

**Biological structure of
fisheries resource in space
and time**

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Spatial and temporal variations

Fish ecologists and managers realize that all ecological systems exhibit heterogeneity and patchiness on a broad range of spatial and temporal scales. We all recognize that these patterns have fundamental effects on biological processes, dynamics of populations and ecosystems, our perception of the environment and, ultimately, how we sample and manage natural resources. Incorporation of space, time, and scale (and their interactions) in theories, modeling, and sampling has improved our understanding of how population dynamics and species interactions respond to the physical (e.g., temperature) and biological (e.g., prey density) spatial structure in the environment.

Multi scale analysis has shown the existence of scale-dependent patterns that can be of biological or physical origin and that can have significant effects on biological processes. Recent advances in hardware and software technologies and analytical techniques have contributed to our abilities to acquire and analyze complex spatial data sets, and to model ecological processes, over a wide range of spatial and temporal scales. Despite these advances and our growing

appreciation for the importance of space, time, and scale, it is still often ignored in field sampling and modeling programs that attempt to evaluate predator-prey interactions, fish growth and production, and sustainability of a fishery.

Strategies to be followed

Use contrasting modeling techniques to explore the potential mechanisms for small and large-scale horizontal migration/dispersal patterns and the corresponding patterns in spatial distribution at scales ranging from meters to thousands of kilometers and from hours to decades. The consequences of these migrations are evaluated in the context of foraging, predator-prey interactions, survival, recruitment, and exotic species invasions.

Use Geographic Information System (GIS) technology to predict the landscape-level spatial distribution of fishes and explore the role of smaller-scale regional processes when predictions fail.

Reduce variance in estimates of contaminant concentrations in fish tissue by considering spatial location of samples and identify distinct “hot spots” that may be responsible for contributing to high contaminant levels.

Understand better the life stage dependent migratory behaviour of fishes in space and time to predict changes in polychlorinated biphenyl levels.

Use stable-isotope ratios of carbon and nitrogen from zooplankton and fish samples to identify seasonal and spatial trends in the source of energy for juvenile fishes, recruitment and nutritional processes in fishes.

Explore the role of spatial process in fisheries-dependent data on our ability to interpret over-exploitation in a fishery. They provide an important lesson on how ignoring spatial issues in a fishery may have devastating consequences to fish populations.

Explore how fine-scale processes affect the vertical spatial distribution of fishes and highlight the implications for foraging and growth. These contributions demonstrate the behavioural plasticity of fishes to changes in their local environment over diel and seasonal time steps, demonstrate and interactive effect of prey abundance and environmental conditions in mediating predator-prey interactions, provide insight into the spatial scale at which visual predators experience patchiness of prey, and provide relevance for the use of spatially explicit models of growth rate potential for quantifying pelagic habitat and changes in quantity and quality in habitat.

Identify key processes controlling populations over various spatial and temporal scales.

Use dimensionless ratios of rates to determine the relative importance of biological and physical processes across scales and demonstrate that dominant processes differ across various scales, life history stages, and species.

Use a recently developed graphical technique to quantify how critical scales change with fish ontogeny.

Develop computer-based tools for the analysis and exploratory comparisons of spatial data sets, patch identification, and quantifying spatial and scale-dependent proximity between predators and prey. These tools may be used for scale-robust hypothesis formulation and testing of spatial patterns of predators and prey.