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How life history patterns and depth zone analysis can help fisheries policy

By Dirk Zeller and Daniel Pauly

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The stocks of an exploited fish species may be utilized by more than one fishery sector during different stages in the species life history. Often, scientists and managers alike view life history patterns as a multi-dimensional problem, with complex interactions between components defined by ecology, time and oceanography. Often this complexity has made it difficult to assimilate effects of multiple fishery sectors on a species and the industry it supports. This may be either due to the perception of multi-dimensional complexity thought to be intractable, or because of an oversight of basic patterns.

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The life-history patterns of fish species are complex. But much of this complexity can be captured in simple diagrams of coastal transects, where juveniles usually occur inshore in large numbers, while adults are often in deeper, offshore waters. Here we argue that this multi-dimensional complexity can be reduced to a simpler, two-dimensional life history pattern, while still capturing the essential information. Both Charles Darwin and Alexander von Humboldt used the method of reduced dimensionality to focus ones attention to the key issues while capturing most of the significant information concerning the topic at hand. For example, after reviewing much literature, Darwin concluded that "latitude is a more important element than longitude" for explaining the distribution of organisms (Barrett *et al.* 1987). It was Humboldt, however, who first used a transect technique to visualize the advantage of reduced dimensionality in explaining observed patterns in distribution (Gayet p. 2284-2287 in Tort 1996). In fisheries science, a classic example of data suitable for reduced dimensionality was presented by Garstang (1909) for the North Sea plaice (*Pleuronectes platessa*, Figure 1 - page 3). Heincke (1913) re-expressed this as a 'law' wherein water depth and/or distance from shore explained most of the observed life history distribution patterns.

The life history characteristics of many species and stocks show generalized two-dimensional patterns, involving water depth and/or distance from shore. For example, FAO (1972) used this approach for many species in their *Atlas of the Living Resources of the Seas.* It is recognized that an inshore/offshore axis may better convey information on structure and processes than an alongshore axis or general geographic map view (Pauly and Lightfoot 1992). A good example of this is demonstrated by comparison of Garstang's map-view of plaice size distribution in the North Sea (Figure 1) with our representation of the same information for the same

Continued on page 4 - Life Histories

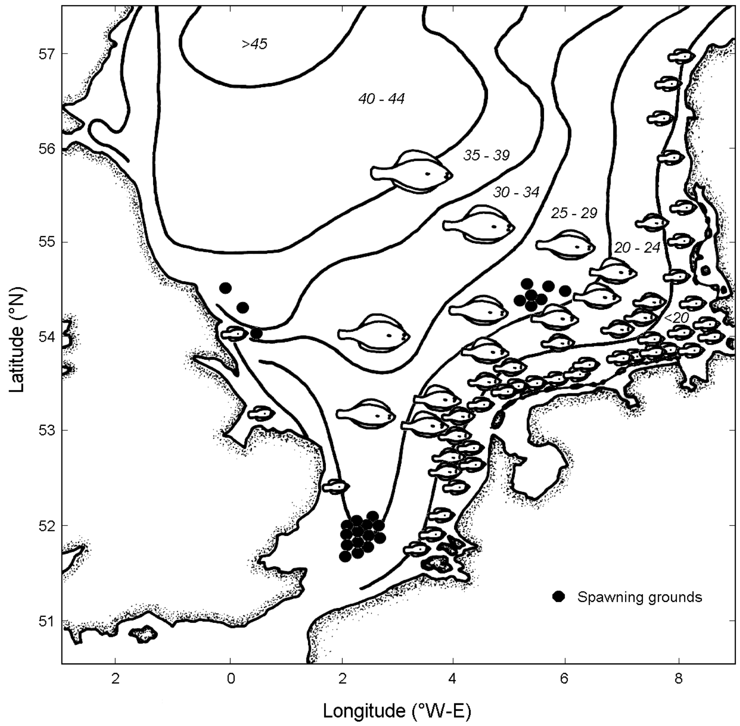

*Figure 1: Schematic representation (geographic map view) of the distribution of plaice (*Pleuronectes platessa*) in the North Sea. Mean sizes (cm TL) are given for each depth isobar (modified after Garstang 1909)*

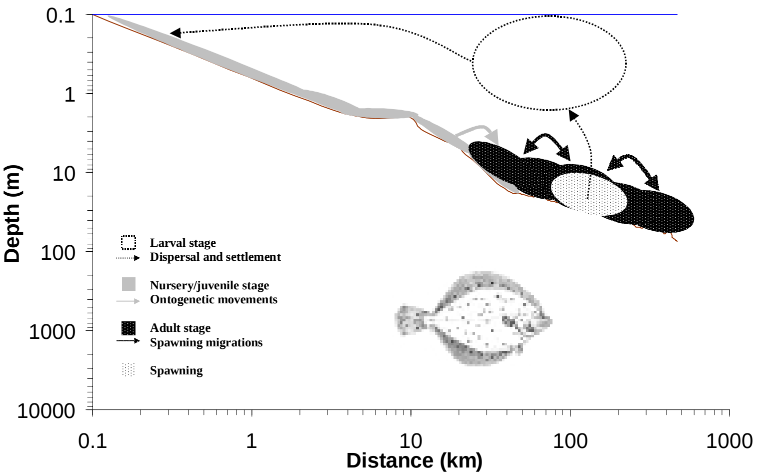

*Figure 2: Generalised life history pattern by depth zone for plaice in the North Sea (*Pleuronectes platessa*). Depth transect from 53.8°N, 8.6°E to 56.9°N, 3.5°E.*

Life Histories - Continued from page 2

species and area (Figure 2 - page 3). Such a transect approach allows the use of icons for key processes, and permits standardization of axis (e.g. log scale), which enables most species or stocks to be directly compared across extensive depth and distance scales. Application of this transect method in the context of the *Sea Around Us Project* will require drawings of similar transects for all important commercial species of the North Atlantic.

The visualization of two-dimensional life history patterns is clearly only a small part in our evaluation of ecosystem effects of fishing (see issue 3, *Sea Around Us* newsletter). Firstly, we will use these transect distributions to help assign catch data to areas such as those described in the classification systems of Large Marine Ecosystems (Sherman and Duda 1999) and 'biogeochemical provinces' (Longhurst 1995). A consensus synthesis approach to these classification systems is being considered by the *Sea Around Us Project* (see Issue 2, Jan/Feb 2000). Secondly, the depth and distance from the coast of major fish population components determines their relative vulnerability to coastal (often small-scale) and offshore (often large-scale) fishing gear and hence potential interactions and conflicts between these different fishery sectors. We will be super-imposing the various scales of operation of each fishery sector onto the life history illustrations of each species concerned. Thus, coastal transects of fish distributions will show different species 'connect', through their life history patterns, different fisheries sectors, such as small with large scale fisheries.

We consider the present approach useful for visualizing the existence, interaction and potential conflicts between different fishery sectors for species or stocks whose life history patterns illustrate the need for improved integration of management of the different fishery sectors. This may apply in particular to rationalization of overcapitalized fisheries. The proposed visualization may be used by management to incorporate the concept of life history interconnectivity between different fishery sectors and may assist in the formulation of more informed policy options for ecosystem-based management of North Atlantic fisheries.

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