting using motorised boats to catch herring<sup>49</sup>. However, by the 1920's the Loch Fyne herring fishery had started to revive, another example of the fluctuations common to herring<sup>51</sup>. Around this time, pressure also began to be placed upon opening up the closed area in the Clyde to trawlers<sup>52</sup> as foreign vessels increasingly frequented the boundaries of the closed area and fished illegally<sup>53</sup>.

The Clyde fishery saw new innovations in the mid-1920s. Two decked boats were built for Campbeltown fishers that were 50ft in length. Open boats of the 19<sup>th</sup> century were long gone, yet conditions were still cramped and uncomfortable, and this extra room would have added much welcomed space to the living quarters. Their catching power was further enhanced by the fitting of a motorised winch to haul in the net<sup>52</sup>.

The rapid innovations in technology led to much more efficient vessels, and by the end of the 1920's overall Scottish fisheries catches had more than doubled in a decade, from 156,460 tonnes in 1917 to 328,226 tonnes in 1926<sup>54</sup>.

### *Juvenile fish*

The Clyde fishery has caused some concern, not so much from the scarcity of fish as from their small size<sup>56</sup>.

By the beginning of the 1930s, catches in the Clyde had once again declined and fishers were now dependent on immature herring<sup>55</sup>. It was established by scientists that the Clyde herring fishery was largely dependent on one year class at a time. Successful recruitment only occurred sporadically, accounting for the large year-to-year differences in catches<sup>56</sup>.

Regulations were applied limiting the quantity of small herring that could be landed each day<sup>57</sup>; however this would have been unlikely to halt the destruction of juvenile fish as the fishing gear in use could not select just large fish. Therefore these regulations would simply have increased the amount of discarding.

Locating herring was still done by sight, but in the 1930s ‘feeling wires’ came into use in the herring fishery. These were weighted wires that could be trailed from the deck of the fishing boat, from which skilled fishers would be able to tell the condition of the ground and locate the presence of herring<sup>14</sup>. Feeling wires were able to detect fish when the long-used techniques for sighting herring were unable to be employed because of unfavourable conditions, and were used until ring-netting itself was discontinued in the 1970’s<sup>14</sup>.

With the onset of the Second World War many fishing grounds were again protected from fishing due to hostilities, but within the Firth of Clyde most of the herring fishing areas remained available, with the inner waters of the Clyde opened when shoals of herring were suspected<sup>58</sup>. The importance of the Clyde area at this time was such that in 1940 the Firth of Clyde provided up to 43% of the total Scottish landings of herring for that year<sup>58</sup>.



*Fleet of ring netters moored c. 1938. Source: Martin, A (2002). Herring fishermen of Kintyre and Ayrshire. House of Lochar, Isle of Colonsay, UK<sup>14</sup>*

### *1950-Present day*

By the 1950s, boats were built on the Clyde that were 50ft long and able to carry 20 tons of fish<sup>59</sup>. The seine net fishery for herring, or ring-netting, was the most important and valuable fishery in the Firth of Clyde<sup>20</sup>. Yet within a few years, herring catches within the Clyde were declining, and catches consisted mainly of juvenile fish<sup>60</sup>. By 1962, there was such a lack of herring during the autumn that fishing was completely stopped<sup>61</sup>. This led to quota restrictions being placed on herring catches in the Clyde in 1963 for the first time<sup>62</sup>.

Whilst herring fisheries began to be restricted, fisheries that had previously been small in comparison to herring were expanding and diversifying.

### *Scallops and queens*

The Scottish fishery for scallops (*Pecten maximus*) started in the late 1930s, but remained a small and localised fishery for the next two decades. It was used to supplement fishers' incomes during the winter months<sup>63</sup>. Fishing for scallops drastically increased as processing factories started to market frozen meats, and a year-round fishery developed from 1961. New markets on the continent led to further expansion into new fishing grounds outside of the Firth of Clyde and up the west coast of Scotland<sup>64</sup>.

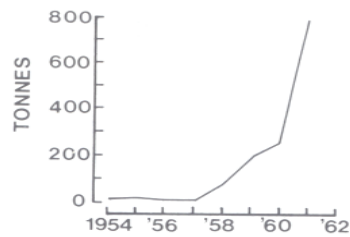
Queenies (*Aequipecten opercularis*), which are smaller than scallops, had been used as bait since the 1880s, but were no longer harvested as line fishing declined in the 1920s<sup>63</sup>. They were often encountered in great abundance in the Firth of Clyde when dredging for scallops, and in 1966 a research vessel off the north coast of Arran caught more than 10,000 queens in two minutes, using only one 6ft dredge<sup>63</sup>. A directed fishery in the Clyde started in 1967 once processing factories made handling queens economical, with a market found in North America<sup>63</sup>.

The gear used to capture scallops is the dredge, which has a fixed toothed bar to dig the scallops out of the seabed. Queens in the Clyde are caught using an otter trawl which captures queens as they swim away from the approaching gear<sup>63</sup>.

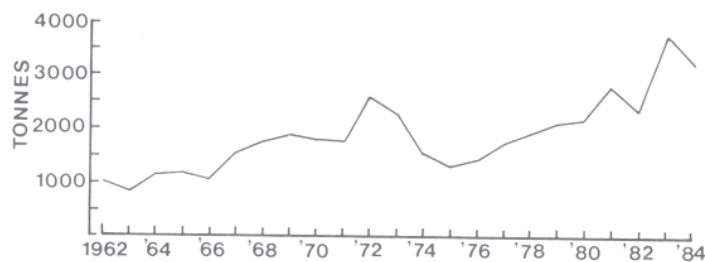
### *Rise of Nephrops and demersal fisheries*

A directed fishery for *Nephrops* prawns began in the 1950s and quickly increased in importance in the Clyde area and the rest of Scotland. *Nephrops* had become the most valuable species landed in Scotland by the 1970s, with the 1972 total Scottish catch valued at £3,854,754<sup>65</sup>. Seine nets were used in the Clyde until a Byelaw came into effect in 1962 which allowed trawling for *Nephrops* within the 600 square miles that had been closed to trawlers since 1889<sup>66</sup>. In the late 1970s a creel fishery developed in the Clyde, landing high quality *Nephrops* which were sold whole<sup>66</sup>. The increase in demersal prawn trawling also enhanced fish catches as any valuable species caught would be retained for market<sup>67</sup>. Large specimens of cod, hake and saithe were also caught in great quantities in the 1970s by the recently invented mid-water pair trawl<sup>59</sup>.

a)



b)



*Graphs of Nephrops landings in the Firth of Clyde zone as defined by DAFS, from 1952 to 1984. Landings are shown by seine net until 1961(a), with trawl landings shown from 1962(b). Seine nets were used in the Clyde until 1962, when trawling was once again permitted. A drastic increase in landings occurred in the early 1960s, with landings by trawlers continuing to rise until the 1980s. Source: Bailey, N., Howard, F.G. and Chapman, C.J (1986). Clyde Nephrops: biology and fisheries. Proceedings of the Royal Society of Edinburgh Section B (Biological Sciences), 90: 501-518<sup>66</sup>.*

### *Technological change*

The advent of the echo-sounder made locating fish much easier. Traditional methods were still very much in use<sup>59</sup>, but as echo-sounders increased in accuracy, fishers abandoned these approaches, although it was felt by some that this may have caused a few chances to have been missed, as Matt Sloan, a former Clyde herring fisher recalled in 2001,

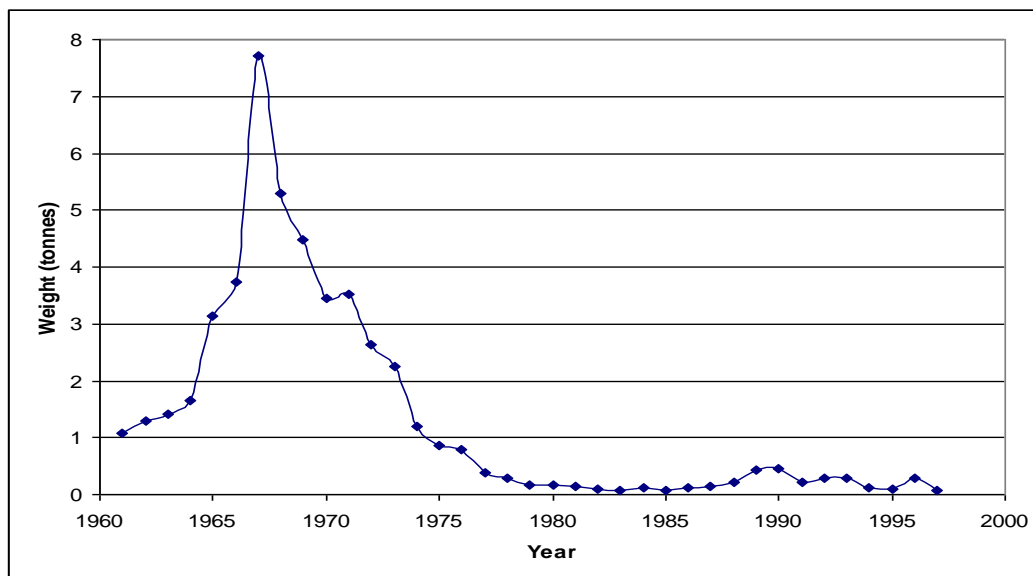
‘I’d be the first tae confess,’ he said, ‘that there wasnae the same attention paid by a man lyin on the bow once the sounder came into being, because if ye wir goin over them wi the sounder goin, ye wid see some indication underneath; but A’m quite certain there were occasions when herrin wir high up – perhaps sheddin off the boat – they might’ve been seen by this sparks in the water in wintertime. And yet if they wir sheddin off the boat, often an often ye wir goin along an ye wirnae seein anything underneath on the sounder at all’<sup>14</sup>.

During the 1960s, most of the Clyde fleet switched to full-time demersal trawling<sup>59</sup>. A combination of market forces that upped the price of *Nephrops* and the reduction in labour compared to seine netting, encouraged the switch<sup>59</sup>. As trawlers increased in power and adopted rock-hopper gear, they were able to trawl in grounds that had previously been out of reach to fishers due to the rocky nature of the seabed<sup>59</sup>.

Those that did stay on in the herring fishery started to use pair-trawls to catch fish. With this invention, whole shoals of herring no longer had to be located, instead, the mid-water trawl could be towed behind the boats and herring captured gradually<sup>59</sup>. By the 1970s seine netting for herring was in decline, with the last ring-net boat, the ‘Alliance’, built in 1974<sup>14</sup>. Towing along the mid-water column also allowed many of the larger, supposedly demersal fish to be found<sup>59</sup>, and the increased speed that nets were dragged meant that fewer animals could out-swim the boats.

## *Lamlash Festival*

In the past the Island of Arran boasted a popular recreational fishing industry, hosting two annual fishing festivals; the Lamlash Festival and the Brodick Festival. The Lamlash Festival was held over a weekend and attracted 150-200 anglers every year on average, and was at the height of its popularity in the 1960s when over 7 tonnes of fish were caught in 1967.



*Tonnes of fish landed at the Lamlash Festival. Source: COAST.*

Throughout the 1970s, catches began to fall. Whether the catches fell first and led to fewer people making the annual trip to the Arran coast or whether the festival simply fell out of favour is questionable, since data on the exact number of fishers attending the festival each year are not available. Neil McClean was the president of the Arran Sea Angling Association throughout the Lamlash festival years, and is also a highly successful international sea angler. He equates the fall in catches to the increase of trawling in the area and the destruction of fish habitats (Neil McClean, pers.comm.). Since the allowance of trawling back into the previously closed area of 600 square miles, the 3 mile coastal exclusion had also been increasingly illegally fished by some trawlers. In the late 1970s this limit was completely abolished, leaving all waters open to trawling<sup>59</sup> and signalled the end of the angling competitions as catches fell (Neil McClean, pers. comm.).



In recent years it was recognised by members of the Arran community that the coastal areas around the island needed some sort of protection from fishing. The Community of Arran Seabed Trust (COAST) was established to encourage support for the creation of a no-take zone in Lamlash Bay off the coast of Arran<sup>68</sup>, the aims of which are to protect vulnerable habitats such as maerl beds and enhance local fish and shellfish populations. Surveys of the sublittoral zone were undertaken by local divers. These revealed important habitats such as maerl and sea grass beds, but also revealed damage caused by scallop dredging to these vulnerable communities<sup>7</sup>.

### *The decline of herring*

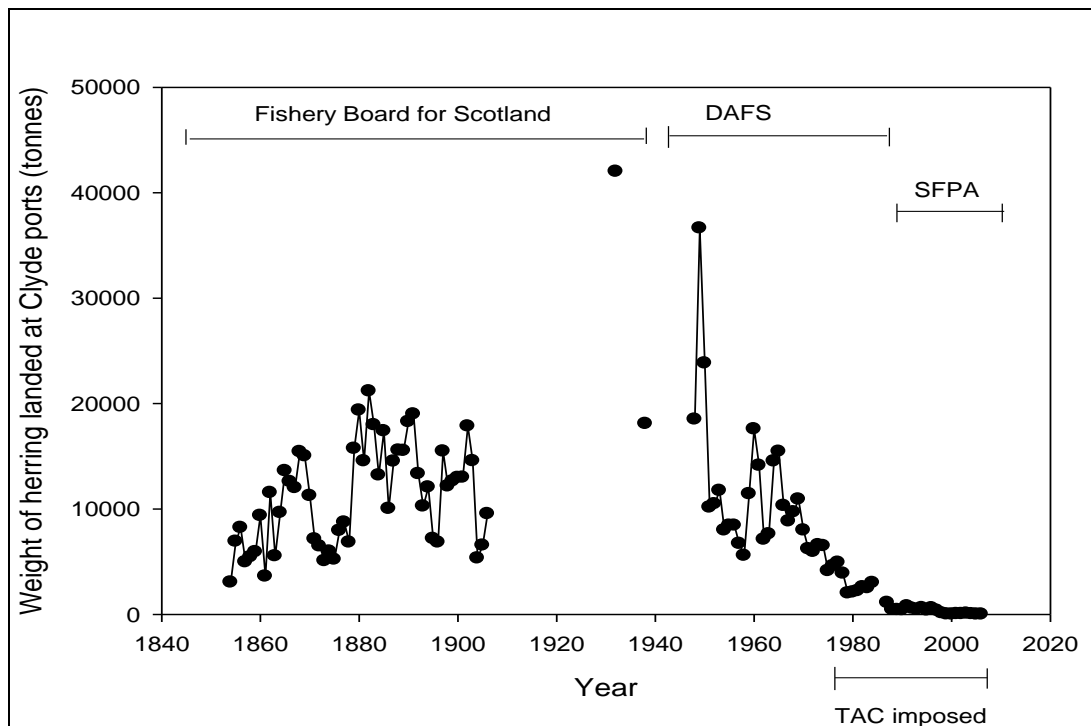
The trend that had occurred in the Firth of Clyde herring fishery, of declining catches that had become dependent upon one strong year class, was repeated around the rest of Scotland. The Clyde came under quota for the first time in 1976, with a limit of 4000 tonnes of herring, as well as an established closed time between January to March to protect spawning stocks<sup>69</sup>. Despite the quotas, landings continued to decline throughout Scotland, until the whole North Sea was closed to herring fishing in 1978. The separately managed Clyde area continued to supply herring, although their quota decreased, with only 2000 tonnes allowed by 1979<sup>70, 71</sup>.

Throughout the documented history of the herring fishery, large fluctuations had occurred in the past. But with the industrialisation of the fisheries the amount of spawning herring taken had become too great, and, coupled with weak recruitment, the herring stocks were driven to an all time low<sup>73</sup>. The recovery of these fish was slower than expected<sup>72</sup>, and as they recovered, fishers needed to find another resource that was economically viable, as a DAFS report of 1978 noted:

Almost all the herring fleet is now capable of diverting to white fish and other pelagic, notably mackerel, fishing<sup>73</sup>.

Year	Quota (tonnes)	Percentage uptake
1996	1,000	69.8
1997	1,000	37.1
1998	1,000	11.3
1999	1,000	1.6
2000	1,000	0.1

Total allowable catch for herring in the Clyde area. As fishing for herring became more restricted, fishers had to adapt to catching new species, meaning that the quotas were not even filled. Source: Scottish sea fisheries statistics, [www.seafisheries.gov](http://www.seafisheries.gov)



Landings of herring in the Firth of Clyde showing the gradual increase during the 19<sup>th</sup> and early 20<sup>th</sup> century. A peak of 42,000 tonnes was reached in 1932, followed by a rapid decline from 1950 onwards, until TACs were imposed in the late 1970s. By the turn of the century, these quotas were no longer filled. Source: Different sources of information were used to assemble the graph, including Fishery Board for Scotland Reports, Department of Agriculture and Fisheries for Scotland and Scottish Fisheries Protection Agency.

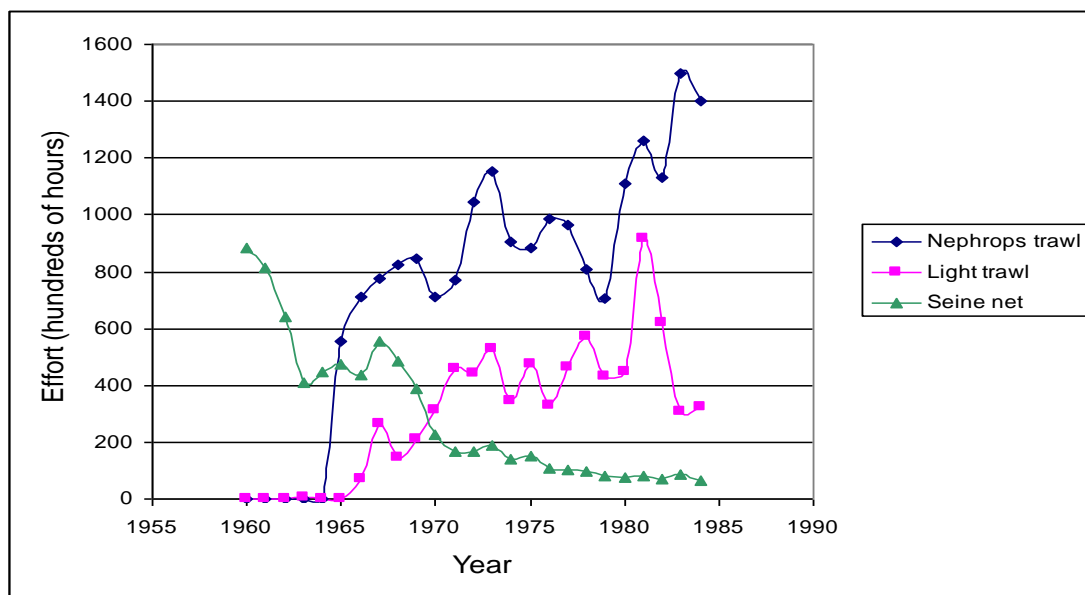
During the period of decline, the composition of herring in the catches changed.

Almost the entire basis for the historical herring fishery in the Clyde was the spawning herring on Ballantrae Bank, which had been important since at least the 15<sup>th</sup> century<sup>74</sup>. By the late 1960s and early 1970s very few spring spawners arrived on the Banks<sup>74</sup>. During this time, the proportion of herring spawning in the Clyde in the autumn increased, indicating a major change in the populations<sup>74</sup>. Today, quotas are set at the low level of 1000 tonnes, reflecting the population decline of Clyde herring.

### Demersal fisheries

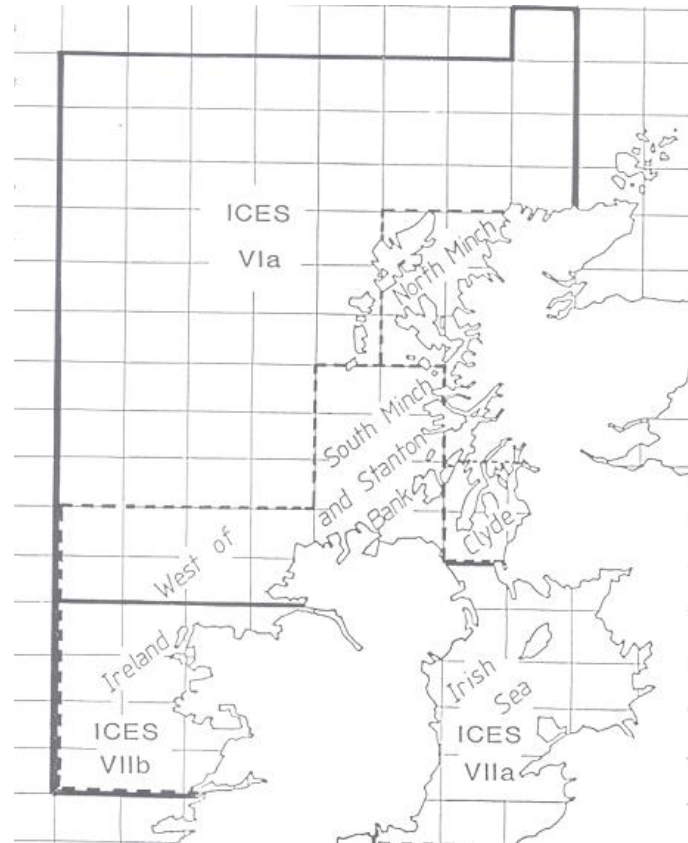
As low herring populations pushed fishers to diversify, other fish stocks were targeted. Mid-water trawls and faster demersal trawling allowed many more fish to be taken, with larger fish caught than had been seen for years<sup>59</sup>. Throughout the 1970s and 1980s, this successful fishing continued, until many people fished for these species full time<sup>59</sup> rather than as a supplementary fishery between herring seasons.

However, by the late 1980s many of these fisheries started to decline. Effort increased, and technology again shifted, this time away from seine nets towards demersal trawling. The increase in trawling was almost entirely due to *Nephrops*<sup>67</sup>, but this fishery landed significant amounts of other species, of which the demersal fish were retained and marketed.

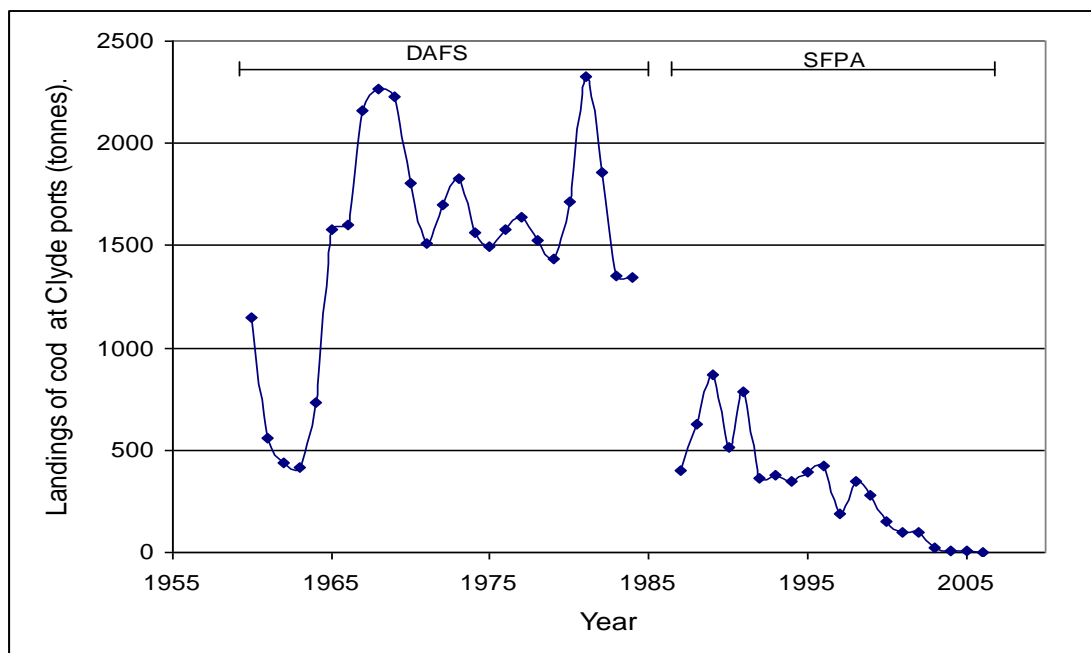


*Increases in effort and changes in technology: after the 1960s the seine net began to decline in use whilst trawling increased sharply in the late 1960s. Light trawling is a method of fishing for demersal species but in reality Nephrops and light trawling have few differences, and are only differentiated by mesh size (slightly smaller to target Nephrops) and the proportions of fish to Nephrops when landing. Source: DAFS. In, Hislop, J.R.G (1986). The demersal fishery in the Clyde sea area. Proceedings of the Royal Society of Edinburgh Section B (Biological Sciences), 90: 423-437<sup>67</sup>.*

Data for the following graphs were gathered from the Department of Agriculture and Fisheries for Scotland (DAFS) from 1960 to 1984, and the Scottish Fisheries Protection Agency (SFPA) from 1987 to 2006.



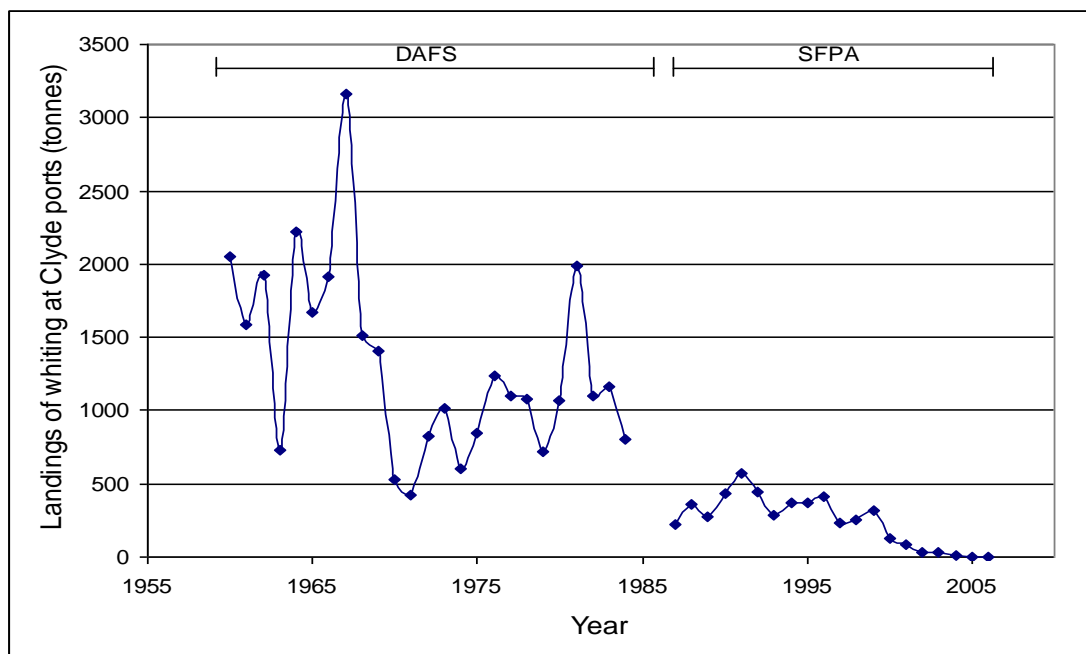
The boundaries of ICES sub-areas, showing the limits of the Clyde as defined by DAFS between 1960 and 1984. Limits after 1987 are not so clear, but likely represent a similar or larger area as data is gathered from landings at ports within the Firth of Clyde. Source: Hislop, J.R.G (1986). *The demersal fishery in the Clyde sea area. Proceedings of the Royal Society of Edinburgh Section B (Biological Sciences), 90: 423-437*<sup>67</sup>.



Landings of cod from Firth of Clyde 1960-2006. Source: Department of Agriculture and Fisheries for Scotland (DAFS) and Scottish Fisheries Protection Agency (SFPA).

Landings of cod exhibited rapid increases in the early 1960s, which continued as effort increased, remaining fairly stable and consistent with total effort until the early 1980s when sharp declines began. Between 1968 and 2006, landings have decreased by over 99%. In the 1950s, cod up to 1.5 metres long were reported<sup>20</sup>, but by the 1970s, sizes had fallen, with the larger specimens generally only 1 metre in length (Interviews, pers. comm.). Today, cod are only occasionally caught, and often weigh as little as 2.25 kg (Tony Wass, pers. comm.).

Measures were put into place in 2001 in an attempt to protect spawning cod stocks. These include limiting *Nephrops* trawlers to 25 days at sea per month, and closing an area in the south of the Clyde from 14<sup>th</sup> February to 30<sup>th</sup> April as it is a significant cod spawning area<sup>75</sup>. A recent decommissioning scheme has decreased the number of whitefish trawlers, but the number of *Nephrops* trawlers – with their smaller mesh size and decreased selectivity – has remained stable. According to ICES in 2006, Clyde cod populations are in serious danger, their spawning stock biomass has reached an historic low, and their reproductive capability has been reduced as the stocks continue to be over-exploited<sup>76</sup>.

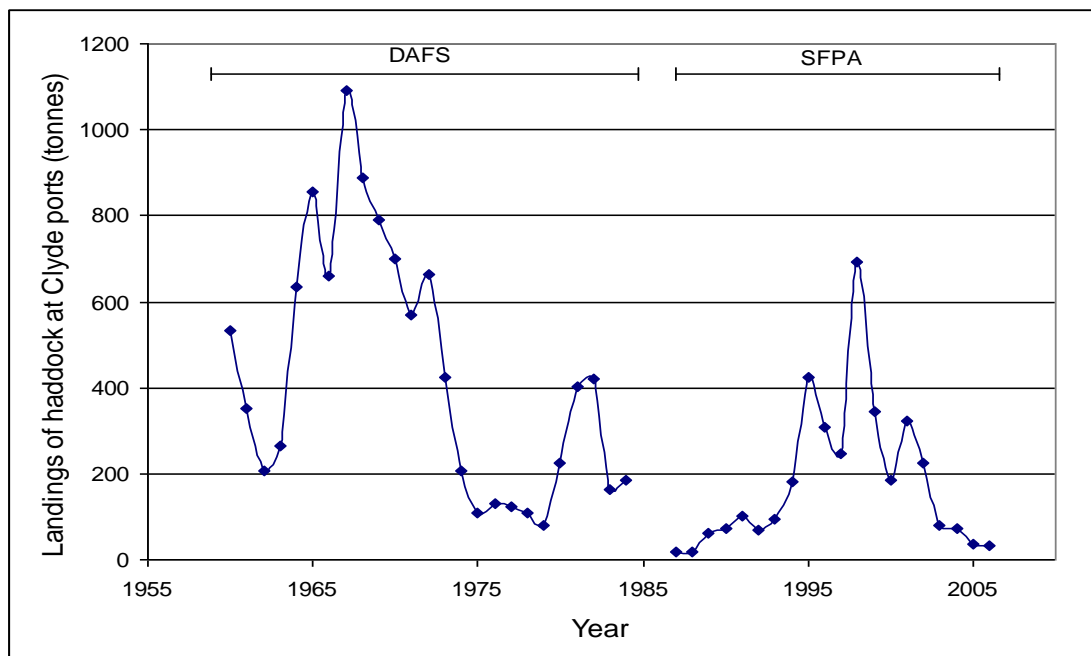


Landings of whiting from Firth of Clyde 1960-2006. Source: DAFS and SFPA.

Whiting have also undergone a drastic decrease since the 1960s, with landings peaking in 1967 and not being met since within the Clyde area. A decline of over

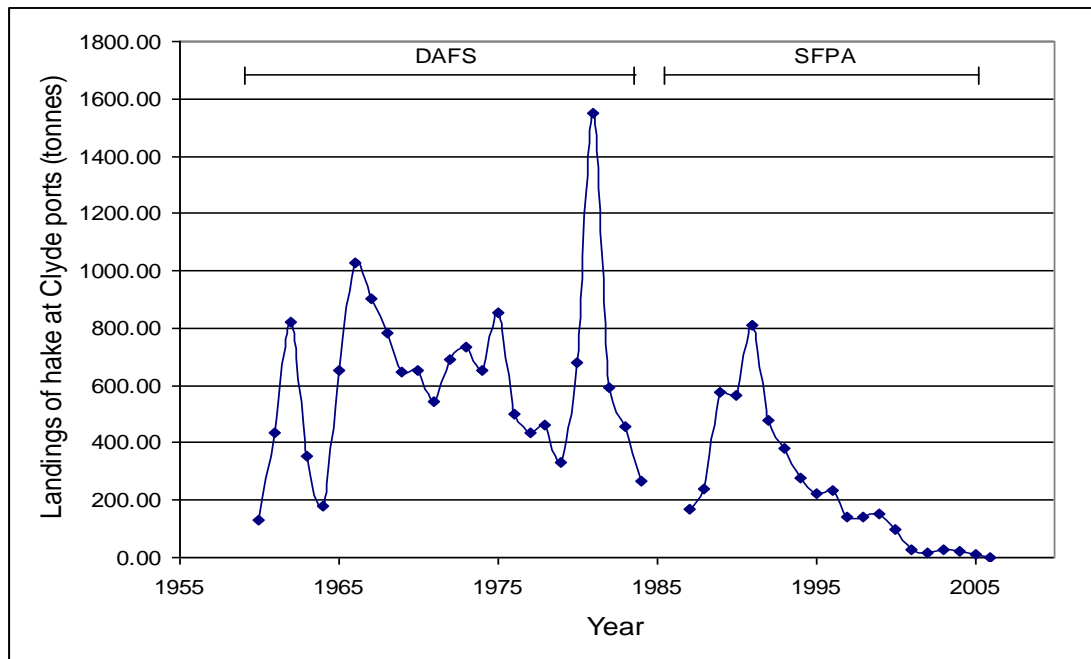
99% has occurred in whiting landings, with a noticeable decline beginning in the early 1970s and continuing until the present day. Haddock, on the other hand has seen greater fluctuations in landings, but has still exhibited an overall decline of over 95% since the 1960s, although a peak in landings occurred as late as 1998.

Changes in effort over the years have occurred and to a certain extent may have been responsible for large catches of cod, whiting and haddock for some years in the late 1960s and early 1970s. However, as these species are intensively exploited, variations in catches are mostly dependent on recruitment of younger fish, therefore reflecting the status of the stocks<sup>67</sup>. Whiting and haddock are also at historically low abundance, continuing to be caught in *Nephrops* trawls<sup>77, 78</sup>.



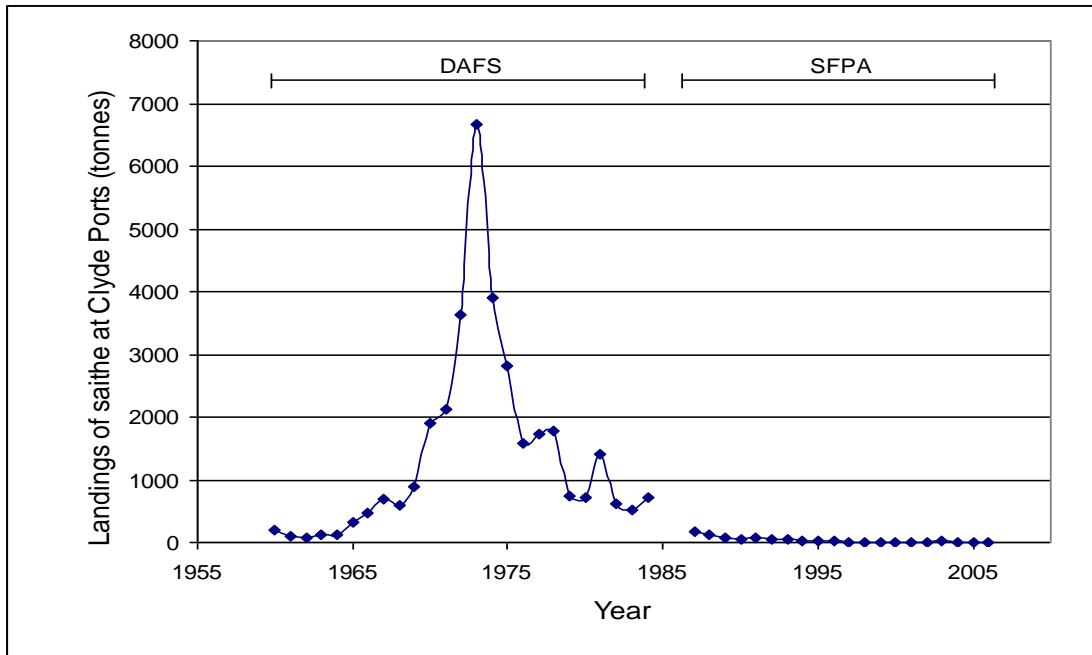
Landings of haddock from Firth of Clyde 1960-2006. Source: DAFS and SFPA.

Economic factors have an important role to play in deciding which species are targeted by fishers. Along with cod, hake was one of the most important species in terms of value in the 1980s, with up to 57% of the total Scottish landings of hake taken in Clyde waters in the early 1980s<sup>67</sup>.



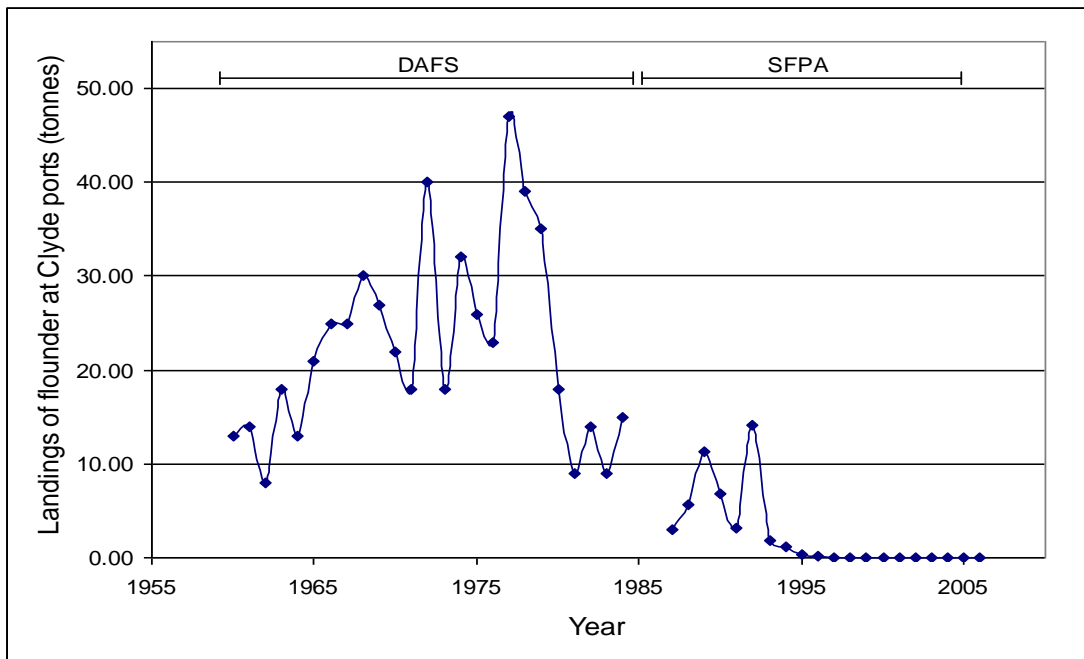
*Landings of hake from Firth of Clyde 1960-2006. Source: DAFS and SFPA.*

Saithe catches were also largely driven by economic factors in the 1970s and 80s. Landings of saithe reached a peak of over 6500 tonnes in 1973, which accounted for over 50% of demersal landings in the Clyde that year<sup>67</sup>. This was driven by the increased prices paid for all whitefish at this time, due to the establishment of EEZs which closed off many traditional distant water fishing grounds to British fleets. The price of saithe was particularly high, encouraging greater landings. However, in recent years the catch has been so low as to account for more than just economic forces at work.



Landings of saithe from Firth of Clyde 1960-2006. Source: DAFS and SFPA.

Flounder landings have also declined, with zero landings reported from 1996 to 2006 and no evidence of set quotas for the area. Catches increased up until the late 1970's, but had fallen to zero less than 20 years later.

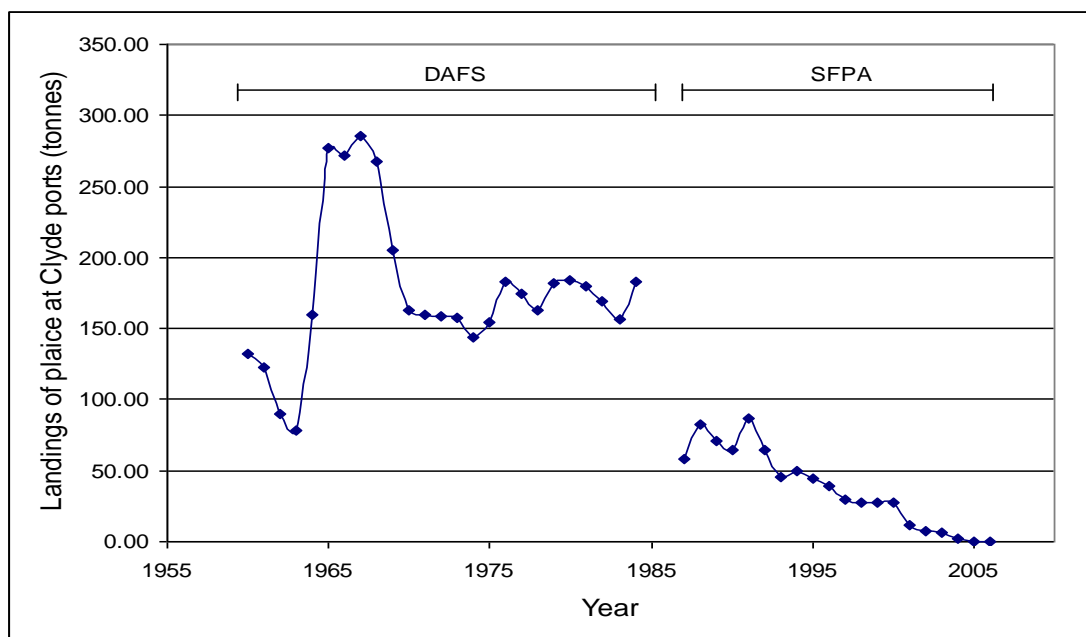


Landings of flounder from Firth of Clyde 1960-2006. Source: DAFS and SFPA.

The low abundance of plaice in the Firth of Clyde was questioned more than a century ago by Thomas Fulton, who noticed a substantial difference in the number of flat fish



between the Clyde and the Firth of Forth, particularly for plaice<sup>36</sup>. This led to, in part, to the closure of some of the Clyde grounds to trawling, which lasted nearly 80 years, until trawling for *Nephrops* was permitted<sup>66</sup>. It is possible then, that the low abundance of plaice in the mid-20<sup>th</sup> century was due to declines witnessed 50-60 years before. However, this decrease became more severe during the 20<sup>th</sup> century, leading to extremely low catches by the turn of the 21<sup>st</sup> century.



Landings of plaice from Firth of Clyde 1960-2006. Source: DAFS and SFPA.

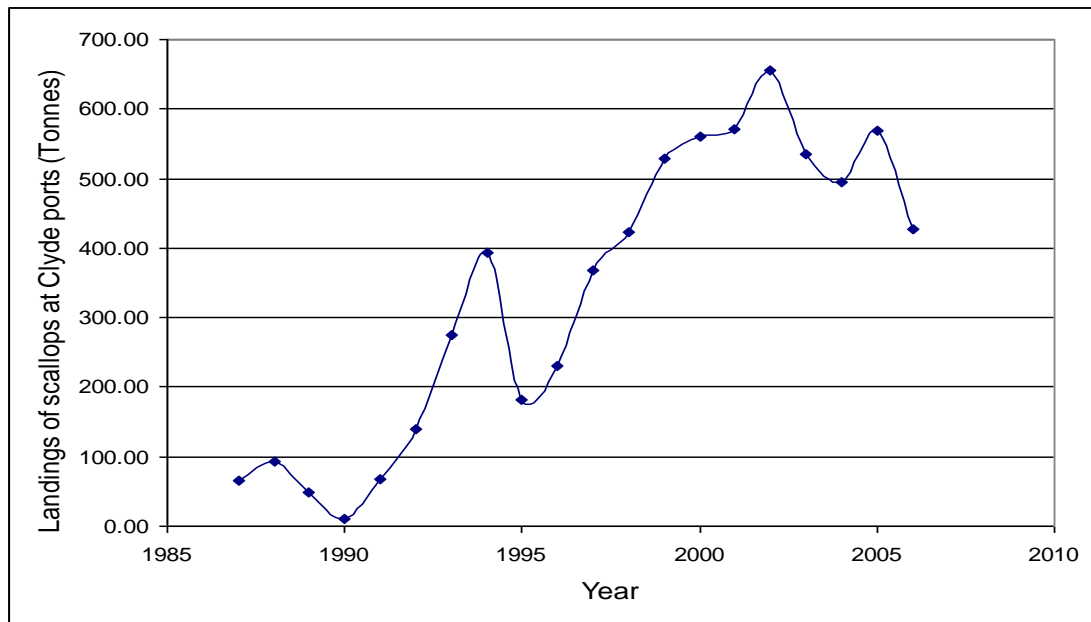
The trend indicated by all of these demersal fishery graphs, is one of gradual decline until the 1980s, then a severe decline into the 1990s and beginning of the 21<sup>st</sup> century, with little sign of recovery. Many species are at an all time low level, even though there are few, if any, directed fisheries in the Clyde as almost all Clyde-based mobile fisheries now fish almost exclusively for *Nephrops*<sup>79</sup>. The only way these declines can be halted is if *Nephrops* fisheries are reduced and restricted to certain areas. Current management measures are failing to halt declines of these stocks<sup>76</sup>.

### *The scallop fishery*

As the scallop fishery expanded outside of the Firth of Clyde and new fishing grounds were discovered in the mid-1970s, it was found that the size of scallops and the number of rings on their shells were much greater than those in the Clyde<sup>80</sup>, showing

the effects of exploitation on the age structure of a population. After 40 years of fishing in the Clyde, scallops were simply not reaching their former sizes and ages.

Concerns were raised in 1975 by fishers about the conservation of scallops and queens, as 3 and 4 ring scallops now made up more than 50% of the catch, but results of investigations failed to show severe overfishing<sup>81</sup>.



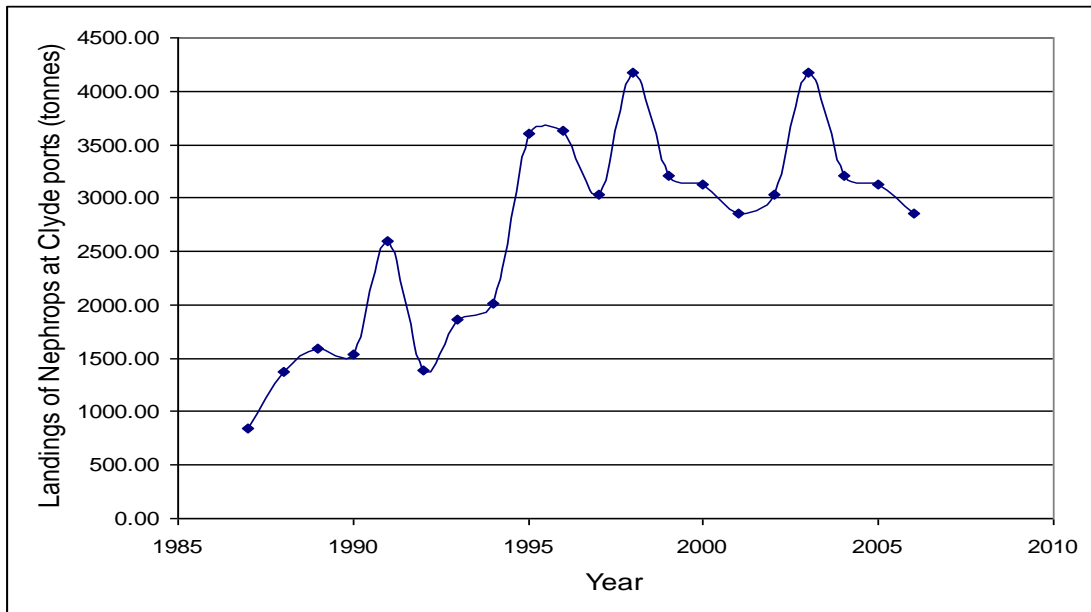
Landings of scallops in the Firth of Clyde between 1987 and 2006. Source: SFPA

### *The Nephrops fishery*

Total demersal catch increases in the 1960s and 1970s were almost entirely due to a rise in trawling for *Nephrops*<sup>67</sup>, which came about as prices for scampi increased and as fishers diversified. *Nephrops* are now caught by trawlers and to a lesser extent, creels, which tend to catch high quality *Nephrops* that are then transported live to the continent. *Nephrops* is now the most valuable fishery in the Clyde area, with around 120 vessels dedicated to this fishery and 90% of landings made by resident Clyde trawlers<sup>82</sup>.

The majority of Clyde fishers are now reliant on this single species, with the stock currently thought to be being fished sustainably<sup>83</sup>. A limited number of days at sea and mesh size restrictions are in place to prevent over-exploitation<sup>84</sup>, but this fails to

protect habitats and non-target species. Discard ratios are extremely high in the Clyde *Nephrops* fishery, with 9kg of bycatch produced for every 1kg of *Nephrops* caught<sup>84</sup>. **25,000 tonnes of discards** are generated every year in the Firth of Clyde from *Nephrops* trawling alone<sup>85</sup>, many of which die when returned to the sea<sup>86</sup>. Discards also provide food for scavenging seabirds and benthic animals, probably subsidising scavenging populations and changing the composition of communities<sup>85</sup>.



*Landings of Nephrops in the Firth of Clyde. An increase in the 1980s and 90s occurred, with landings fluctuating but remaining relatively stable since. Landings values are slightly different from earlier statistics in the 1970s and 1980s because these results incorporate a different area of the Clyde, being taken from vessels landing at Clyde ports which may have worked outside of the area. Source: SFPA.*

## Discussion: causes of change

### *Major changes to the Firth of Clyde ecosystem*

In the 1880s, it was estimated that 500,000 people in Scotland were involved in the fisheries in some form, either as fishers, gutters, curers or for the supply of boats and gear<sup>87</sup>. By this point, the fishing industry in the Clyde had already had a substantial impact on the marine ecosystem. The fishing grounds were frequently referred to as ‘exhausted’<sup>31</sup>, and references were commonly made to the diminution of species<sup>25, 36</sup>. By 1890 there was already a feeling that the Clyde fisheries (except perhaps for the herring) had passed their greatest productivity.

Important technological advances occurred in the Clyde throughout the end of the 19<sup>th</sup> century, until the latter half of the 20<sup>th</sup> century. Within this time, the scale of transformation of the Clyde ecosystem was extensive. By the 1960s, the famous herring fishery had suffered severe declines, and even improved technology could no longer find enough herring. The same pattern occurred for demersal species once the herring had gone, but the rise and fall of these fisheries took a much shorter period of time. This was probably because of the many previous years of fishing pressure, and the large catches that could be taken quickly by very efficient gear.

The way these species were fished almost certainly contributed to their and other species decline, as demersal trawls and dredges are not selective and damage and destroy the habitats they are dragged through. Improved technology also left nowhere for the fish to hide, therefore few animals were able to reproduce to continue supplying the fishery. Those interviewed stated that declines in both the size and abundance of fish occurred as trawling increased (pers. comm.).

Boris Worm and colleagues recently investigated in to the declines of commercial fish populations and the impact this may have on ecosystem services<sup>88</sup>. They classed fisheries as collapsed where there had been a 90% or greater decline from maximum catches. Records dating from 1960 will not record the maximum abundance of cod, haddock, whiting and other species, as these have been exploited for hundreds of years. Nevertheless, using the top recorded landings for each of these species in the

1960s, and comparing them to landings in the last couple of years, cod and whiting show declines of over 99%, and haddock over 95%. **These fisheries are collapsed, and now commercially extinct.**

**These species are not yet biologically extinct, but they are ecologically extinct and no longer perform functional roles in the Firth of Clyde ecosystem. This environment is now less biologically complex and with much lower abundance of species and is therefore less resilient to environmental fluctuations<sup>89</sup>.** This decline of fish in the Firth of Clyde may in part account for the success of the *Nephrops* and scallop fisheries which target species subject to much reduced predation pressure, increasing population sizes.

The transformation of the Clyde has been swift and may be irreversible if current practises continue. The fisheries of the 19<sup>th</sup> century concentrated on herring but also included many diverse fisheries for demersal and invertebrate species. Today, the composition of main species fished has changed greatly. Fish no longer dominate catches, and invertebrates from the bottom end of the food chain are the main species fished today.

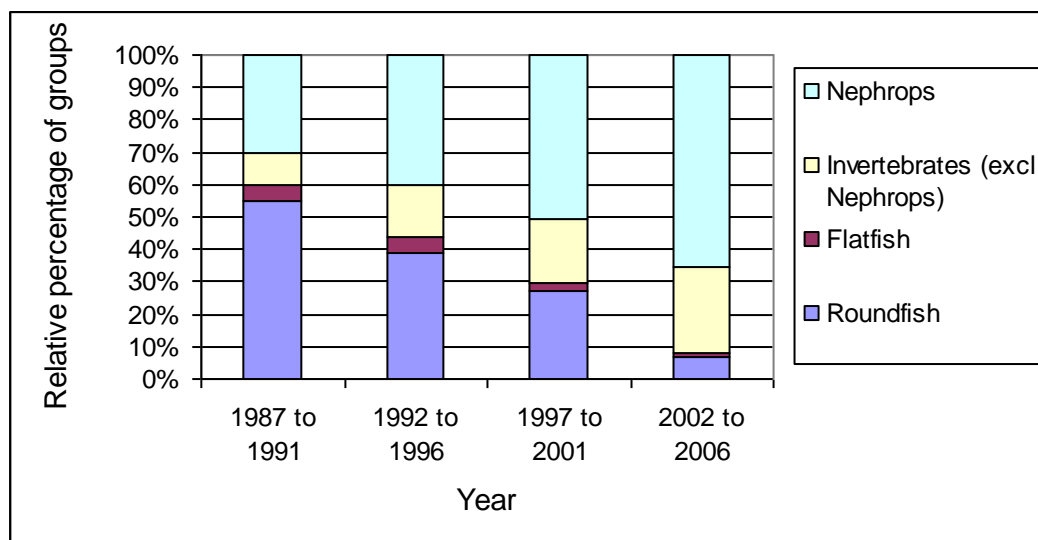


Figure showing the relative proportions of species landed in the Clyde from 1987 to 2006. Nephrops now dominate catches, and other invertebrates have increased. The proportion of finfish has lessened to less than 10%. Source: SFPA.

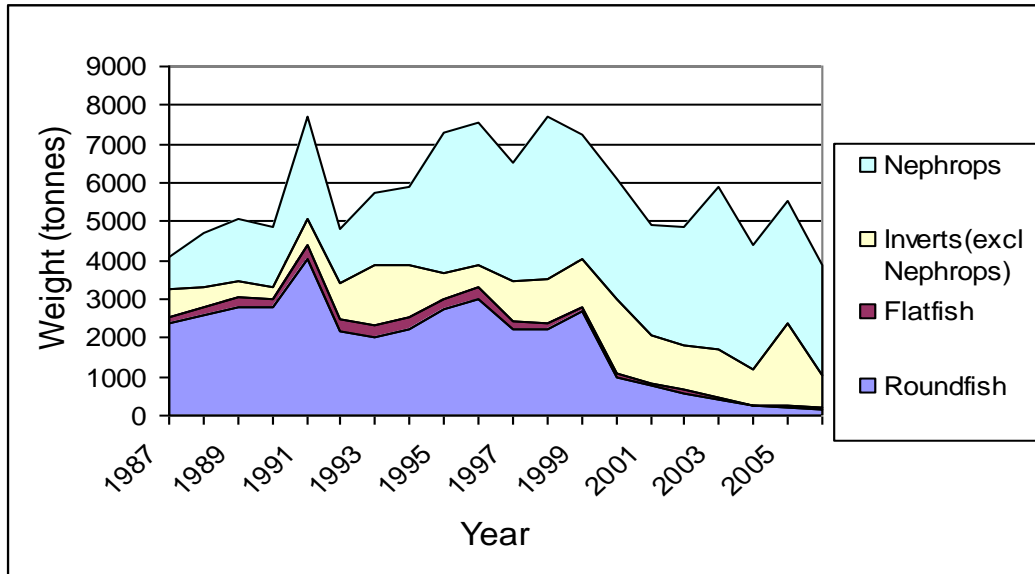


Figure showing the quantities of groups of species landed in the Firth of Clyde from 1987 to 2006. Overall landings peaked at nearly 8000 tonnes in 1992 but have since decreased. Flatfish landings have become insignificant and roundfish have greatly declined in the last 6 years. Invertebrates dominate catches. Source: SFPA.

The value of Clyde fisheries is now mainly supported through *Nephrops* catches, which contributed 85% of the Clyde's total fisheries value in 2006. This contrasts greatly with Clyde fisheries at the turn of the century, when herrings dominated the composition and value of catches, taking 81% of the value in 1913<sup>48</sup>.

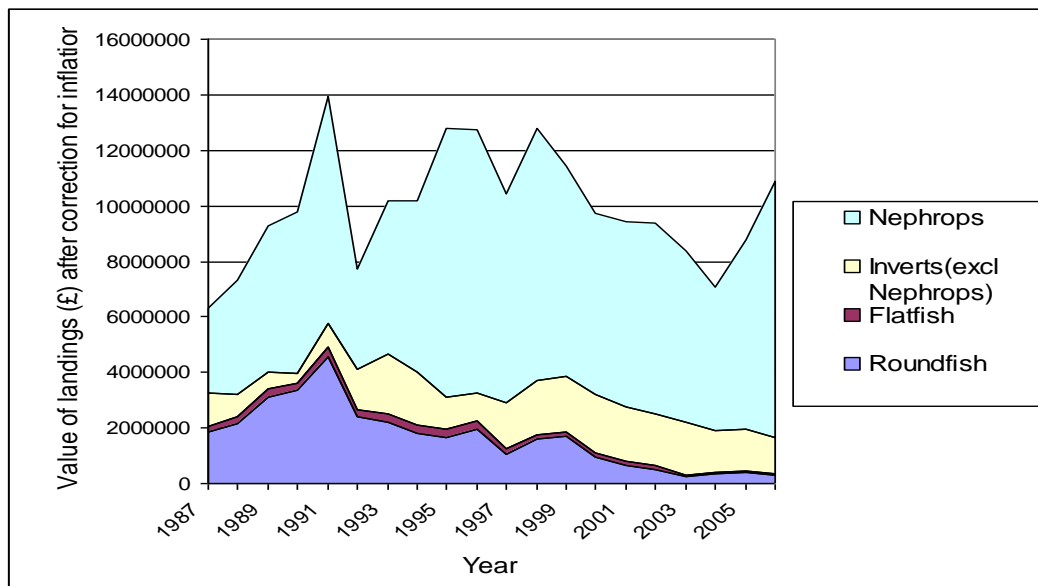


Figure showing the value of landings of groups of species landed in the Firth of Clyde from 1987 to 2006. Nephrops dominate landings by value. Source: SFPA.

*Why has this transformation occurred? A global perspective*

The origins of intensive exploitation of fisheries for herring and cod can be traced back to 1000 AD when there was a sudden expansion of marine fisheries, thought to be due to urban population growth, an increase in agriculture and the subsequent decrease of freshwater resources<sup>90</sup>. By the twelfth century, herring and cod were being cured and widely traded. The early development of the east coast of North America from the 15<sup>th</sup> century was based on the trade in cod, whilst in northern Europe herring became a staple food during lean winters<sup>91</sup>.

From the mid-1800s the industrial revolution concentrated a growing population in the cities, increasing demand for food<sup>91</sup>. Much of this was from the sea, as transport expanded and improved, and the use of ice increased to preserve fish on their journey from expanding fishing grounds to inland populations<sup>92</sup>.

Technological improvements continued throughout the early 20<sup>th</sup> century as diesel engines came into use, enabling fishers to travel further out to sea, or surround shoals of fish faster with their nets and prevent fish from escaping<sup>93</sup>. Synthetic nets came into widespread use by the 1950s, which were much stronger and allowed the scaling up of fishing activities<sup>93</sup>, as did the invention of rock-hopper gear in trawls a few years later. Innovations in technology, coupled with a rise in effort led to a dramatic growth in fisheries, and global landings rose from 19 million tonnes in 1950 to 64 million tonnes in 1970<sup>93</sup>. This rise in catches continued until the 1980s, when despite the fact that efforts continued to increase, landings declined<sup>94</sup>. This was not noticed until much later however, because of massive over-reporting from China<sup>94</sup>.

It has only been in recent years that people have started to understand the major changes that have taken place within marine ecosystems due to human influences. People rarely see the harm that is being caused by human activities, as it is hidden underneath the surface of the sea. Another reason for the lack of understanding is that historical changes to the marine environment have rarely been documented, or, if references do exist, these are taken as anecdotal and assumed to be exaggerated<sup>3</sup>. It is easy for people to fail to appreciate changes in abundance and size of marine species because of the ‘shifting baseline syndrome’, which was described by Daniel Pauly<sup>95</sup>.

This is where each successive generation comes to see the current status of fish stocks as the baseline for a normal abundance.

Changes in people's perceptions of what is natural, can therefore take place extremely rapidly. The fluctuations that are so often seen in marine populations also have a hand in buffering our ability to see gradual declines and changes. Descriptions by past fishermen and anglers then become fanciful tales that seem as if they could not possibly have been true. Rapid changes in environmental baselines have been shown by Saenz-Arroyo and colleagues<sup>96</sup> for fishers in the Gulf of California, where young fishers failed to appreciate the sizes and abundances of fish quoted by older fishers. The fact that baselines have shifted so rapidly, emphasises the importance of taking into account those few 'anecdotal', qualitative references that we have of past oceans, and using these to determine how much marine ecosystems have changed through human influences.

#### *Possible sources of bias*

Fishery statistics had to be taken from a few different sources covering slightly different areas in the Firth of Clyde. However it was felt that the statistics were still comparable because the data regions did not change to a great extent over the years.

Questionnaires were to be conducted to assess people's perceptions of the changes to the Firth of Clyde ecosystem (see Appendix 1). However, I experienced a few difficulties when trying to contact fishers. I was only able to contact 8 people, and I did not believe that this constituted a representative sample. While the questionnaires were unable to be used in any statistical analysis, people's comments and views were included.

Regrettably, when trying to contact other fishers through the Scottish Fisheries Federation, the links with York University essentially halted my investigation, and I was not able to contact anyone who may have had important views on the reasons behind the declines of finfish in the Clyde. This is unfortunate, as whilst some people may mistakenly feel that their views would be either misrepresented or disagreed with; without their input, their views cannot be represented at all.



## Conclusions

The literature that details the fisheries in the Firth of Clyde from 1882 documents some profound changes throughout the years. Some of these changes, such as technological innovations, were adopted extremely quickly and had a major effect on fishers' work. However, other biological changes that occurred were not noticed as quickly, yet still had a profound effect on the way people fished. The days when the herring was king are long gone, and *Nephrops* is now the most sought after animal in the Clyde.

The techniques used to capture herring had negative ecological effects, in that the natural abundance of fish was slowly reduced, and also that many juvenile fish were caught and destroyed. But the *Nephrops* fishery potentially has a far more damaging effect on habitats and the capture of non-target species. This fishery has so far been sustained, but in the last few years, the mixed demersal fishery that occurs whilst trawling for *Nephrops* has seen fewer numbers of species such as cod, whiting, haddock and flatfish. Many of these species spawn close to or within the Clyde, and except for the recently implemented closed area in the south Clyde between February and April for spawning cod, there is little to protect spawning stocks.

This project makes it clear that humans have been *the* major driving force in the transformation of the Clyde. Trawling and technological improvements, as well as political decisions to open up closed areas have left fish nowhere to hide, and long-term trends have documented devastating shifts and declines in marine biodiversity through human activities. Similar trends are being repeated all over the world, and the situation is desperate. Global biodiversity loss is increasing<sup>97</sup>, and marine species that were once assumed to be widespread, abundant and inexhaustible are in danger of extinction<sup>98</sup>.

In the Firth of Clyde the members of COAST have been fighting for over 10 years to allow a small area around Arran to become no-take. Although they have succeeded in informing their community and others about the need to protect some areas from the effects of fishing, this no-take zone has not yet been approved. It was quite clear to

Professor Ewart and Dr Fulton in the 1880s and 1890s that habitats and fish needed to be protected, long before the drastic declines seen today.

The Firth of Clyde needs to stop being managed for a few species, and start being managed as the complex ecosystem that it is, where it is recognised that people's actions have ramifications that extend further than just the target animals. Marine species need to be protected before our baselines shift again, to an empty desert that people once claimed was able to produce 5-pound cod and the occasional herring.



*Days gone by c. 1900. Source: Martin, A (2002). Herring fishermen of Kintyre and Ayrshire. House of Lochar, Isle of Colonsay, UK.*

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## References

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- <sup>1</sup> Pauly, D. and Maclean, J (2003). In a perfect ocean: the state of fisheries and ecosystems in the North Atlantic Ocean. The Sea Around Us Project. Island Press, Washington DC, USA.
- <sup>2</sup> Caddy, J.F. and Cochrane, K.L (2001). A review of fisheries management past and present and some future perspectives for the third millennium. *Ocean & Coastal Management* 44: 653–682.
- <sup>3</sup> Jackson, J.B.C., Kirby, M.X., Berger, W.H., Bjorndal, K.A., Botsford, L.W., Bourque, B.J., Bradbury, R.H., Cooke, R., Erlandson, J., Estes, J.A., Hughes, T.P., Kidwell, S., Lange, C.B., Lenihan, H.S., Pandolfi, J.M., Peterson, C.H., Steneck, R.S., Tegner, M.J. and Warner, R.R (2001). Historical overfishing and the recent collapse of coastal ecosystems. *Science* 293: 629-638.
- <sup>4</sup> Pandolfi, J.M., Bradbury, R.H., Sala, E., Hughes, T.P., Bjorndal, K.A., Cooke, R.G., McArdle, D., McClenachan, L., Newman, M.J.H., Paredes, G., Warner, R.R. and Jackson, J.B.C (2003). Global trajectories of the long-term decline of coral reef ecosystems. *Science* 301: 955-958.
- <sup>5</sup> Jennings, S., Kaiser, M.J. and Reynolds, J.D (2001). *Marine fisheries ecology*. Blackwell Science Ltd, Oxford, UK.
- <sup>6</sup> Reiser, A., Hudson, C.G. and Roady, S.E (2005). The role of legal regimes in marine conservation. In, Norse, E.A. and Crowder, L.B (2005) (Eds). *Marine Conservation Biology: The Science of Maintaining the Sea's Biodiversity*. Marine Conservation Biology Institute, Island Press, Washington DC, USA.
- <sup>7</sup> COAST (2005). Community of Arran Seabed Trust. The Arran marine regeneration trial: development of a community-based marine protected area. [www.arrancoast.co.uk](http://www.arrancoast.co.uk)
- <sup>8</sup> WWF (2003). Tangle of the Clyde: why we must reform the management of Scotland's marine environment. Joint Marine Programme, WWF Scotland and Scottish Wildlife Trust.
- <sup>9</sup> Tivy, J (1986). The geography of the estuary and Firth of Clyde. *Proceedings of the Royal Society of Edinburgh B (Biological Sciences)*, 90: 7-23.
- <sup>10</sup> Boyd, J.M (1986). The environment of the estuary and Firth of Clyde – an introduction. *Proceedings of the Royal Society of Edinburgh B (Biological Sciences)*, 90: 1-5.
- <sup>11</sup> Young, A (1885). Appendix G: The salmon rivers of Argyllshire: the Clyde. In, Boyd, T.J., Smith, J.G., Toms, G.H., Irvine, A.F., Maitland, J.R.G., Williamson, S., Ewart, J.C., Graham, J.M. and Grieve, J. J (1885). *Third Annual Report of the Fishery Board for Scotland, being for the year 1884*. Edinburgh, UK.
- <sup>12</sup> Thompson, D.B.A., Curtis, D.J. and Smyth, J.C (1986). Patterns of association between birds and invertebrates in the Clyde estuary. *Proceedings of the Royal Society of Edinburgh B (Biological Sciences)*, 90: 185-201.
- <sup>13</sup> Scottish Sustainable Marine Environment Initiative (2005). SSMEI Clyde Pilot Project Proposal – Technical Annex, Scottish Executive, Wildlife & Habitats Division, Edinburgh.
- <sup>14</sup> Martin, A (2002). *Herring fishermen of Kintyre and Ayrshire*. House of Lochar, Isle of Colonsay, UK.
- <sup>15</sup> Esslemont, P., Smith, J.G., Thoms, G.H.M., M'Kechnie, D., M'Intosh, W.C., Smith, W.A., Boyd, W., Johnston, J. and Welch, J.R (1894). Appendix O: Reports from the different fishery districts. *Twelfth Annual Report of the Fishery Board for Scotland, being for the year 1893*. Edinburgh, UK.

- 
- <sup>16</sup> Wilson, P (1887). Appendix J: The herring fishing in Ballantrae district. In, Boyd, T.J., Smith, J.G., Thoms, G.H., Irvine, A.F., Maitland, J.R.G., Ewart, J.C., Graham, J.M. and Grieve, J.J (1887). Fifth Annual Report of the Fishery Board for Scotland, being for the year 1886. Edinburgh, UK.
- <sup>17</sup> Hannah, W (1887). Fisherman. Appendix B: Notes of evidence taken before the committee of the fishery board for Scotland at Girvan, 29<sup>th</sup> December 1887. In, Ewart, J.C., Maitland, J.R.G., Boyd, W. and Johnston, J (1888). Fishery Board for Scotland: report of a committee of the Fishery Board for Scotland as to the regulation of trawling and other modes of fishing in the Territorial Waters. Edinburgh, UK.
- <sup>18</sup> Martin, D (1887). Fisherman. Appendix (B): Courtroom, Campbeltown. In, Appendix A: Preliminary report and evidence taken by Sir James Maitland and Professor Ewart as to the influence of trawling and other modes of fishing in the Clyde estuary. In, Ewart, J.C., Maitland, J.R.G., Boyd, W. and Johnston, J (1888). Fishery Board for Scotland: report of a committee of the Fishery Board for Scotland as to the regulation of trawling and other modes of fishing in the Territorial Waters. Edinburgh, UK.
- <sup>19</sup> Scott, T (1900). The fishes of the Firth of Clyde. In, Sutherland, A., Crawford, D., Thompson, D.W., Welch, J.R., Duguid, W.R., Milloy, L., Mearns, D. and Robertson, W.M.C (1900). Eighteenth Annual Report of the Fishery Board for Scotland, being for the year 1899. Edinburgh, UK.
- <sup>20</sup> Blake, G (1952). The Firth of Clyde. Collins, London.
- <sup>21</sup> Boyd, T.J., Smith, J.G., Thoms, G.H., Irvine, A.F., Maitland, J.R.G., Ewart, J.C., Johnston, J., Boyd, W. and Smith, W.A (1891). Ninth Annual Report of the Fishery Board for Scotland, being for the year 1890. Edinburgh, UK.
- <sup>22</sup> Brook, G (1886). Appendix E: report on the herring fishery of Loch Fyne and the adjacent districts during 1885. In, Boyd, T.J., Smith, J.G., Thoms, G.H., Irvine, A.F., Maitland, J.R.G., Williamson, S., Ewart, J.C., Graham, J.M. and Grieve, J.J (1886). Fourth Annual Report of the Fishery Board for Scotland, being for the year 1885. Edinburgh, UK.
- <sup>23</sup> Sutherland, A., Patrick, R.W.C., Crawford, D., Murray, J., Welch, J.R., Duguid, W.R. and Jameson, A (1896). Appendix N: Reports from the different fishery districts. Fourteenth Annual Report of the Fishery Board for Scotland, being for the year 1895. Edinburgh, UK.
- <sup>24</sup> Sutherland, A., Crawford, D., Murray, J., Welch, J.R., Duguid, W.R., Jameson, A., Milloy, L. and Robertson, W.C (1898). Appendix L: Reports from the different fishery districts for 1897. Sixteenth Annual Report of the Fishery Board for Scotland, being for the year 1897. Edinburgh, UK.
- <sup>25</sup> Ewart, J.C., Maitland, J.R.G., Boyd, W. and Johnston, J (1888). Fishery Board for Scotland: report of a committee of the Fishery Board for Scotland as to the regulation of trawling and other modes of fishing in the Territorial Waters. Edinburgh, UK.
- <sup>26</sup> Fulton, T.W (1900). Report of an enquiry on the action of the herring seine-net. In, Sutherland, A., Crawford, D., Thompson, D.W., Welch, J.R., Duguid, W.R., Milloy, L., Mearns, D. and Robertson, W.M.C (1900). Eighteenth Annual Report of the Fishery Board for Scotland, being for the year 1899. Edinburgh, UK.
- <sup>27</sup> Sutherland, A., Crawford, D., Thompson, D.W., Welch, J.R., Duguid, W.R., Milloy, L., Mearns, D. and Robertson, W.M.C (1900). Eighteenth Annual Report of the Fishery Board for Scotland, being for the year 1899. Edinburgh, UK.
- <sup>28</sup> Ewart, J.C (1888). Appendix E: Further report as to the influence of trawling and other modes of fishing in the Clyde estuary. Ewart, J.C., Maitland, J.R.G., Boyd, W. and Johnston, J (1888). Fishery Board for Scotland: report of a committee of the Fishery Board for Scotland as to the regulation of trawling and other modes of fishing in the Territorial Waters. Edinburgh, UK.

- 
- <sup>29</sup> Henry, R (1887). District Fishery Officer for Campbeltown. Appendix (A). In, Maitland, J.R.G. and Ewart, J.C (1888). Appendix A: Preliminary report and evidence taken by Sir James Maitland and Professor Ewart as to the influence of trawling and other modes of fishing in the Clyde estuary. In, Ewart, J.C., Maitland, J.R.G., Boyd, W. and Johnston, J (1888). Fishery Board for Scotland: report of a committee of the Fishery Board for Scotland as to the regulation of trawling and other modes of fishing in the Territorial Waters. Edinburgh, UK.
- <sup>30</sup> Wason, J (1887). Postmaster. Appendix B: Notes of evidence taken before the committee of the fishery board for Scotland at Girvan, 29<sup>th</sup> December 1887. In, Ewart, J.C., Maitland, J.R.G., Boyd, W. and Johnston, J (1888). Fishery Board for Scotland: report of a committee of the Fishery Board for Scotland as to the regulation of trawling and other modes of fishing in the Territorial Waters. Edinburgh, UK.
- <sup>31</sup> Campbell, A (1887). Boat-owner and rope manufacturer. Appendix (B). In, Maitland, J.R.G. and Ewart, J.C (1888). Appendix A: Preliminary report and evidence taken by Sir James Maitland and Professor Ewart as to the influence of trawling and other modes of fishing in the Clyde estuary. In, Ewart, J.C., Maitland, J.R.G., Boyd, W. and Johnston, J (1888). Fishery Board for Scotland: report of a committee of the Fishery Board for Scotland as to the regulation of trawling and other modes of fishing in the Territorial Waters. Edinburgh, UK.
- <sup>32</sup> Bain, W (1887). District Fishery Officer for Greenock. Appendix (A). In, Maitland, J.R.G. and Ewart, J.C (1888). Appendix A: Preliminary report and evidence taken by Sir James Maitland and Professor Ewart as to the influence of trawling and other modes of fishing in the Clyde estuary. In, Ewart, J.C., Maitland, J.R.G., Boyd, W. and Johnston, J (1888). Fishery Board for Scotland: report of a committee of the Fishery Board for Scotland as to the regulation of trawling and other modes of fishing in the Territorial Waters. Edinburgh, UK.
- <sup>33</sup> Jones, D.T (1919). Appendix 1: Post-war problems. In, Sutherland, A., MacKenzie, W.L., Thomson, D.W., Breadalbane., Archibald, J., Irvin, J.H., Smith, M. and Jones, D.T (1919). Thirty-seventh Annual Report of the Fishery Board for Scotland, being for the year 1918. Edinburgh, UK.
- <sup>34</sup> Sutherland, A., Crawford, D., Murray, J., Welch, J.R., Duguid, W.R., Jameson, A. and Robertson, W.C (1897). Fifteenth Annual Report of the Fishery Board for Scotland, being for the year 1896. Edinburgh, UK.
- <sup>35</sup> Smith, T.D (2002). A history of fisheries and their science and management. Chapter 4 in, Hart, P.J.B. and Reynolds, J.D (eds). Handbook of fish biology and fisheries, Blackwell.
- <sup>36</sup> Ewart, J.C., Maitland, J.R.G., Boyd, W. and Smith, N.A (1888). The influence of trawling. In, Boyd, T.J., Smith, J.G., Thoms, G.H., Irvine, A.F., Maitland, J.R.G., Ewart, J.C., Johnston, J., Boyd, W. and Smith, W.A (1888). Sixth Annual Report of the Fishery Board for Scotland, being for the year 1887. Edinburgh, UK.
- <sup>37</sup> Ewart, J.C. and Maitland, J.R.G (1888). Report on the trawling experiments of the Garland and field statistics of the East Coast fisheries. In, Boyd, T.J., Smith, J.G., Thoms, G.H., Irvine, A.F., Maitland, J.R.G., Ewart, J.C., Johnston, J., Boyd, W. and Smith, W.A (1888). Sixth Annual Report of the Fishery Board for Scotland, being for the year 1887. Edinburgh, UK.
- <sup>38</sup> Boyd, T.J., Smith, J.G., Thoms, G.H., Irvine, A.F., Maitland, J.R.G., Ewart, J.C., Johnston, J., Boyd, W. and Smith, W.A (1890). Eighth Annual Report of the Fishery Board for Scotland, being for the year 1889. Edinburgh, UK.
- <sup>39</sup> Fulton, T.W (1895). Report on the trawling experiments of the Garland and on the statistics of the East Coast fisheries relating thereto. In, Sutherland, A., Smith, J.G., Thoms, G.H.M., M'Kechnie, D., M'Intosh, W.C., Smith, W.A., Boyd, W., Johnston, J. and Welch, J.R (1895). Thirteenth Annual Report of the Fishery Board for Scotland, being for the year 1894. Edinburgh, UK.
- <sup>40</sup> Kyle, H.M (1897). Report on the pelagic ova, larvae and young fishes procured by the Garland during the greater part of 1896. In, Sutherland, A., Crawford, D., Murray, J., Welch, J.R., Duguid,

---

W.R., Jameson, A. and Robertson, W.C (1897). Fifteenth Annual Report of the Fishery Board for Scotland, being for the year 1896. Edinburgh, UK.

<sup>41</sup> Fulton, T.W (1898). The influence of trawling. In, Sutherland, A., Crawford, D., Murray, J., Welch, J.R., Duguid, W.R., Jameson, A., Milloy, L. and Robertson, W.C (1898). Sixteenth Annual Report of the Fishery Board for Scotland, being for the year 1897. Edinburgh, UK.

<sup>42</sup> Boyd, T.J., Smith, J.G., Thoms, G.H., Irvine, A.F., Maitland, J.R.G., Williamson, S., Ewart, J.C., Graham, J.M. and Grieve, J.J (1886). Fourth Annual Report of the Fishery Board for Scotland, being for the year 1885. Edinburgh, UK.

<sup>43</sup> Esslemont, P., Smith, J.G., Thoms, G.H.M., M'Kechnie, D., M'Intosh, W.C., Smith, W.A., Johnston, J., Boyd, W. and Welch, J.R (1893). Eleventh Annual Report of the Fishery Board for Scotland, being for the year 1892. Edinburgh, UK.

<sup>44</sup> Sutherland, A., Crawford, D., Thompson, D.W., Welch, J.R., Duguid, W.R., Jameson, A., Milloy, L. and Robertson, W.C (1899). Appendix L: Reports from the different fishery districts for 1898. Seventeenth Annual Report of the Fishery Board for Scotland, being for the year 1898. Edinburgh, UK.

<sup>45</sup> Wilson, P (1887). District Fishery Officer for Girvan. Appendix (A). In, Maitland, J.R.G. and Ewart, J.C (1888). Appendix A: Preliminary report and evidence taken by Sir James Maitland and Professor Ewart as to the influence of trawling and other modes of fishing in the Clyde estuary. In, Ewart, J.C., Maitland, J.R.G., Boyd, W. and Johnston, J (1888). Fishery Board for Scotland: report of a committee of the Fishery Board for Scotland as to the regulation of trawling and other modes of fishing in the Territorial Waters. Edinburgh, UK.

<sup>46</sup> Boyd, T.J., Smith, J.G., Thoms, G.H., Maitland, J.R.G., Ewart, J.C., Johnston, J., Boyd, W. and Smith, W.A (1892). Tenth Annual Report of the Fishery Board for Scotland, being for the year 1891. Edinburgh, UK.

<sup>47</sup> Sutherland, A., Crawford, D., Thompson, D.W., Duguid, W.R., Milloy, L., Mearns, D., Watson, H. and Robertson, W.M.C (1906). Twenty-fourth Annual Report of the Fishery Board for Scotland, being for the year 1905. Edinburgh, UK.

<sup>48</sup> Sutherland, A., MacKenzie, W.L., Thomson, D.W., Breadalbane., Archibald, J., Irvin, J.H., Smith, M. and Jones, D.T (1914). Appendix L: Reports by the Inspectors of Sea Fisheries and District Fishery Officers. Thirty-second Annual Report of the Fishery Board for Scotland, being for the year 1913. Edinburgh, UK.

<sup>49</sup> Sutherland, A., Morison, T.B., Thompson, D.W., Breadalbane., Archibald, J., Irvin, J.H., Smith, M. and Jones, D.T (1911). Twenty-ninth Annual Report of the Fishery Board for Scotland, being for the year 1910. Edinburgh, UK.

<sup>50</sup> Fulton, T. W (1911). The investigations on the herring fishery in Loch Fyne. In, Sutherland, A., Morison, T.B., Thompson, D.W., Breadalbane., Archibald, J., Irvin, J.H., Smith, M. and Jones, D.T (1911). Twenty-ninth Annual Report of the Fishery Board for Scotland, being for the year 1910. Edinburgh, UK.

<sup>51</sup> Jones, D.T., MacKenzie, W.L., Thompson, D.W., Irvin, J.H., Smith, M., MacIver, D., Miller, W. and Hogarth, G (1921). Thirty-ninth Annual Report of the Fishery Board for Scotland, being for the year 1920. Edinburgh, UK.

<sup>52</sup> Jones, D.T., MacKenzie, W.L., Thompson, D.W., Irvin, J.H., Smith, M., Hall, G., Miller, W. and Hogarth, G (1924). Forty-second Annual Report of the Fishery Board for Scotland, being for the year 1923. Edinburgh, UK.

- 
- <sup>53</sup> Jones, D.T., MacKenzie, W.L., Thompson, D.W., Irvin, J.H., Smith, M., Hall, G., Miller, W. and Hogarth, G (1923). Forty-first Annual Report of the Fishery Board for Scotland, being for the year 1922. Edinburgh, UK.
- <sup>54</sup> Jones, D.T., MacKenzie, W.L., Thompson, D.W., Irvin, J.H., Smith, M., Hall, G., Miller, W. and Hogarth, G (1927). Forty-fifth Annual Report of the Fishery Board for Scotland, being for the year 1926. Edinburgh, UK.
- <sup>55</sup> Hogarth, G., Dickson, J.R., Thompson, D.W., Slater, G., Carstairs, W.M.W., Campbell, G., Hay, J. and Norris, A.A (1937). Fifty-fifth Annual Report of the Fishery Board for Scotland, being for the year 1936. Edinburgh, UK.
- <sup>56</sup> Hogarth, G., Dickson, J.R., Thompson, D.W., Slater, G., Carstairs, W.M.W., Campbell, G., Hay, J. and Norris, A.A (1936). Fifty-fourth Annual Report of the Fishery Board for Scotland, being for the year 1935. Edinburgh, UK.
- <sup>57</sup> Hogarth, G., Blades, D.P., Thompson, D.W., Slater, G., Carstairs, W.M.W., Campbell, G., Hay, J. and Norris, A.A (1938). Fifty-sixth Annual Report of the Fishery Board for Scotland, being for the year 1937. Edinburgh, UK.
- <sup>58</sup> Scottish Home Department (1949). Report on the Fisheries of Scotland 1939-1948. Edinburgh, UK.
- <sup>59</sup> McCrindle, H (2006). Cleaning the Clyde. Glasgow Naturalist 24: Part 4.
- <sup>60</sup> Scottish Home Department (1958). Report on the Fisheries of Scotland 1957. Edinburgh, UK.
- <sup>61</sup> Department of Agriculture and Fisheries for Scotland (1963). Fisheries of Scotland Report for 1962, Edinburgh, UK.
- <sup>62</sup> Scottish Fisheries Bulletin 21 (1964). Department of Agriculture and Fisheries for Scotland, Edinburgh, UK.
- <sup>63</sup> Mason, J. and Fraser, D.I (1986). Shellfish fisheries in the Clyde sea area. Proceedings of the Royal Society of Edinburgh Section B (Biological Sciences), 90: 439-450.
- <sup>64</sup> Scottish Fisheries Bulletin 32 (1969). Department of Agriculture and Fisheries for Scotland, Edinburgh, UK.
- <sup>65</sup> Department of Agriculture and Fisheries for Scotland (1973). Fisheries of Scotland report for 1972. Edinburgh, UK.
- <sup>66</sup> Bailey, N., Howard, F.G. and Chapman, C.J (1986). Clyde *Nephrops*: biology and fisheries. Proceedings of the Royal Society of Edinburgh Section B (Biological Sciences), 90: 501-518.
- <sup>67</sup> Hislop, J.R.G (1986). The demersal fishery in the Clyde sea area. Proceedings of the Royal Society of Edinburgh Section B (Biological Sciences), 90: 423-437.
- <sup>68</sup> [www.arrancoast.co.uk](http://www.arrancoast.co.uk)
- <sup>69</sup> Department of Agriculture and Fisheries for Scotland (1977). Fisheries of Scotland report for 1976. Edinburgh, UK.
- <sup>70</sup> Department of Agriculture and Fisheries for Scotland (1979). Fisheries of Scotland report for 1978. Edinburgh, UK.
- <sup>71</sup> Department of Agriculture and Fisheries for Scotland (1980). Fisheries of Scotland report for 1979. Edinburgh, UK.

- 
- <sup>72</sup> Department of Agriculture and Fisheries for Scotland (1981). Fisheries of Scotland report for 1980. Edinburgh, UK.
- <sup>73</sup> Department of Agriculture and Fisheries for Scotland (1978). Fisheries of Scotland report for 1977. Edinburgh, UK.
- <sup>74</sup> Bailey, R.S., McKay, D.W., Morrison, J.A. and Walsh, M (1986). The biology and management of herring and other pelagic fish stocks in the Firth of Clyde. Proceedings of the Royal Society of Edinburgh Section B (Biological Sciences), 90: 407-422.
- <sup>75</sup> ICES WGNSDS Report (2006). Annex 9: Quality Handbook Annex: WGNSDS- Cod VIa.
- <sup>76</sup> ICES Advice (2006). Cod in Division VIa (West of Scotland) 5.4.21.  
<http://www.ices.dk/committe/acfm/comwork/report/2006/oct/cod-scow.pdf>
- <sup>77</sup> ICES Advice (2006). Whiting in Division VIa (West of Scotland) 5.4.25.  
<http://www.ices.dk/committe/acfm/comwork/report/2006/oct/whg-scow.pdf>
- <sup>78</sup> ICES Advice (2006). Haddock in Division VIa (West of Scotland) 5.4.23.  
<http://www.ices.dk/committe/acfm/comwork/report/2006/oct/had-scow.pdf>
- <sup>79</sup> Watson, J.M. and Bryson, J.T (2003). The Clyde inshore fishery study: key features. Seafish Industry Authority, Edinburgh, UK. [www.seafish.co.uk](http://www.seafish.co.uk)
- <sup>80</sup> Department of Agriculture and Fisheries for Scotland (1975). Fisheries of Scotland report for 1974. Edinburgh, UK.
- <sup>81</sup> Department of Agriculture and Fisheries for Scotland (1976). Fisheries of Scotland report for 1975. Edinburgh, UK.
- <sup>82</sup> ICES WGNSDS Report (2006). Annex 5: Quality Handbook: WGNSDS - Clyde *Nephrops* (FU13).
- <sup>83</sup> <http://www.gla.ac.uk/centres/marinestation/CFDP/index.htm>
- <sup>84</sup> Bergmann, M., Wieczorek, S.K., Moore, P.G. and Atkinson, R.J.A (2002). Discard composition of the *Nephrops* fishery in the Clyde Sea area, Scotland. Fisheries Research 57: 169-183.
- <sup>85</sup> Bergmann, M., Wieczorek, S.K., Moore, P.G. and Atkinson, R.J.A (2002). Utilisation of invertebrates discarded from the *Nephrops* fishery by variously selective benthic scavengers in the west of Scotland. Marine Ecology Progress Series 233: 185-198.
- <sup>86</sup> Bergmann, M. and Moore, P.G (2001). Mortality of *Asterias rubens* and *Ophiura ophiura* discarded in the *Nephrops* fishery of the Clyde Sea area, Scotland. ICES Journal of Marine Science 58: 531-542.
- <sup>87</sup> Boyd, T.J., Smith, J.G., Thoms, G.H., Irvine, A.F., Maitland, J.R.G., Williamson, S., Ewart, J.C., Graham, J.M. and Grieve, J.J (1885). Third Annual Report of the Fishery Board for Scotland, being for the year 1884. Edinburgh, UK.
- <sup>88</sup> Worm, B., Barbier, E.B., Beaumont, N., Duffy, J.E., Folke, C., Halpern, B.S., Jackson, J.B.C., Lotze, H.K., Micheli, F., Palumbi, S.R., Sala, E., Selkoe, K.A., Stachowicz, J.J. and Watson, R (2006). Impacts of biodiversity loss on ocean ecosystem services. Science: 314: 787-790.
- <sup>89</sup> Hsieh, C., Reiss, C.S., Hunter, J.R., Beddington, J.R., May, R.M. and Sugihara, G (2006). Fishing elevates variability in the abundance of exploited species. Nature 443: 859-862.
- <sup>90</sup> Barrett, J.H., Locker, A.M. and Roberts, C.M (2004). The origins of intensive marine fishing in medieval Europe: the English evidence. Proceedings of the Royal Society of London B 271: 2417-2421.



- 
- <sup>91</sup> Valdimarsson, G. and James, D (2001). World fisheries – utilisation of catches. *Ocean & Coastal Management* 44: 619-633.
- <sup>92</sup> Roberts, C.M (2007). *The unnatural history of the sea*. Island Press, Washington DC, USA.
- <sup>93</sup> Valdemarsen, J.W (2001). Technological trends in capture fisheries. *Ocean & Coastal Management* 44: 635–651.
- <sup>94</sup> Pauly, D., Christensen, V., Guenette, S., Pitcher, T.J., Sumaila, R., Walters, C.J., Watson, R. and Zeller, D (2002). Towards sustainability in world fisheries. *Nature* 418: 689-695.
- <sup>95</sup> Pauly, D (1995). Anecdotes and the shifting baseline syndrome of fisheries. *Trends in Ecology and Evolution* 10: 430.
- <sup>96</sup> Saenz-Arroyo, A., Roberts, C.M., Torre, J., Carino-Olvera, M. and Enriquez-Andrade, R.R (2005). Rapidly shifting environmental baselines among fishers of the Gulf of California. *Proceedings of the Royal Society B* 272: 1957-1962.
- <sup>97</sup> Sala, E. and Knowlton, N (2006). Global marine biodiversity trends. *Annual Review of Environment and Resources* 31: 93-122.
- <sup>98</sup> Roberts, C.M. and Hawkins, J.P (1999). Extinction risk in the sea. *Trends in Ecology and Evolution* 14: 241-246.