The Reliability of Fishing Statistics as a Source for Catches and Fish Stocks in Antiquity

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In 1985 T.W. Gallant published an influential essay on the potential productivity of fishing in the ancient world. He concluded that: "*the role of fishing in the diet and the economy would have been, on the whole, subordinate and supplementary…*"[1] His methodological approach was original in using modern fishery data to estimate the productivity of ancient fisheries. Unfortunately his work suffered from several severe misunderstandings about ecosystems, the nature of a fishery and its biological interaction with its environment.

The purpose of this paper is to discuss the statistical background for Gallant's conclusions about fishery and the usefulness of modern catch data for historical fishery research. In order to do so, the author adopts the viewpoint of marine-environmental history, with some reference to other authors' work on ancient fisheries.

1. Applied fishery statistics and biological literature

Gallant's ambition is to provide some estimates about the social and economical role of fishing in antiquity. Finding the available historical sources insufficient, he chooses to base his analyses primarily on modern fishery statistics, since they have the richness and continuity that older sources lack. The different types of fishery statistic he uses to back up his argumentation can roughly be divided into two groups: Catch data and catch-per-unit-effort (CPUE) data.[2]

The first type of data consists of information on 19th century Adriatic fishery and fishery statistics, mainly from the Mediterranean and from the period 1922-69; most of the data is from the 1950s and 1960s.[3] Gallant does not tell us much about these data: whether they are total landings by country, whether they are based on commercial catch records or estimates, and how much effort was involved in the fishery. This of course makes it difficult to evaluate the quality and accuracy of the data. It is surprising that Gallant chose such a weak and incoherent statistical material since better data were available. FAO, for example, has published yearly catch data (on a national level and per species) from 1950 onwards.[4]

The content of the CPUE data is even more blurry, with some data deriving from a study of a Malaysian fishery, where there are no references to the exact catch area, species caught, or the fishing effort evolved. Gallant also seems to use some CPUE data of unknown origin. This is clear in his Figure 1 where he tries to estimate the extent to which the use of different types of fishing gear could provide sufficient fish for the daily diet of the fisherman himself.[5] Such a calculation has to be based on some sort of CPUE, but no references are given. It goes without saying that estimates such as those given in Gallant's Figure 1 are highly doubtful and must be used with great caution.

In biological matters, Gallant draws heavily on G.L. Faber's work from 1883 and his observations on fisheries ecology, especially with regard to the exploitation of pelagic species. This is problematic since marine fisheries ecology was still in its early stages at that time and little was known about the interaction between fishing and fish abundances.[6]

Using Faber in this uncritical way leads Gallant to some erroneous conclusions, e.g., he quotes Faber as saying that fishing has little or no influence on the catch of pelagic species, and that the wide fluctuations between annual catches are only due to natural phenomena such as climate.[7] At the time it was widely accepted that due to massive spawning, the recruitment of juvenile fish could not be affected seriously by fishing.[8] Today we know that this is certainly not the case. In reality the fluctuations in yearly catches observed by Faber could have been caused by overfishing as well as by natural phenomena.

The use of outdated fishery biology led Gallant to conclude – inaccurately – that the irrational movement and fluctuation of pelagic species did not allow them to be commercially exploited in antiquity. Clearly, Gallant's source material is not optimal, and in some cases out of date, but is it at all possible to use modern fishery statistics to estimate the likely output of a historical fishery and the level of exploitation?

2. Ecosystem changes

From a biological point of view, Gallant makes the serious mistake of seeing nature as a constant factor, which doesn't change over time and space. In reality, ecosystems change and fluctuate over periods of time. In a marine ecosystem, these fluctuations will affect the abundance of fish and therefore eventually the catches.[9] These fluctuations can originate from natural processes such as temperature, salinity, primary production, predator – prey relationships, etc., but also from human activities such as fishing, draining and pollution.[10]

When Gallant argues that it is possible to compare ancient fishing methods and modern catch data, he also assumes that the marine environment has not changed, that temperature, salinity etc. have always been the same, that the abundance of species is identical, and that human exploitation has not had any

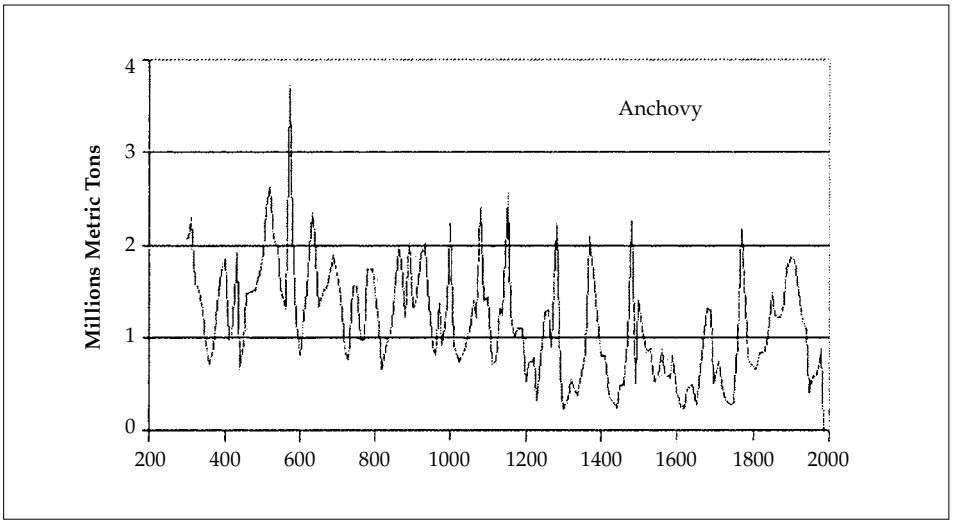

Fig. 1. From R.C. Frances, Exploited seas, *2001, 134.*

affect on the fish stocks. Two examples will show that ecosystems can indeed change dramatically over time, due to both natural and human factors.

2.1. Example 1: Anchovy in the Pacific

The case of the Coastal Pelagic Abundance of Anchovy in the California Current Ecosystem is an example that illustrates nature driven changes in the abundance of fish.

The change in the distribution of the stock seems to be a natural phenomenon, since the anchovy was not commercially exploited before the end of the 19th century. In the case of the Californian anchovy, the climate seems to play a significant role, and it is possible to establish a link between the cadence of the Pacific Decadal Oscillation (PDO)[11] and the abundance of anchovy. Note that there are both low frequency changes in distribution, as well as long-term changes.[12]

2.2. Example 2: Cod in the North Sea

An example of how human activity can affect the abundance of fish is seen on the graphics representation of the decline of cod stock in the North Sea. The Spawning Stock Biomass expresses the well being of the stock but, as seen on the graph, the cod stock in the North Sea has been declining since 1971 due to high levels of exploitation.[13]

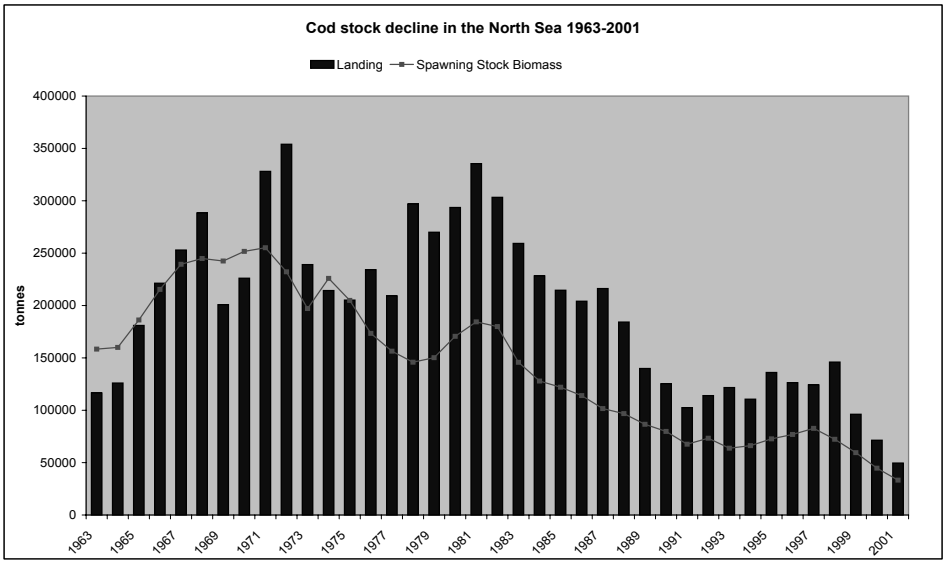

Fig. 2. ACFM Report *2003*[14]

Observe that the catches continue to grow until around 1981, even though, by that date, the stock has been declining over a ten-year period. In a high-efficiency fishery it is possible to maintain high catches even though stock is depleting. As long as the fishing technology becomes correspondingly more efficient, or cheaper, the fisherman's economical income will remain somewhat stable.[15]

When Gallant uses catch statistics from the 1950s and 1960s, we must keep in mind that the fishing effort in the Mediterranean and Black Sea by 1950 and 1960 was enormous compared to the effort in antiquity, and the level of exploitation today is therefore much higher. Thus, one cannot assume that the CPUE is necessarily higher in a high-efficiency fishery than in a more primitive fishery: the modern ecosystem might be depleted, whilst the antique ecosystem may have been at its pristine stage. It is very likely that the main fish stocks and species in the Mediterranean and Black Sea became maximal or over-exploited during the second half of the 20th century, and that the massive fishing effort in the modern period was necessary to maintain an adequate catch.[16] Keeping this in mind, it is quite possible that a *smaller* fishing effort in antiquity would produce a substantially *larger* catch than those of modern times.

The reasons why modern fish-statistics cannot be used to estimate the likely output of ancient fishery can be summarised in two main arguments:

1. That climate changes over time, and climate affects the distribution of species

2. While a large fishing effort today only results in a modest catch due to heavy exploitation of the stocks, a low fishing effort in antiquity could have given a considerable catch.

This means that Gallant's main argument about the ancient fisherman's CPUE being so diminutive compared to modern CPUE might be wrong, because he is comparing two fundamentally different ecosystems.

If one accepts Gallant's data and methodology as somewhat trustworthy, despite the reservations already mentioned, we still need to examine how he interprets the data.

3. Gallant's theses

It is possible to summarise Gallant's main theses about ancient fishery in the Mediterranean and Black Sea in five statements:

1. The fishing technology was too primitive/labour intensive to sustain a large-scale fishery, especially for pelagic species.
2. Fishery statistics from modern times (Mediterranean and Black Sea), where more effective fishing gear was used, indicate that catches in antiquity were much smaller. Modern fishery data from Malaysia where similar fishing technology was used shows that the catch per effort is so low that fishery could only be a part-time occupation, supplementing farming etc.
3. Therefore, fish was fished and eaten locally as a supplement to the daily diet, because the amount of calories gained from the fishery could not feed the fisherman himself.
4. Furthermore the price of [fresh] fish was so high, compared to grain, that it should be considered a luxury food, and therefore fish would not have been an important part of the general diet in antiquity.
5. Finally, large-scale processing and long-distance trade were not possible because the catches were small and irregular and the techniques for preservation inefficient.

This led Gallant to conclude that:

> the role of fishing in the diet and the economy would have been, on the whole, subordinate and supplementary … Its main function would have been to supply a source of sustinence during periods of food scarcity due to reduced crop yields.[17]

Gallant's first argument about the low catch-per-unit-effort (CPUE) of the ancient fishing gear is of course true compared to more modern gear such as high sea vessels and trawlers. But, in general, he tends to underestimate the efficiency and craftsmanship of the ancient fishing gear. For example he states

that the potential effectiveness of gill-nets is very small since they had to be accurately tied and such skills were not sufficiently mastered in antiquity.[18] This contradicts the fact that gill nets are known to have been widely used for fishing in ancient Mesopotamia, long before the existence of industrially manufactured nets and lines.[19]

In the final analysis, the catch power of fishing gear, or potential productivity as Gallant calls it, is not the only thing that determines the size of the catches. If the resources being exploited are plentiful, the CPUE may be high, but if the resource is depleted, the corresponding CPUE will be low. As we have discussed above, the marine ecosystems in antiquity are quite likely to have been healthier than the present ecosystem. From this it follows that Gallant's second thesis is also wrong, since ecosystems fluctuate over time. His argument that the low CPUE in the Malaysian fishery is similar to that in antiquity does not hold, as he is trying to compare two fundamentally different ecosystems that are divided by time and space.

The amount of fish consumed on board or in the fisherman's household is, in general, not included in the official catch statistics, since they are normally based on the actual landings destined for trade.[20] In order to estimate the total harvest from the sea, not only should the consumption of the fisherman and his dependents be added to the catch records, but also the discards at sea of juvenile or commercially worthless species. The catch statistics therefore only cover the marketable surplus, after the needs of the fishermen and their dependents have been met.

Thesis no. 3 is based on the assumption of low output in ancient fishery, but since the output may well have been larger, fish may well have played a more significant role in the diet, and also have been so vast a resource that it might have been a commodity for trade.

Gallant bases his fourth thesis, that fish was a luxury food, on price lists from the Boeotian *polis* of Akraiphia. According to these prices, only the wealthiest citizens could afford to buy fish on a regular basis. However, Gallant overlooks that the prices are probably for fresh fish. Because a fresh fish decays quickly it has to be eaten soon after it is caught—how soon depends on the preferences of the consumers, but it is likely that the fish had to be brought to market and consumed within 1 to 3 days after it was caught.[21] Such a high quality product would obviously be expensive. Furthermore, several of the 12 species Gallant has deduced from the list are only found in salt water, and since Akraiphia is without access to the sea, these fish had to be transported some distance before reaching the consumers, which would add to their cost.

We have to consider that the price list is only for fresh fish brought to market as an article for commercial trade. A lot of fresh fish would have been consumed locally by the fisherman himself or traded as part of a local subsistence economy. So fresh fish might be an expensive imported food item in the polis, but at the same time a common food source consumed locally.

So far, we have only discussed fish as a high quality fresh food item, but it is possible to preserve fish by several methods, thereby extending the time the product can be stored or transported.

In his fifth thesis, Gallant argues that an export oriented fishing industry was not possible because of the fluctuations in catches and the inefficient preservation techniques. His theory about fluctuations in catches is erroneously based on the modern fishery statistics and outdated fish biology, as already discussed, and several studies of processed fish in antiquity indicate that *garum* was an important part of the ancient economy, especially in the Roman Empire.[22]

Another preservation technique, which might prove fruitful in explaining how a significant fishing industry could easily process and trade its products, was the drying of fish. The archaeological evidence for the production of dried fish is non-existent since only a rack or a flat area for drying is needed. Dried fish might be a low quality product, but requires no equipment and can be used both for large and small quantities. This would make it a cheap, non-perishable source of food. It would probably be produced locally and some of it would be part of a local subsistence economy and therefore not visible in the written sources, but some of it might have been traded on a commercial basis to supply the poorest part of the population with cheap proteins.

The lack of archaeological evidence and the low status of the product could be the reason why we do not know much about trade in dried fish.

Conclusion and suggestions for future research

It should by now be evident that estimates of catches and stocks for historical fisheries cannot be based on modern catch data. Instead, estimates must be based on archaeological evidence and historical sources, possibly combined with historical ecology and paleoclimatology.

A systematical mapping of sites where objects related to fishing were found would give some ideas about the distribution of the fishery. Unfortunately, however, fish bones and fishing gear are poorly represented on most sites, but this absence of fishing-related items does not necessarily exclude the occurrence of fishing activities.

One way to approach the question of the extent of the ancient fishery would be to calculate the capacity of the fish processing sites along the Mediterranean and Black Sea coasts. These sites would give an idea about the extent of the garum-related fishery. Another way of addressing the problem would be to use the remains of garum amphorae to estimate the amount of fish used to produce such amounts of garum.

The sites where fresh fish was processed into garum would probably be located near the migration routes of the main pelagic species. If these were mapped according to when they were functioning it might be possible to estimate the historical migration patterns for some of the main pelagic species.

The fishery for fresh fish consumption is hard to estimate as it leaves few archaeological traces, and because some of the catch never reaches the markets but is consumed locally by the fisherman himself. Still, the existence of communities in areas with bad farming land, but with access to marine resources, indicates that for some fishermen fishing was a primary occupation. The question is whether the fisherman only fished for his own consumption, or was fishing for a larger processing industry.

Notes

1 Gallant 1985, 43.
2 Unit-effort can be boats per year, catch per hour, person-days spent fishing etc.
3 Gallant 1985, 12, Fig. 2, Fig 3.
4 *FAO Yearbook* 1950-.
5 Gallant 1985, 24.
6 Smith 1994, 35.
7 E.g., Gallant 1985, 29.
8 Smith 1994, 53-54.
9 Jennings 2001, 88.
10 Coull 1993, 23-27.
11 PDO is a pattern of Pacific climate variability where cold and warm regimes shift in 20-to-30 year cycles.
12 The reconstruction is based on twentieth-century fishery stock assessments and paleo-reconstructions in the Santa Barbara Basin. Francis et al. 2001, 134-135.
13 *ACFM Report* 2003, 35-36.
14 The Advisory Committee on Fishery Management (ACFM) provides advice, on behalf of ICES, on the status of *fish and shellfish stocks* in the Northeast Atlantic Ocean, including the Baltic Sea.
15 Jennings 2001, 227.
16 FAO's *The State of World Fisheries and Aquaculture* 2002, 25-26 states that about 47% of all main marine stocks and species are fully exploited and therefore producing catches that are to (or have reached) the stock's maximum sustainable limits. A further 18% of all marine stocks and species are over-exploited.
17 Gallant 1985, 43-44.
18 Gallant 1985, 21.
19 Sahrhage and Lundbeck, 1992, 35.
20 In the Danish Limfjord fishery in the 1890s a conservative estimate of the value of the fish transferred directly to the fisherman's own household amount to 7% of the total value of the fishery. The Limfjord fishery was market oriented, but in a less commercialized fishery with a lot of semi-professional fishermen the amount could go much higher. Jacobsen, 2003, 14
21 Assuming that no cooling techniques were used.
22 Bekker-Nielsen 2002a, 33.