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Migratory patterns of pelagic fishes and possible linkages between open ocean and coastal ecosystems off the Pacific coast of North America

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Abstract

We review studies relevant to the migration of pelagic fishes between the coastal and open-ocean ecosystems off the subarctic coast of North America. We review the life history strategies of these migratory fish and to compare to the life history strategies of major coastal migrants. The oceanography in this region is dominated by north and south currents that provide a boundary between the offshore and coastal waters. Commercial fisheries off the west coast of North America are virtually all inshore of this oceanographic separation. Migrations for some species in these major fisheries are also north and south rather than east and west. However, exceptions occur for Pacific salmon, species associated with seamounts, and for transitional pelagic species such as tuna, squid and sharks.

Three species of Pacific salmon, sockeye, pink and chum salmon, migrate along the coast in their first marine year and move off shore in the fall and winter in their first marine year. Three other species, coho salmon, chinook salmon, and steelhead trout, also migrate offshore, although they are less abundant and some stocks remain within the coastal regions. Pacific salmon species are a dominant daytime biomass in the surface waters in the offshore areas.

It is known that albacore tuna and some sharks migrate between the offshore and coastal areas, but more research is needed to assess the relative importance of these migrations. Although the biomass of species on seamounts is small relative to coastal areas, the similarity in fauna is evidence that there is recruitment from coastal ecosystems.

1. Introduction

The purpose of this symposium was to collate biological and physical data on coastal and open-ocean waters in the north Pacific in an attempt to describe potential transfers of energy between the two ecosystems. The coastal ecosystems off the west coast of North America are readily separated from offshore ecosystems by the Alaska and California Current systems, which flow north and south respectively off the west coast of North America. Despite this natural boundary, some

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pelagic fishes migrate between the open ocean and coastal systems. Pacific salmon are the group of fishes that clearly dominate migrations between the coastal and open-ocean ecosystems. Major offshore migrations occur for sockeye salmon (*Oncorhynchus nerka*), pink salmon (*O. gorbuscha*), chum salmon (*O. keta*), and steelhead trout (*O. mykiss*) (Groot and Margolis, 1991). Less extensive migrations occur for coho (*O. kisutch*) and chinook salmon (*O. tshawytscha*). By international agreement through the North Pacific Anadromous Fish Commission, there is no fishing for Pacific salmon on the high seas. It is during their return to the coastal marine waters as adults that they are fished. The individuals that escape the fishery migrate into fresh water, spawn, and die. The anadromous behaviour of Pacific salmon benefits the salmon by providing a relatively safe refuge in fresh water for the individual fish to spawn and for the young to rear. The migrations into the vast feeding areas of the subarctic Pacific allow Pacific salmon to grow larger and be more abundant than would result from a life history that confined them to fresh water. Associated with the anadromous behaviour is a transport of energy/nutrients (as accumulated body mass) from the open ocean into fresh water. Energy is produced in coastal and freshwater ecosystems through photosynthesis. Additionally, the products of primary production can be transported into these ecosystems through the decay of fish that accumulated body mass in the open ocean. The release of nutrients in fresh water can be incorporated into the trophodynamics of fresh water as well as being washed into estuaries and nearshore marine areas.

Other fishes such as albacore tuna (*Thunnus alalunga*) and selected elasmobranches move between the open ocean and coastal waters. The relationship between fish fauna on seamounts and coastal ecosystems is poorly understood. Given the increasing interest in seamounts as potential marine protected reserves, we briefly review their potential linkages within coastal ecosystems. Seamounts also offer insights into the behaviour of populations of coastal marine fishes. It is believed that the colonization of seamounts is through accident or some random event. However, it is also possible that the dispersion of coastal fishes to seamounts and to other coastal habitats is through processes that have resulted in species adaptations at the larval and juvenile stages. According to this idea, the abundance on seamounts is regulated more by available habitat than by the randomness of currents. In addition, we describe some major north–south migrations within the coastal ecosystem, since these movements redistribute energy obtained from the open ocean with coastal ecosystems. This symposium was a focus for fish movement between coastal and offshore areas. However, in order to appreciate the relevance of such movements to major fish species, we believe that it is important for a reader not familiar with fish and fisheries to have some information about major coastal migrations. Furthermore, there are unsolved mysteries relating to the reasons some of our major species migrate. Dismissing coastal migrations as having little relevance to offshore–inshore migrations at best is premature.

2. Domains of the Northeast Pacific Ocean

The open-ocean and coastal areas have sufficiently distinct bio-physical characteristics that allow boundaries to be identified (Ware and McFarlane, 1989): the Coastal Upwelling, the Coastal Downwelling and the Central Subarctic Domains (Fig. 1). The Coastal Upwelling Domain lies adjacent to the coast from Baja California to the northern tip of Vancouver Island and is characterized by an equatorward flowing shelf-break current, and the equatorward flowing branch of the Subarctic Current called the California Current. The Coastal Downwelling Domain (Fig. 1) extends from Queen Charlotte Sound in British Columbia, northward along the coast of southeast Alaska to Prince William Sound, and then westward along the Aleutian islands. The dominant features are the Alaska Current and Alaska Coastal Current. The Alaska Current flows adjacent to the coast of North America and sweeps poleward, seaward of the continental margin. The Central Subarctic Domain (open ocean, Fig. 1) is bounded by the Subarctic Current to the south, the Alaska Current to the east, and the Alaska Stream to the north.