

TRENDS IN AQUATIC SCIENCE RESEARCH: CLASSIFICATION ANALYSIS OF THE *ASFA* DATABASE

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ABSTRACT: The perception that a shift in research funding towards “Applied Science” has resulted in a decline of “Basic Science” was tested for aquatic research by analyzing trends in the subject-category composition of *ASFA* over the last 24 years. It was found that the proportion of descriptive, basic research (e.g. Taxonomy) has indeed declined, and more applied research (e.g. Genetics) has increased. Nonetheless, there are several indications that Basic Science continues to be well funded, albeit indirectly through Applied mega-research programmes.

Introduction:

The *Aquatic Sciences & Fisheries Abstracts (ASFA)* database undergoes frequent analysis to ensure it meets the evolving requirements of its international audience. Improvements in accessibility and companion products are considered (e.g. *Web Resources Database*), but the focus of quality control is on the breadth and depth of coverage. As a United Nations-sponsored partnership of 35 national and international agencies, *ASFA* is well suited to provide comprehensive coverage of aquatic science throughout the world. The database is divided into three parts: *ASFA-1: Biological Sciences & Living Resources*; *ASFA-2: Ocean Technology, Policy & Non-Living Resources*; and *ASFA-3: Aquatic Pollution & Environmental Quality*. The content of each is organized by subject categories, *ASFA-1* with the largest number (>120) and *ASFA-3* having less than 10 (FAO 1997). With few exceptions, the subject categories have remained unchanged since 1971, and as a result, trends in aquatic research can be identified by analyzing the annual composition of the *ASFA* database based on subject category.

There is the perception that the ebb and flow of research disciplines are a response to the funding vagaries of government programmes. To varying extents, the “Basic” versus “Applied” notion of research has been superimposed on the general evolution of aquatic science from its descriptive inception lasting over 2000 years – Aristotle to the Challenger Expedition in the late 1800’s –, through its relatively recent analytical and applied phases in the last half of the 20th century. Today, however, the controversy of Basic vs. Applied is particularly acute, as many believe that there is inordinate pressure on universities to produce research that is increasingly applied; i.e. with a promise of immediate economic benefits. It may be possible to validate this perception – at least in aquatic science – from an analysis of the *ASFA* subject categories.

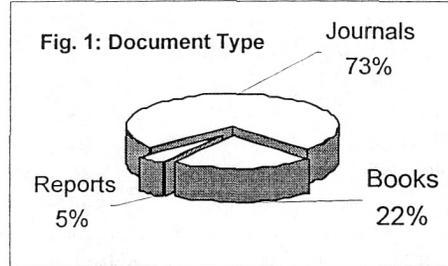
Hypothesis & Rationale:

Several of the subject categories in *ASFA* can be easily partitioned into either Applied or Basic research. It is hypothesized that the proportion of the *ASFA* database within the Applied category should reflect a positive trend, and Basic, a negative trend. The subject categories under consideration, and expectations, are shown in Table 1.

Table 1: Expected trends in composition of *ASFA* based on subject category.

Discipline	Dataset	Expected Trend	Subject Code	Example
POPULATION BIOLOGY	<i>ASFA-1</i>	Negative	201-376	Taxonomy, Physiology
COMMUNITY ECOLOGY	<i>ASFA-1</i>	Negative	381-542	Species interactions
FISHERIES	<i>ASFA-1</i>	Positive	561-567 601-645	Fishery management, Fishery Oceanography
AQUACULTURE	<i>ASFA-1</i>	Positive	581-588	Fish culture
DESCRIPTIVE OCEANOGRAPHY & LIMNOLOGY	<i>ASFA-2</i>	Negative	141-150	TSD Distribution
RESOURCES	<i>ASFA-2</i>	Positive	401-406	Oil & Gas, Mining
SUPPORT SERVICES	<i>ASFA-2</i>	Positive	381-393	Cables, Power Systems
OFFSHORE STRUCTURES	<i>ASFA-2</i>	Positive	321-327	Pipelines, Drilling Rigs
EFFECTS OF POLLUTION	<i>ASFA-3</i>	Positive	504	Bioassays, toxicity tests
ENVIRONMENTAL CHANGES	<i>ASFA-3</i>	Positive	521	Climate change

ASFA must meet several criteria to be representative of the entire scope of aquatic research, namely that its content is all-inclusive, and that it has historical relevancy to the hypothesis. *ASFA* does not include research on Ground Water, Wastewater Treatment, and Drinking Water Resources *per se*, however, all other aspects of biological and physical aquatic sciences are included. With over 670,000 records derived from over 4,700 journals and grey literature (Fig. 1, FAO 1999a), *ASFA* is statistically suited for quantitative analysis. (An additional 110,000 records exist from the first few years of *ASFA*, but these are print-only or are available only through DIMDI. These records should be added to the main electronic database – CSA’s Internet Database Service – by 2003.)



International scope is reflected by authors’ affiliations; although most research has been conducted by scientists in the United States (29%), over 200 other countries are represented. As in many scientific disciplines, articles are mainly English-language (83%), but >40 other languages such as Spanish, French and Russian are included. These original language abstracts are now a component of *ASFA* when possible, with the English translation provided by the worldwide network of input centres.

An environmental-regime bias in the aquatic literature is also apparent in *ASFA*. Fifty-six percent of the articles are marine-only, 32% freshwater, and the remaining brackishwater,

or a combination of the three. The oldest record in the database was published in 1956, but most articles were published after 1974. This 25-year timespan should be adequate to detect general shifts in research, considering many of the perceived funding changes have occurred during this period.

ASFA must also have consistency of indexing and classification. Consistency is a challenge given that articles are indexed and abstracted by a number of editors rather than computer algorithms, but made easier through the use of the ASFIS "Tools" (FAO 1999b). These FAO publications provide the common standards and detailed guidelines for processing articles appearing in *ASFA*. *ASFIS Reference Series, No. 2 (Revision 2): Subject Categories & Scope Descriptions*, and *ASFIS Reference Series, No. 5: ASFIS Guidelines for Subject Categorization & Indexing* are particularly helpful in this regard. Scope descriptions define the subject areas included and excluded by each category, and give cross-references to other related categories. The Basic vs. Applied distinction could have been derived from the *ASFA* thesaurus indexing terms, but it was thought that even greater consistency would be provided by an analysis of the 245 subject categories.

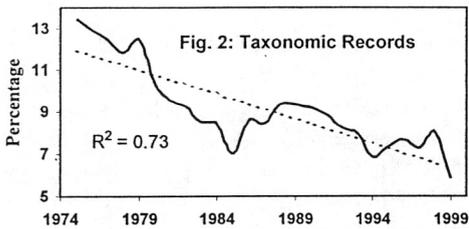
Protocol:

The number of records within each subject category of each *ASFA* series was determined using field-coded searches (using CL and PY) in the Internet Database Service, V.5. (<http://www.csa.com>). Records published before 1975 were excluded, as were records published after 2000. (Records with a publication date of 2000 started to appear in September 1999.) Trends were identified by visual analysis of the percentage composition of *ASFA* plotted against publication year. Simple linear regression was performed on appropriate categories, normalized if required. Level of significance was based on $p < 0.05$ and the coefficient of determination (R^2) was displayed.

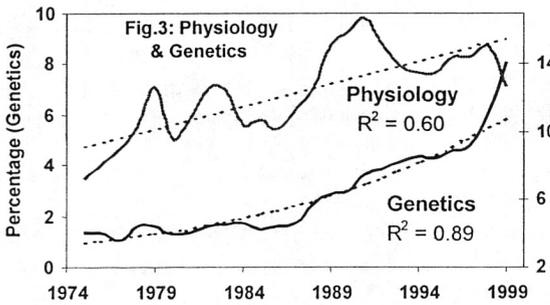
Results and Discussion:

ASFA-1 If research is indeed primarily governed by government funding, and if this funding is skewed towards Applied science, one would expect a decline in the proportion of research in POPULATION BIOLOGY and COMMUNITY ECOLOGY subject categories. At this scale of grouping, this was not the case. ECOLOGY accounted for 37% of *ASFA-1* on average (30-47% in any given year), and POPULATION BIOLOGY represented a slight positive trend from 1975 to 1999 (4-5%). At smaller scales (i.e. subcategories), however, significant trends were evident.

Nothing better epitomizes the Basic/Descriptive nature of aquatic research than that of TAXONOMY. Not surprisingly, there was a highly-significant negative trend in the proportion of taxonomic articles, with a high of 13% in the 1975 and only 6% in 1999



(Fig. 2). Despite the importance of taxonomic research, economic benefits are not immediately forthcoming, and funding has suffered. Headlines such as “Taxonomists are an endangered species in Europe” (Buyck 1999) are not altogether rare. Most other subject categories did not decline, however, and

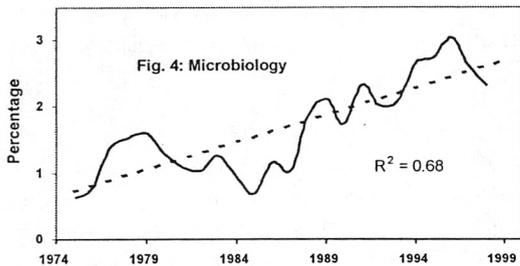


several exhibited a positive trend. Contrary to expectations, a positive trend was observed for the GENETICS, and PHYSIOLOGY subject categories (Fig. 3).

GENETICS, in particular, experienced an exponential rise in research, and almost 90% of the variance was explained by the fitted curve. While less steep, there was also a significant trend

in physiology research, rising to ~14% in 1999 from a low of 7% in 1975. The rapid rise

in genetics research in *ASFA* starting in the mid 1980's was likely a direct result of technology advances. Polymerase chain reaction (PCR) and recombinant DNA technology, in particular, have greatly advanced genetics research. Since most of this research had focused on microorganisms, one would expect a parallel trend in the



MICROBIOLOGY category, and clearly, this is the case (Fig. 4).

Because of its Applied nature, the proportion of *ASFA-1* that is fisheries-related (e.g. fishery management, seafood, fishery economics) is continually high (~15%) and does not show a positive trend. AQUACULTURE is applied as well, but there is a definite rise in the significance of this category since the mid-1980's (Fig. 5), and a concomitant interest by *ASFA* researchers (Table 2). This rise is most likely a response to the collapse of fish stocks and the shifted demand for protein towards farmed fish and shellfish. The slow recovery of fish stocks, the development of new culture techniques and species, and the burgeoning world population suggest this trend will likely continue.

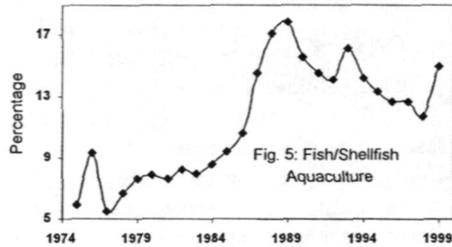


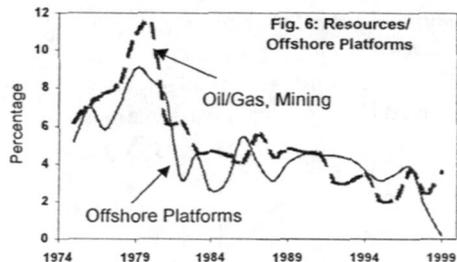
Table 2: Common search terms used by *ASFA* researchers.

Database	Search Term	Database	Search Term	Database	Search Term
<i>ASFA-1</i>	Feeding	<i>ASFA-2</i>	Accretion rate	<i>ASFA-3</i>	Mangroves
	Salmon		El Nino		Blue-green Algae
	Striped Bass		Climate Change Modelling		Cyanobacteria
	Aquaculture				El Nino

ASFA-2 In a similar situation to the Fisheries categories in *ASFA-1*, the detection of Basic-Applied trends is problematic in the physical sciences. Nonetheless, one category – DESCRIPTIVE OCEANOGRAPHY AND LIMNOLOGY – is clearly Basic in nature and, in accordance with the hypothesis, experienced a negative trend, dropping from a high of 10% in the late '70's to a low of <4% in the 1990's.

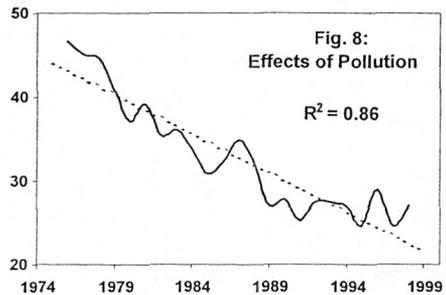
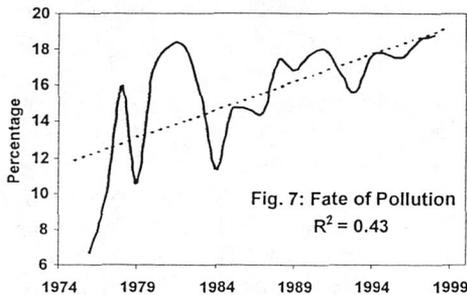
A negative trend in Applied categories such as RESOURCES, or SUPPORT SERVICES, would be surprising, but was, in fact, observed (Fig. 6). A contributing factor to this trend may be the decline in oil and gas exploration since the peak of the late 1970's and 1980's, (e.g. North Sea, Gulf of Mexico) in response to the oil crisis of the early '70s. In today's favourable oil market, the lack of incentive for research on alternative power (e.g. wave or tidal power), has also contributed to the decline in resource-oriented publications. Technological hurdles of deep-sea mining of manganese nodules and the associated international legal disputes have furthered the decline of research in this subject category.

GEOLOGY & GEOPHYSICS has always been a strong component of *ASFA-2*, accounting for 20-25% of the database. Much of this category includes research on sediment transport, particularly in environmentally-sensitive coastal zones. Dredging, coastal erosion, and beach nourishment have received particularly high attention in recent years. METEOROLOGY – the ocean-atmosphere system – has also experienced an increasing trend due to the global impact

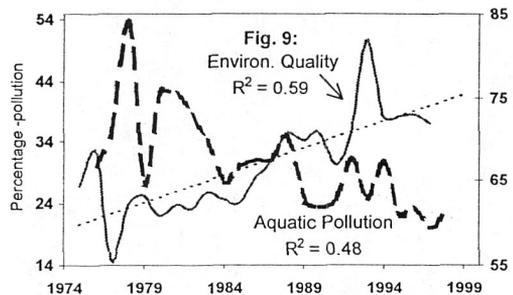


of climate change (e.g. global warming) and the El Niño/Southern Oscillation phenomena. Parallel trends in the ENVIRONMENTAL CHANGES category of *ASFA-3* were observed.

ASFA-3 As with *ASFA-2*, the POLLUTION/ENVIRONMENTAL QUALITY series of *ASFA* is primarily applied in nature, and trends reflecting a Basic-Applied science shift would not be expected. Other changes, however, are evident in differences between POLLUTION research and the more general ENVIRONMENTAL QUALITY sections. Since *ASFA-3*'s creation in 1990 as a stand-alone product, the database has been composed primarily of research on aquatic pollution (80%), and within this section, EFFECTS OF POLLUTION ON ORGANISMS is the largest component (31%). The only subject category to experience a positive trend was FATE OF POLLUTION, and that only weakly (Fig. 7). Increased research in this area has resulted from the advances in computer technology and mathematical models which allow the accurate prediction of pollution dispersion in harbours and other coastal areas. The most significant trend in the POLLUTION category, however, is a decrease in the number of articles on EFFECTS OF POLLUTION ON ORGANISMS (Fig. 8). Research on indicator species and complex bioassay experiments are still an important component, but the bulk of these publications originated in 1960's and 1970's when baseline toxicity experiments were conducted.



These years were also a period of intense public activism regarding water pollution, but this awareness has shifted to larger-scale environmental impacts. At the same time as the proportion of pollution-oriented research is declining, there is a significant rise in research on ENVIRONMENTAL QUALITY (Fig 9), including nature conservation, wildlife management, but most significantly, ENVIRONMENTAL CHANGES. Since the early 80's, there has been a large research emphasis placed on large-scale perturbations in the environment which are governed by the ocean-atmosphere system. Global warming, the greenhouse effect, ozone depletion and natural periodic events



such as the El Niño – Southern Oscillation have received widespread attention in recent years.

Summary

Despite the shift towards applied funding in many parts of the world, it is clear that Basic Science is still the focus of much research. Certain disciplines such as Taxonomy may experience a decrease in funding, but there is overall strength in research that is not directly Applied, such as Ecosystem Ecology. It is important to stress that granting agencies which favour large, multi-disciplinary projects such as the Joint Global Ocean Flux Study (JGOFS), still provide room for basic research within an Applied framework. More importantly, most academic research is still supported by government agencies which continue to have a strong mandate to fund basic research (e.g. National Science Foundation in the United States). The perceived shift to applied research is more a reflection of the shift in source of funding, from government-based grants to the research 'loans' of private industry.

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