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ECOSYSTEM OVERVIEW:

PACIFIC NORTH COAST INTEGRATED MANAGEMENT AREA (PNCIMA)

APPENDIX H: PELAGIC FISHES

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1.0 INTRODUCTION

Pelagic fishes are those species that spend most of their adult life near the surface or in the water column. Tuna and billfishes are species considered typical pelagics in offshore waters. In the coastal zone, characterized by the Pacific North Coast Integrated Management Area (PNCIMA; Figure H.0), there are both shallow and deeper water components. The pelagic species in this area include a number of resident 'forage' species that occur in the shallower inshore waters as well as seasonal transient visitors (Table H.0). The seasonal species are either typically offshore pelagics that intermittently venture into PNCIMA when oceanic conditions permit (albacore tuna, bonito, pomfret, sunfish, and saury), or migrants from the south (sardine, anchovy, shad, hake, mackerel, and salmonids such as coho) that spend the summer feeding in PNCIMA before returning south to breed. However, in this chapter, we focus on the resident or coastal species, most of which are small, abundant, schooling, forage fishes. A few key migratory species are also described: Pacific sardine, American shad, northern anchovy, and albacore tuna. Pacific hake and salmonids, while pelagic, are discussed in the groundfish and salmon appendices, respectively.

The coastal pelagic forage species discussed in detail are comprised of five families. Possibly the most ecologically important species in PNCIMA are the Clupeidae represented by Pacific herring (*Clupea pallasii*). The Ammodytidae are represented by sand lance (*Ammodytes hexapterus*), which is also believed to be ecologically important but is not well studied. The Embiotocidae, or surfperches, are represented by several species and are treated as a group. The Osmeridae, or smelts, are represented by a few important species: the anadromous eulachon (*Thaleichthys pacificus*), capelin (*Mallotus villosus*), and surf smelt (*Hypomesus pretiosis*). The northern smoothtongue (*Leuroglossus schmidti*) is a member of the Bathylagidae, the deepsea smelts, and represents the mesopelagics, a potentially important but poorly studied group. Brief synopses of these species can also be found in Hart (1973), Gillespie (1993), or Stocker *et al.* (2001).

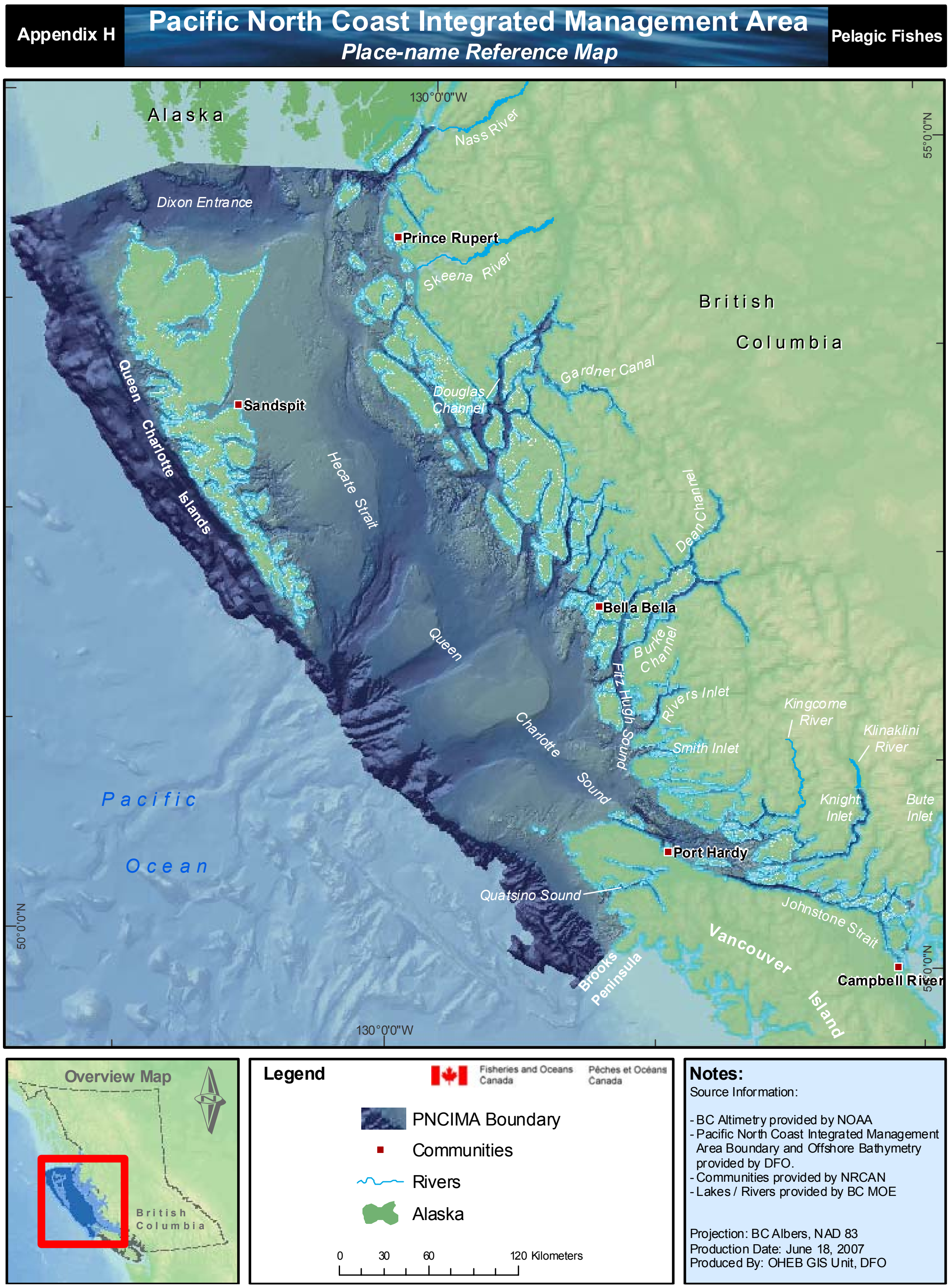


Figure H.0 PNCIMA region showing locations and features of BC waters.

Table H.0 General occurrence and taxonomic classification of pelagic fish species found in the PNCIMA ecosystem. Other pelagic fish such as salmonids, sharks, Pacific hake, pollock, and midwater rockfishes are discussed in the salmon and groundfish appendices.

Phylum Chordata
Class Osteicthyes

COMMON NAME	PRIMARY HABITAT**	FAMILY	GENUS & SPECIES
Pacific herring+	Offshore<->Inshore	Clupeidae	*Clupea pallasii*
Sand lance+*	Inshore	Ammodytidae	*Ammodytes hexpterus*
Surfperches+		Embiotocidae	
Pile perch	Inshore<->Offshore		*Rhacochilus vacca*
Shiner perch	Inshore<->Offshore		*Cymatogaster aggregata*
Striped seaperch	Inshore		*Embiotoca lateralis*
Kelp perch	Inshore		*Brachyisticus frenatus*
Redtail surfperch	Inshore		*Amphistichus rhodoterus*
Walleye surfperch	Inshore		*Hyperprosopon argenteum*
Silver surfperch	Inshore		*Hyperprosopon ellipticum*
White seaperch	Inshore		*Phanerodon furcatus*
Smelts		Osmeridae	
Eulachon+	Offshore<->In-river		*Thaleichthys pacificus*
Capelin+*	Inshore		*Mallotus villosus*
Surf smelt+	Inshore		*Hypomesus pretiosus*
Whitebait smelt	Inshore		*Allosmerus elogatus*
Rainbow smelt	Inshore		*Osmerus mordax*
Night smelt	Inshore		*Spirinchus starski*
Longfin smelt	Inshore		*Spirinchus thaleichthys*
Seasonal pelagic fish			
Pacific sardine+	Offshore->Inshore	Clupeidae	*Sardinops sagax*
Northern anchovy+*	Offshore->Inshore	Engraulidae	*Engraulis mordax*
American shad+*	Offshore->In-river	Clupeidae	*Alosa sapidissima*
Albacore tuna+	Offshore, oceanic	Scombridae	*Thunnus alalunga*
Chub mackerel	Offshore->Inshore	Scombridae	*Scomber japonicus*
Pacific bonito	Offshore, oceanic	Scombridae	*Sarda chiliensis*
Jack mackerel	Offshore->inshore	Carangidae	*Trachurus symmetricus*
Pacific pomfret	Offshore, oceanic	Bramidae	*Brama japonica*
Ocean sunfish	Offshore, oceanic	Molidae	*Mola mola*
Pacific saury	Offshore, oceanic	Scomberesocidae	*Cololabis saira*
Deepsea smelts			
Northern smoothtongue+*	Inshore, Mesopelagic	Bathylagidae	*Leuroglossus schmidti*

+ Species or family discussed in this chapter
* Non-commercial species in British Columbia
** <-> indicates annual offshore to inshore movement, -> indicates seasonal movement from offshore to inshore habitat.

2.0 PACIFIC HERRING

Clupea pallasii (Valenciennes 1847)

Pacific herring (*Clupea pallasii*) is a north temperate species ranging from the Yellow Sea on the Asian coast north through the Bering Sea and into the Arctic Ocean. On the North American coast, herring are found from the Beaufort Sea south to southern California (Haegele and Schweigert 1985). Herring is a migratory pelagic species occurring in both offshore and inshore waters. Within PNCIMA, three major migratory herring populations are recognized and managed separately: the Queen Charlotte Islands, the Prince Rupert District, and the Central Coast (Figure H.1). Additional minor herring populations occur throughout the PNCIMA area (Hay and McCarter 2002) but only the stocks on the west coast of the Queen Charlotte Islands and those spawning in Quatsino Sound (NW Vancouver Island) are managed individually. The two major herring populations in southern BC spawn on the West Coast of Vancouver Island (WCVI) and in the Strait of Georgia (SOG). Major and minor herring spawning sites are spread throughout the entire coast of British Columbia (BC) (Figure H.2).

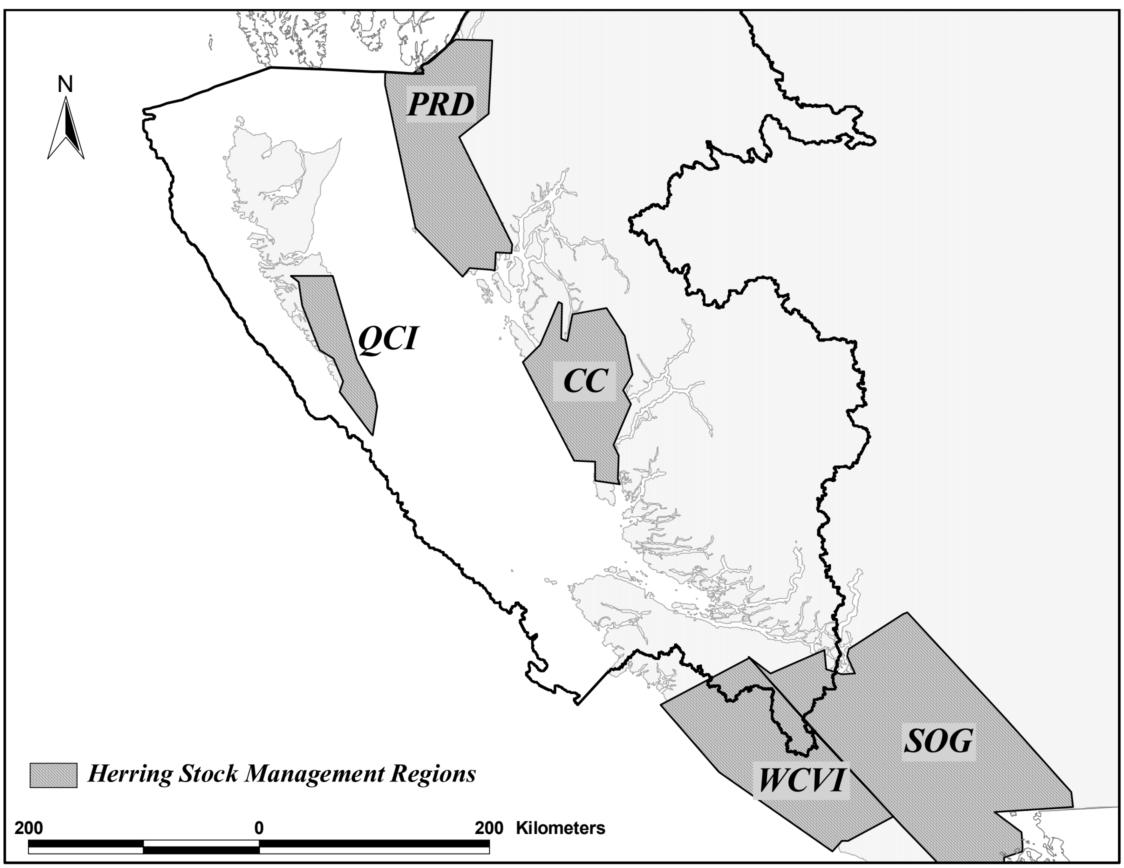


Figure H.1 The major herring stock assessment regions. Source: Fisheries and Oceans Canada, Stock Assessment Division, Nanaimo, BC.

Pacific herring is a schooling species with populations that undertake both short range (within inlets) and longer range migrations (offshore). It is relatively short-lived, with a maximum recorded age of 15 years, although most fish live only 7-8 years (Hourston and Haegele 1980). Throughout its distribution, herring become sexually mature predominantly between the ages of two and five. Within its range, the age of recruitment tends to increase with latitude (Stocker *et al. eds*. 2001). Most BC herring mature at age three. Inshore spawning migrations occur during October to December from offshore feeding grounds, (west coast of Vancouver Island in the south and Hecate Strait in the north), towards inshore spawning grounds. Herring congregate in large schools in the vicinity of spawning areas over the winter awaiting final maturation (Hay 1985; Fisheries and Oceans Canada 1994; Haegele and Schweigert 1985). On the BC coast, herring spawn in late winter, from February to as late as July, with the majority of spawning occurring in March and early April, on beaches from the high tide mark down to 20 m in the subtidal. Female herring consistently produce an average of 200 eggs g^{-1} of female weight in all areas of the BC coast (Hay 1985). Spawn deposition occurs in high-energy environments, on intertidal and shallow subtidal bottom substrate and vegetation. Both sexes of Pacific herring make physical contact with the spawning substrate onto which adhesive eggs are deposited (Haegele and Schweigert 1985). Males release milt directly into the water, which produces a milky white discolouration on the spawning grounds (Figure H.3). Temperature and salinity are important in determining when and where herring spawn occurs, and subsequent survivorship. Eggs are generally tolerant to temperatures ranging from 5-15 °C and a salinity range of 3-33‰ (Haegele and Schweigert 1985).

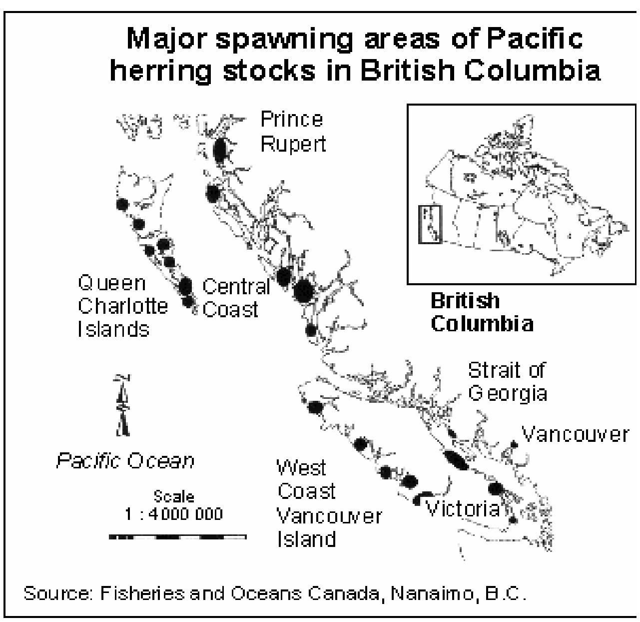


Figure H.2 Pacific Canada's major coastal spawning areas of Pacific herring stocks in British Columbia.

Photo credit: N. Akune

Figure H.3 Herring spawns observed along the eastern shores of Hornby Island.

Eggs hatch in 10-21 days, releasing 7-8 mm larvae. Larvae concentrate in the surface layers (0-20 m depth) near shore, aggregated by currents. At about 25 mm, metamorphosis to the adult form occurs in conjunction with schooling. At this stage, herring begin diurnal migrations, descending to deep water during the day, and rising to the surface at night. Offshore migration by juvenile herring begins in some areas in the fall of their first year and in other areas late the following spring (Hourston and Haegele 1980). Foraging adults are most commonly found in deeper waters (80-180 m) along the edges of offshore banks (*e.g.,* Goose Island Bank). Herring are about 100 mm in length at the end of their first year, and ~180 mm at sexual maturity. Most adults range from 175-250 mm in length at 3-8 years of age (Taylor 1964).

Herring have a long history of commercial exploitation dating back to at least 1877. In the early 1900s the expanding fishery was focused on providing bait for other fisheries and by the 1920s was exporting a dry salted product to the Orient (Taylor 1964; Hourston and Haegele 1980). In the early 1930s a rapidly expanding reduction fishery was exploiting all of the herring stocks coast wide leading eventually to a collapse and fishery closure in 1968 (Hourston 1980). The modern roe herring fishery began in 1972 and has continued to present harvesting a maximum of 20% of the forecast biomass providing that it exceeds the fishing threshold (Schweigert 2004). There are currently four fisheries that target Pacific herring: roe, spawn-on-kelp, special use, and food and bait (Rusch *et al*. 2003). These fisheries utilize only two gear types, purse seine and gillnet. The roe fishery is the largest, focusing on a specialty market in Japan and harvesting about 25-30,000 tonnes of herring annually. Spawn-on-kelp (SOK) is primarily a First Nations' fishery that impounds herring to induce spawning on kelp to provide a specialty product to Japanese consumers (Hourston and Haegele 1980). It produces an average of 250-300 tonnes of spawn-on-kelp each year. The food and bait and special use fishery are marginal, harvesting about one thousand tonnes each, primarily for food and commercial and sports bait. However, only the roe and SOK fisheries are active in the PNCIMA area. The management of these fisheries was reviewed by Stocker (1993).

The abundance of the five major herring populations (Figure H.1) is assessed annually by surveying herring spawning beds and hind-casting abundance from observed egg numbers and knowledge of population fecundity, sex ratio, and age structure using catch-age analysis (Schweigert 2004). In total, the mature biomass of herring in the PNCIMA area averages about 100,000 metric tonnes. Herring populations may undergo large inter-annual fluctuations in abundance (Figure H.4), largely as a result of variation in recruitment of first time spawners. The survival of herring from the egg to the age of sexual maturity varies as a function of oceanographic conditions that affect availability of food and the impact of predators on juvenile herring (Schweigert and Noakes 1991; Schweigert 1997). For herring populations in southern BC, sea surface temperature is inversely related to recruitment of herring to the spawning population (Ware 1991; Schweigert 1993). It appears that during warm years, a greater influx of predators from the California Current system has a negative effect on herring survival off the west coast of Vancouver Island.

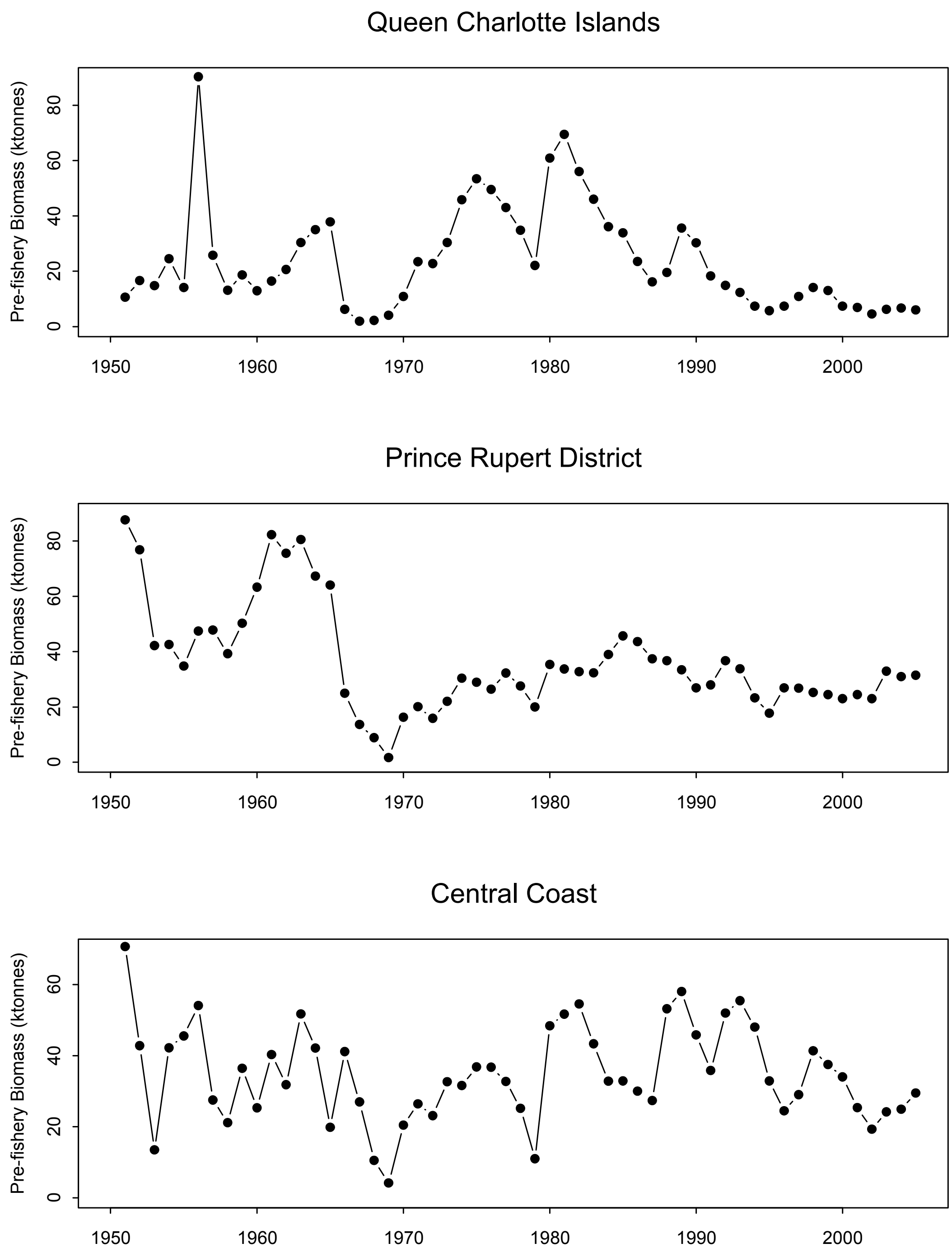


Figure H.4 Estimates of pre-fishery spawning stock biomass for northern BC herring stock assessment regions, 1951-2005.

Pacific herring are an essential component of a complex coastal marine food web in the PNCIMA region. During their larval to juvenile phase, their diet changes from invertebrate eggs, copepods and diatoms to slightly larger prey items such as barnacle larvae, mollusc larvae, bryozoans, rotifers, and young fishes. Copepods remain the most important prey item until about midway through the first year of life, when euphausiids become the key component of their diet for the remainder of their life. Many species of marine fish, birds, and mammals prey upon herring at each life stage (egg, larva, juvenile, and adult) (Hourston and Haegele 1980). Herring is a major prey item of Pacific cod, halibut, lingcod, coho salmon, and harbour seals, and contributes 30-70% to the summer diet of adult chinook salmon. Herring and their seasonal spawn depositions are an important part of the diet of invertebrates, as well as eagles, migrating seabirds, and grey whales, providing plentiful energy during breeding seasons (Hall *et al.* 2004; Booth 2000).

3.0 PACIFIC SAND LANCE

Ammodytes hexapterus (Pallas 1814)

Pacific sand lance are distributed throughout coastal areas of the North Pacific from Baja California to the southern Beaufort Sea and westward into the Sea of Japan and Sea of Okhotsk (Hart 1973). Robards *et al.* (1999b; 2002) reported that the highest abundances have been found near fine sand or gravel burrowing habitat that is sheltered from disturbance by storm waves, in areas where bottom currents keep oxygen levels high and at depths of less than 50 m. Although some summer-fall, offshore-inshore movements have been observed prior to spawning, most adult populations are thought to forage and spawn in close proximity to their burrowing habitat (Hobson 1986; Robards *et al.* 1999a; 1999b). Two characteristic defense tactics against predation are burrowing into sand and balling up into tightly packed schools (Robards *et al.* 1999b).

The Pacific sand lance is a small, elongate, tubular schooling forage fish up to 20 cm long. Mortality at all life stages is high, especially from predation, and its maximum life span is usually no more than five years, although it is capable of living upwards of seven years (Robards *et al.* 1999b). Most fish reach sexual maturity at two years of age and then spawn annually in dense schools in the intertidal or subtidal zones. They spawn primarily in the fall (observations from Prince William Sound, Alaska indicate August to October) and females deposit slightly adhesive eggs near or on bottom substrates and many of the spawned eggs mix into beach substrate, which is thought to provide some protection against predators and desiccation (Pentilla 1995). Embryos generally develop into larvae within 1-2 months, depending on ambient temperatures (Field 1987), and larvae develop into juveniles by early spring peaks in planktonic prey abundance (Robards *et al.* 1999d).

Although this species is relatively widespread and prevalent in most inshore waters of BC with sand-gravel substrates, no stock assessment data are available to provide information on stock trends. Sand lance are difficult to sample with most traditional sampling gear, but are frequently taken as bycatch in trawls. Relative abundance can be inferred from their prevalence as prey in seabird colonies on localized scales (Litzow *et al.* 2000;

Bertram 1999). Sand lance can be captured intertidally by beach seining or digging up substrate at low tides (Robards *et al.* 1999a; 1999c). SCUBA diving has been used to assess relative abundance in localized areas (Golet *et al.* 2002). No commercial fisheries currently exist in BC for sand lance, although small harvests for food occur in Japan and they are captured for bait in the United States. Sport fishing for sand lance has been permitted in BC, but there has been negligible catch effort.

Adult sand lance feed on a variety of prey, such as copepod zooplankton, epibenthic invertebrates, fish larvae and eggs (such as herring). Larvae feed on phytoplankton and early zooplankton stages. Sand lance is an important prey species for many fish, seabirds, and marine mammals throughout much of its range because of its apparent abundance and nutritional content (Field 1987; Robards *et al.* 1999a; 1999b; 1999c; Golet *et al.* 2002; Iverson *et al.* 2002; Pearsall and Fargo 2007). Prominent fish predators include: Pacific halibut and many other flatfish (arrowtooth flounder, speckled sand dab, English sole, rock sole, butter sole, and sand sole); sablefish; Pacific cod; skates (big and longnose); spiny dogfish; rockfish (redbanded and yellowtail), and salmon (McFarlane *et al.* 1984; Field 1987; Pearsall and Fargo 2007). Seabird predators include scoters, cormorants, auklets, loons, murres, pigeon guillemot, and grebes, and marine mammal predators include sea lions, seals, and humpback whales (Field 1987; Robards *et al.* 1999b; Golet *et al.* 2002; Gregr 2004).

4.0 SURF PERCH

Embiotocidae

The surfperch family (*Embiotocidae*) consists of twenty marine and one freshwater species, most of which are restricted to the eastern Pacific with the number of species increasing from north to south (Lane *et al.* 2002). There are eight species in BC, four species are distributed coast wide (Table H.1) and include the pile perch (*Rhacochilus vacca*), shiner perch (*Cymatogaster aggregata*), striped seaperch (*Embiotoca lateralis*), and kelp perch (*Brachyistius frenatus*). Four additional species are restricted to southern Vancouver Island (their northern range limit) and include the redtail surfperch (*Amphistichus rhodoterus*), walleye surfperch (*Hyperprosopon argenteum*), silver surfperch (*H. ellipicum*), and white seaperch (*Phanerodon furcatus*).

All members of the family are viviparous, with females giving birth to highly developed, free-swimming young (Turner 1947). Most species will rarely give birth to more than 20 individuals, but fecundity is size and species dependent (Cannon 1956; Lane *et al.* 2002). Gestation periods are relatively long due to this live-bearing life history strategy. Often as much as 5 months are required to develop the young. Maturity for most species is reached at 1-2 years of age, with a maximum age of 6-10 years. The pile perch is the largest species at approximately 1 kg and the oldest at 10 years. Surfperch generally are widespread, inshore species occupying a variety of habitats including sandy beaches, rocky shorelines and reefs, kelp beds, and estuaries (Tarp 1952; Roedel 1953; Hubbs and Hubbs 1954; Peden 1966; Hobson 1971; Feder *et al.* 1974; Hobson and Chess 1986; Lamb and Edgell 1986; Anderson 1994; Anderson and Sabado 1999), with water temperature being the primary factor affecting distribution (Karpov *et al.* 1995).

Table H.1 Biological and habitat characteristics of four common commercial surfperch.

Species	Length	Habitat	Depth
Shiner Perch	To 15 cm	Pilings and floats, in bays and kelp beds	Surface to 150 m
Striped perch	To 37.5 cm	Rocky reefs and pilings, in kelp beds	Surface to 20 m
Pile Perch	To 43 cm	On floats, pilings and reefs	Surface to 80 m
Kelp Perch	To 22 cm	Kelp beds	Surface to 20 m

(Source: Harbo 1999)

Due to extremely low fecundity, maintenance of populations is likely dependent upon a high survival of the young (Quinnell 1986). Thus, surfperch are believed to be prone to overfishing and slow population recovery. Overfishing may have already occurred in California, where recreational and commercial catches have steadily declined since the 1960s (Fritzsche and Collier 2001). In BC, surfperch are landed in both recreational and commercial fisheries, the latter mostly as bycatch (Lane *et al.* 2002). Recreational fishing for surfperch is common, especially on wharves, docks, and piers where younger anglers can participate. In contrast, a specialized commercial fishery exists for surfperch in BC. Catches are mainly by beach seine (hook-and-line and dip-nets also are permitted) which has raised concerns regarding bycatch of non-target species, especially salmonids, and negative impacts on nearshore habitats through destruction of macrophytes (*e.g*., eelgrass beds). Shiner perch are routinely caught as bycatch in the shrimp trawl fishery, including the Prince Rupert District fishery, but catch rates are considerably lower in the north compared to the south, especially the Strait of Georgia (Hay *et al.* 1999). The fisheries are managed under an integrated fishery management plan (IFMP) that enforces a seasonal spawning closure from May 15 to August 30 and significantly limits directed effort. Commercial fishers are required to submit logbooks of their activity and harvest. Limited understanding of the species biology and population dynamics especially of harvested populations is an area of concern. Low reproductive capacity makes the species susceptible to serial depletion even under relatively low levels of exploitation.

The species in this family have developed specialized feeding niches that limit competition within nearshore environments (DeMartini 1969). Surfperch are usually bottom or pile grazers, but are known to feed throughout the water column. Typical prey items are primarily small invertebrates including molluscs (bivalves and gastropods), isopods, amphipods, decapods, and polychaetes (Hubbs and Hubbs 1954; Gordon 1965; Gnose 1967; Feder *et al.* 1974; Lane *et al.* 2002). Surfperch are prey for a variety of predators including sea birds, otters, pinnipeds, and a variety of marine fish including rockfish and lingcod (Odenweller 1975; Stenson *et al.* 1984; Karpov *et al.* 1995).

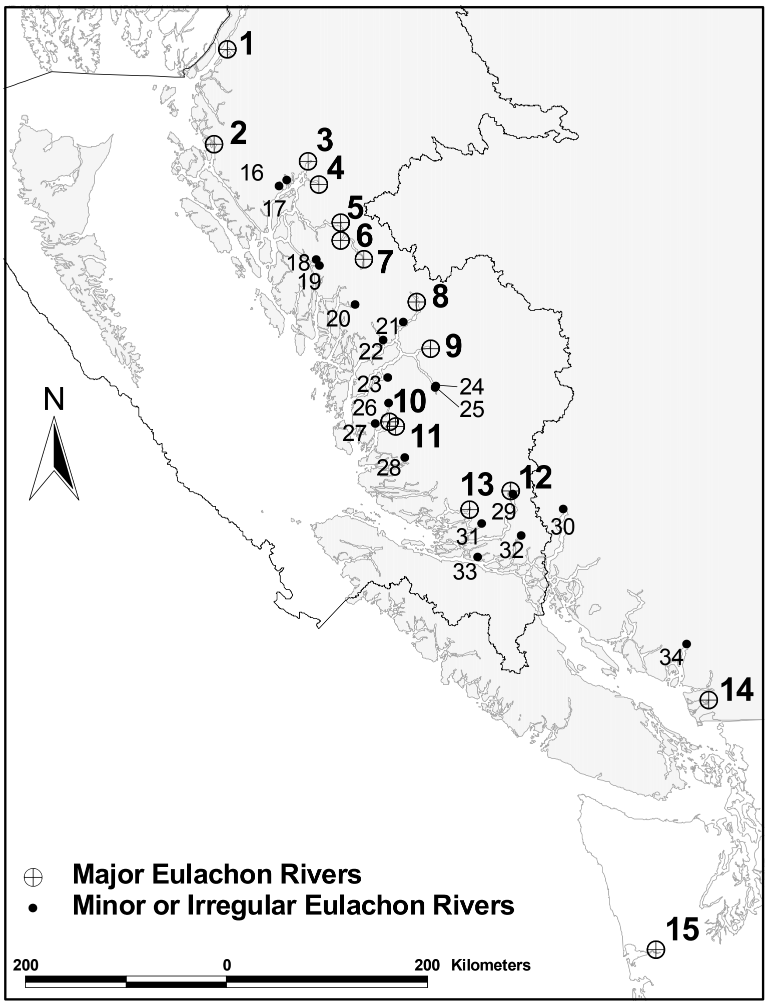
5.0 EULACHON

Thaleichthys pacificus (Richardson 1836)

Eulachon (*Thaleichthys pacificus*) is a small, anadromous smelt distributed in the Pacific Ocean from northern California to the southern Bering Sea. Eulachon spend up to 95% of their life in the ocean and return to freshwater streams and rivers to spawn. Over thirty spawning rivers are distributed along the entire west coast of BC (Figure H.5). As recently as 1999, new rivers have been identified as supporting eulachon runs, where they had not previously been documented (McCarter and Hay 1999). Thirty (or 88%) of the spawning rivers indicated in Figure H.5 are located in the PNCIMA region, including 13 of the 15 rivers classified as having regular or sustained runs. The largest eulachon run in the world occurs in the Columbia River (January-February) in Washington State. The Fraser River (April-May) and Nass River (March) have particularly large runs compared to other BC runs, which typically occur in March. Adult eulachon return only to rivers that drain major snow packs or glaciers (snow-dominant watersheds). These rivers are characterized by predominant spring flooding or freshets. Eulachon spawning rivers are also associated with coastal temperate rainforests (Hay and McCarter 2002). There are no sustained eulachon runs in rainfall-dominated watersheds (*i.e.*, rivers that drain Vancouver Island or Queen Charlotte Islands) that have predominant fall freshets following heavy rains in November and December (Hay *et al.* 2002).

The marine distribution of adults in BC includes the deeper portions of the continental shelf around Dixon Entrance, Hecate Strait, Queen Charlotte Sound, and the west coast of Vancouver Island, generally at depths of 80-200 m. Eulachon, like Pacific salmon, are anadromous (hatch in streams, migrate to the ocean, and return to their natal streams to spawn). Eulachon are also believed to be semelparous, meaning they die soon after spawning (Hay and McCarter 2000; Stoffels 2001). Spawning activity is limited to the lower reaches of suitable rivers. Females deposit approximately 30,000 small, adhesive eggs that attach themselves to sand grains and pebbles. At ambient temperatures (3-10 °C), eggs hatch within 3-5 weeks. The small larvae (4-6 mm) are quickly swept out into the marine environment. Age determination remains difficult, so it is not possible to accurately determine the length of time spent at sea before maturing, but it is thought to be 2-5 years. There is a large incidence of post-spawning mortality. Adults reach a length between 15-20 cm, and weigh between 40-60 grams (Hay *et al.* 2002; DFO 1999; Stocker *et al. eds*. 2001). Eulachon biology and distribution along the Pacific coast of Canada was reviewed in detail and summarized by Hay and McCarter (2000) (Fisheries and Oceans Canada 2002a).

Eulachon is of particular significance to First Nation communities as a culturally and spiritually important diet staple. They are very high in oil content and were commonly referred to as candlefish because of their ability to incinerate after drying. Eulachon fishery landings from the Fraser River during the mid-1900s were in the range of several hundred tonnes and were utilized mostly for animal feed and meal. In the 1980s, ten to fifty tonnes were harvested annually and much of the product was directed at the fresh fish market or used as bait. First Nation food fisheries also occur on the Fraser River and on most other major spawning rivers along the BC coast. Nass River annual catches, for example, have been in the range of 100-300 tonnes, but have recently declined in 2006. All fishing is done during the spawning run. At the peak of the run, fish are caught by dipnet, trap, seine, or gillnet. Since 2000, several eulachon runs in the PNCIMA region (runs 3, 8, 9, 10, and 11 in Figure H.5) have been declared insufficient to support even food, social, and ceremonial First Nations' fisheries. Eulachon harvests in the Columbia River in Washington State have been the largest on the west coast of North America, approximately 1,000 tonnes per year until the mid-1990s, declining to less than 10 tonnes in 2006.



Stream Name	#
Nass	**1**
Skeena	**2**
Kitimat River	**3**
Kildala River	**4**
Giltoyees Inlet	16
Foch Lagoon	17
Kitlope River	**7**
Kowesas River	**6**
Kemano/Wahoo River	**5**
Khutze River	19
Aaltanhash River	18
Kainet or Lard Creek	20
Bella Coola River	**9**
Kimsquit/Dean Rivers	**8**
Noeick River	24
Taleomy River	25
Skowquiltz River	21
Cascade Inlet	22
Kwatna River	23
Chuckwalla/Kilbella	**10**
Wannock/Oweekeno	**11**
Clyak River, Moses Inlet	26
Hardy Inlet (unknown source)	27
Nekite River, Smith Inlet	28
Kingcome River	**13**
Kakweiken River	31
Klinaklini River	**12**
Franklin River	29
Port Neville	33
Stafford/Apple Rivers	32
Homathko River	30
Squamish River	34
Fraser River	**14**
Columbia River	**15**

Figure H.5 Eulachon bearing rivers along the British Columbian coast (listed from north to south; major rivers in bold). Source: Fisheries & Oceans Canada, Habitat and Enhancement Branch, Nanaimo, BC.

Declines in eulachon spawning runs were observed from California to southeast Alaska during the early to mid 1990s (Hay and McCarter 2000). Monitoring of eulachon in BC waters is limited, so that some declines were not well documented or confirmed. In recent years, particularly since 1994, eulachon abundance has declined synchronously in many rivers and virtually disappeared in California. This decrease has been noticeable in the PNCIMA region, with very poor runs in Douglas Channel, Gardner Canal, Dean/Burke channels, and Rivers Inlet areas in the past five years. It is suspected that these declines may be related to large-scale climate change. Recent studies suggest rivers that normally experience spring freshet events may gradually be changing to summer and fall freshets that may impair eulachon spawning runs (D.E. Hay, DFO, Pacific Biological Station, Nanaimo BC, pers. comm., 2004). Declining abundance is not coast wide, as medium to good runs were observed in various southeast Alaska rivers, the Columbia, Nass, Skeena, Klinaklini, Kingcome, and Fraser rivers between 2001 and 2002. However, the Fraser River has experienced a steady decline from 2002 to 2005 and is presently at a historic low level (Therriault and McCarter 2005). Temporary increases in the abundance of eulachon in offshore waters of BC and parts of Alaska occurred during 2001-2002 but have subsequently declined in some of these areas. Bycatch is monitored during annual shrimp trawl research surveys and in shrimp trawl fisheries (D. Rutherford, DFO, Pacific Biological Station, Nanaimo BC, pers. comm., 2004). In recent years the shrimp trawl industry has adopted bycatch reduction devices but their efficacy remains uncertain.

Eulachon have been an important component of the coastal ecosystem. Larval eulachon feed on copepod larvae, adding phytoplankton, mysids, ostracods, barnacle larvae, cladocerans, and worm larvae, as well as cannibalizing their own species, as they grow (Hart 1973). Juveniles and adults feed on copepods and euphausiids. Eulachon are important prey for dogfish, sturgeon, halibut, Pacific cod, porpoise, finback whale, killer whale, seals, sea lions, gulls, and other piscivorous birds during their annual spawning migration (Hart 1973). At other times, they are an important food item for fur seals and salmonids off the west coast of Vancouver Island.

6.0 CAPELIN

Mallotus villosus (Muller 1776)

Capelin (*Mallotus villosus*) belongs to the smelt family. Their distribution on the Pacific coast extends from Juan de Fuca Strait, north through Alaska and into the Arctic Ocean. Relatively little is known about capelin in the BC waters of the northeast Pacific Ocean; they are more closely monitored and studied in Alaska and Atlantic Canada where they are more common. Fall spawning capelin were observed throughout the 1930s to 1970s from several Strait of Georgia beaches near Nanaimo, Denman Island, and Ladner (D.E. Hay, DFO, Pacific Biological Station, Nanaimo BC, pers. comm., 2004) based on reports from local residents and fishermen. They subsequently disappeared from these waters, but in the late 1990s, there was an unprecedented influx of capelin into the northern and southern portions of Johnstone Straits as they were frequently captured in purse seine sets and in trawl surveys in the lower PNCIMA region.

Capelin are not utilized commercially in BC; however, they have been recreationally harvested on local beaches. Spawning occurs at high tides often during the full moon in late September or early October. They spawn on beaches with fine gravel, often with groundwater seepage. Fertilized eggs, measuring approximately 1 mm in diameter, stick to the gravel and will hatch within 2-3 weeks, producing slender, 4-5 mm larvae. Little is known of their life history in BC, but elsewhere, capelin live 3 or more years. Specimens captured in the mid-1990s in Bute and Knight inlets were in a ripe condition in March, suggesting the occurrence of spring as well as fall spawning populations (Hay 1998). Adults feed primarily on euphausiids and copepods. In BC, this species is not common enough to be an important food source for most fishes, although it is known to be eaten by chinook and coho salmon (Hart 1973). In the North Atlantic Ocean capelin are widely distributed and are a very important food source for Atlantic cod and harp seals. Capelin are near the southern extent of their range in PNCIMA and not especially abundant. Consequently, they are unlikely to play a significant role in this ecosystem.

7.0 SURF SMELT

Hypomesus pretiosus (Girard 1954)

Surf smelt, *Hypomesus pretiosus*, is a small, silvery, pelagic schooling fish and one of seven representatives of the family Osmeridae in BC, with a distribution that extends from Monterey Bay, California to Prince William Sound, Alaska. Scientific data on the distribution of surf smelt in BC is sparse. They are known to occur in protected areas of the north coast, although they are most abundant in the Strait of Georgia, Rivers and Smith Inlets, and the Skeena estuary (Booth 2000; Fisheries and Oceans Canada 2000). Adults are found near shore and it is believed juveniles also remain in near shore waters. They are repeat batch spawners with females depositing their eggs on gravel beaches during summer months and producing about 20,000 eggs per season, depending on adult size (Schaefer 1936; Hart and McHugh 1944). Spawning activity has been observed and described extensively elsewhere (Schaefer 1936; Thompson *et al.* 1936; Loosanoff 1937; Yap-Chiongco 1941) and is related to both tidal and lunar cycles (Levy 1985). The rising tide assists in burying fertilized eggs in substrates of the upper tidal zone. Embryo development depends on temperature and spawning time, but larvae generally hatch after 11 days when approximately 3 mm long. Most schools are dominated by 2 year old fish (males ~138 mm and females ~ 146 mm) and adults live 4-5 years (Therriault *et al.* 2002b; Fisheries and Oceans Canada 2003b).

There is a long history of First Nations' usage of surf smelt throughout the Pacific Coast. In addition, commercial fisheries have operated in BC since the mid-1800s. There was little demand to export these small fish so catches were primarily for personal consumption or local markets. Over time, commercial landings decreased significantly, likely reflecting lack of demand, low biomass, or a shift from commercial to recreational harvests. Current catch allowances are intended for personal consumption regardless of whether the harvest is by commercial or recreational license. Detailed fisheries information is compiled in Therriault *et al.* (2002b). The surf smelt fishery is also managed by IFMP and currently there are no fishery openings in the PNCIMA area.

Most of the surf smelt fishery in the south occurs in Burrard Inlet and this area is closed seasonally from June 15 to August 15 during the spawning season.

Since little is known about factors that affect surf smelt biomass and distribution in BC, it is difficult to forecast future stock trends. A collaborative use policy has been adopted between government and industry to fund assessments for commercial fisheries. Future assessments will depend on commercial interests and should develop following a "phased approach" currently endorsed for new and developing fisheries. A number of data deficiencies have been identified for surf smelt in BC (Therriault *et al.* 2002b) and should be a priority for future research, including information on distribution, spawning biomass, fishing and natural mortality rates, and the impact of commercial and recreational fishery gear, including associated bycatch (*e.g.*, salmon, perch).

Surf smelt are indiscriminate feeders, eating a variety of zooplankton and zoobenthos including copepods, amphipods, crabs, euphausiids, larvae, marine worms, comb jellies, and a variety of larval fish (Hart 1973). In turn, surf smelt are important prey for larger predatory fish (salmon), marine mammals (harbour seals), and birds (ducks, blue herons, and bald eagles) (Pentilla 1995).

8.0 PACIFIC SARDINE

Sardinops sagax (Jenyns 1842)

Pacific sardine (*Sardinops sagax*) were commonly referred to as 'pilchard' in Canada during the peak of the fishery in the early 1900s. It is one of the most abundant species in the northeast Pacific, distributed from Baja California to southeast Alaska (Schweigert 1988). Pacific sardine spawn off Baja and southern California and migrate northward to feed. Historically, sardine migrated regularly in summer to the west coast of Vancouver Island, south of Brooks Peninsula, less frequently in or off Quatsino Sound, and infrequently in the central and northern parts of the coast (Hart 1973). With the dramatic collapse of the population in the 1940s, the range of the species contracted and they disappeared from BC waters by 1947, not reappearing until 1992 (Hargreaves *et al.* 1994). Uncertainty remains about whether sardine successfully spawn in Canadian waters (Schweigert 1988). However, during the 1997-98 El Niño, sardine eggs and one-year-old juveniles were sampled off the west coast of Vancouver Island. During this warm period, adult sardine were distributed along the entire Canadian coast, extending northward as far as southeast Alaska (McFarlane and Beamish 2001). Sardine are known to spawn regularly off the mouth of the Columbia River (Bentley *et al.* 1996). Analysis of sediment cores from the California coast indicates fairly regular 60 year cycles of sardine expansions and contractions over the last 1700 years (Baumgartner *et al.* 1992; McFarlane and Beamish 2001; DFO 2002). Rodriguez-Sanchez *et al.* (2002) found that variation in the abundance and distribution of sardine appears to be directly related to environmental variability, but there is also complex interaction with the northern anchovy (*Engraulis mordax*).

Sardine are not readily differentiated from Pacific herring, with whom they frequently school. Sardine are characterized by metallic blue or green body, with shading to silver sides, and black spots in a wide variety of sizes and patterns on the dorsal surface. Sardine also have striae on the gill covers and scale-like appendages at the caudal peduncle (Hart 1973). Young sardines are typically found in large schools inshore near beaches, whereas adults are more common offshore. Temperature limits of sardine schools in California range from 7-28 °C (Hart 1973). Spawning occurs from January to June, with the majority occurring in April and May. Spawning temperature ranges between 13 and 22 °C. Approximately half of the fish are mature at 21.5 cm; with essentially all mature at 24 cm. Females produce several batches of eggs with fecundity ranging from 30,000-65,000 eggs (the largest individuals producing about 200,000 in a season). Spawning occurs early in the night, with most of the eggs remaining in the upper (50 m) water layer. Eggs hatch in two to four days at ambient water temperature (14-16 °C), releasing 3 mm larvae. Young fish resemble adults by the time they reach 2.5 cm in length. At maximum age of 10-12 years, fish are about 31 cm long (Schweigert 1988). Females grow faster than males, with a wide variation in growth rates. After their second year, sardine migrate north in early summer, and return south in the autumn. Each year, the distances traveled in these migrations increases, eventually reaching as far north as the west coast of Vancouver Island, and often into the central coast. During very warm years, such as the 1997-98 El Niño and 2005, sardine have been found as far north as southeastern Alaska.

Sardines have been a major component of the fisheries and economies of North America during the first half of the 20th century until their collapse and disappearance in the 1940s (Figure H.6). The sardine fisheries of the mid-1920s to mid-1940s constituted the largest fishery in BC, and were in fact the largest commercial fishery in the Western Hemisphere during the first half of the 20th century (Hargreaves *et al.* 1994; Wolf 1992). The reduction fishery for sardine in BC began in 1917-18 with 70 tonnes landed and by 1926-27 the 44,000 tonne level was surpassed. An average of 40,000 tonnes was sustained for the next two decades until 1947-48 when only 444 tonnes were harvested (Schweigert 1988). Sardine was listed by COSEWIC (Committee on the Status of Endangered Wildlife in Canada) as a species of special concern in 1987. Following the 1992 return of sardines to the BC coast, an experimental fishery was initiated in 1995. With the delisting by COSEWIC in 2002, a commercial fishery was reinstituted. Harvests to date have been small, reaching a maximum of about 4300 tonnes in 2004.

The abundance of the Pacific sardine population is assessed annually by the United States using a catch-age model and estimated egg deposition from egg and larval surveys. The population is currently estimated at about 1 million tonnes, approaching levels observed early in the last century (Hill *et al.* 2005). As for other short-lived pelagic species, oceanic conditions can greatly influence sardine survival and recruitment during the early juvenile stages. Sardine survival and productivity are directly related to ocean temperatures off southern California (Conser *et al.* 2003). Marine conditions off California have been favourable in recent years, supporting the continued recovery and expansion of the population (Figure H.7).

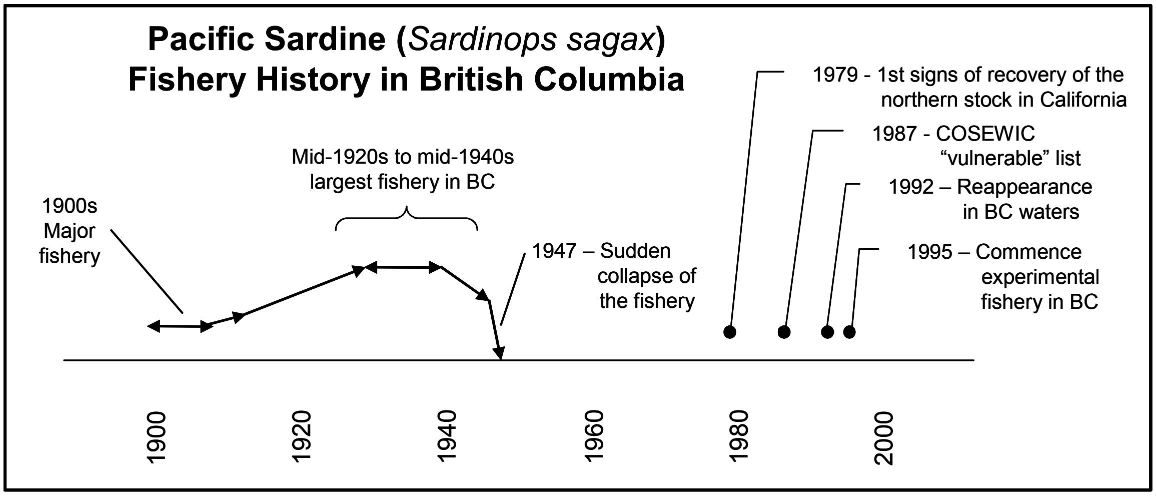


Figure H.6 The past century of the Pacific sardine fishery and notable events along the way (dates compiled from Booth 2000; McFarlane and Beamish 2001).

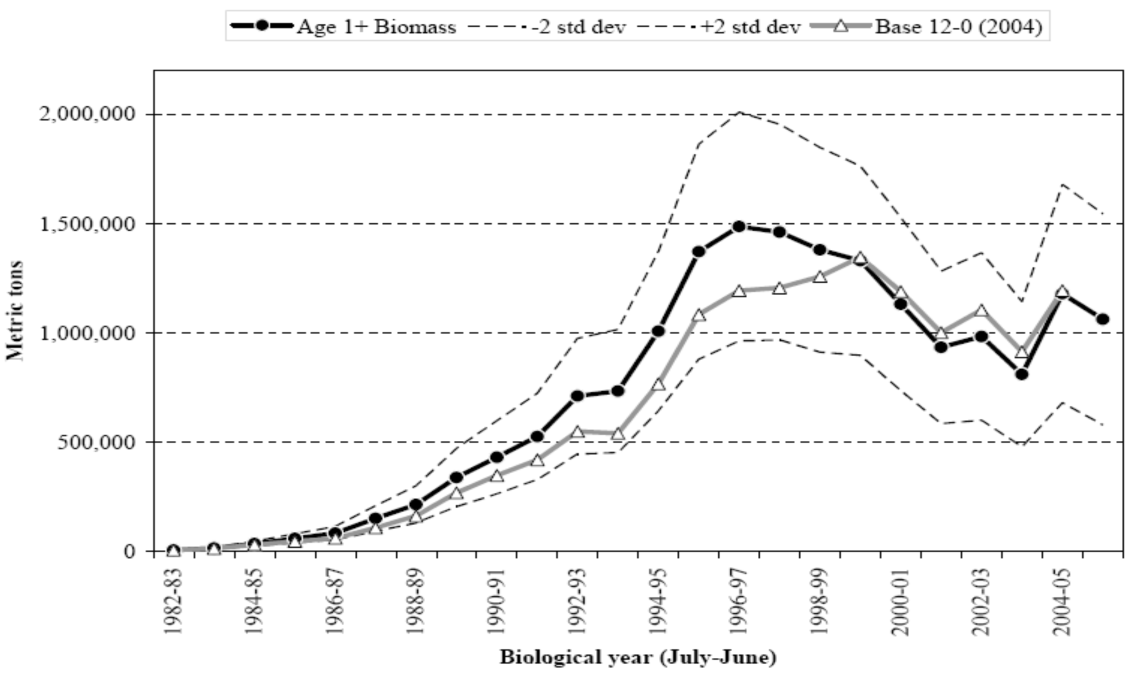


Figure H.7 Pacific sardine stock (ages 1+) biomass estimates (solid circles) along with a 2-standard deviation uncertainty envelope (dashed lines). Biomass estimates from the previous model (triangles, Base 12-0 2004) are also shown (from Hill *et al.* 2005).

During periods of abundance sardine is a very important component of the California Current ecosystem. Young Pacific sardine feed extensively on copepods and switch to diatoms as they mature (Hart 1938; 1973; McFarlane and Beamish 2001). Ahlstrom (1960) and McFarlane *et al.* (2005) noted that sardine are opportunistic, consuming fish larvae and other zooplankton when available. Sardine are prey to a wide variety of predators including commercially important fish species, seabirds, and marine mammals (Bargmann 1998; Ahlstrom 1960). Culley (1971) reports that sardines are prey for tunas, yellowtail, barracuda, bonito, marlin, hake, mackerel, sharks, and seabirds (pelicans, gulls, cormorants). McFarlane *et al.* (2005) found sardine in stomach contents of chinook and coho salmon, Pacific hake, sablefish, dogfish, and soupfin and blue shark. Humpback whales, white-sided dolphins, Dall's porpoise, and sea lions are also known to target sardine as prey. Brown pelicans have been reported to target sardine off the west coast of Vancouver Island.

It has been estimated that about 10% of the sardine population migrates into Canadian waters each year (Ware 1999), a portion of which may penetrate into the PNCIMA area. Tagging studies from the 1930s indicate that sardine annually migrate southward to spawning grounds each fall; however, there are occasional reports of Pacific sardine over-wintering in BC inlets, rather than migrating southward. A number of mass mortalities of sardine have been reported in these areas, both historically and recently (Schweigert 1988; DFO 2002). Historical descriptions of these massive die-offs are similar to recent observations on the west coast of the Queen Charlotte Islands and Douglas Channel, where sardine have succumbed to VHSV (viral hemorrhagic septicaemia virus). The mortality events indicate that sardines have attempted to over-winter as far north as Smith Inlet following the exceptionally warm El Niño summer of 1997 (Ware 1999) and even further north in 2005. While the proximal cause of death was probably VHSV infection, it is likely that increased stress levels, resulting from declining water temperatures and limited food, triggered the disease outbreak. The localized nature of sardine die-offs does not appear to pose a threat to the population as a whole and can provide periodic infusions of high energy food into the local ecosystem.

9.0 NORTHERN ANCHOVY

Engraulis mordax (Girard 1954)

Northern anchovy is a small pelagic schooling marine fish distributed from Baja Mexico to central BC. Three stocks are recognized, southern, central, and northern, with the latter ranging into BC. Northern anchovy are typically found in the upper mixed and surface layers of the continental shelf and adjacent deep-water regions (Hart 1973). Mature and immature fish remain inshore during fall and winter months while the adults move offshore during summer months (Laroche and Richardson 1980).

Northern anchovy have an elongate body with a head that is characterized by a short snout and a large protruding lower jaw enabling the mouth to open widely to strain water through the gills. Coloration varies from blue to green on the dorsal surface and silvery to white on the side and belly. Maximum length for northern anchovy in BC is approximately 168 mm for females at 7 years and 153 mm for males at 6 years, but northern anchovy are typically 120-140 mm averaging 3-4 years old (Pike 1951; Miller 1955). Anchovy captured in BC are slightly smaller at age than the more southerly populations (Parrish *et al.* 1985).

Anchovy school for reproduction, migration, feeding, and predator avoidance beginning at an early larval stage (11-12 mm) (Hunter and Coyne 1982). Spawning may occur in southern BC but is not well documented. Outside of BC, the northern stock spawns during summer months while the two southerly stocks spawn primarily in late winter or all year around (Vrooman *et al.* 1981) and the preferred water temperature for spawning is 13-18 °C. Spawning usually occurs within 100 km of the coast where eggs and milt are released into open water, generally in the upper 30 m of the water column (Moser and Pommeranz 1999). The eggs are pelagic, typically ovoid and 1.23-1.55 mm in length, hatching into 3 mm larvae after 2-4 days depending on temperature (Richardson 1981). Egg buoyancy decreases as embryonic development progresses and after hatching, the larvae are pelagic and spend most of their first year in the surface currents (McHugh 1981). Anchovy begin to resemble the adult form when they are approximately 25 mm in length and develop scales by the time they reach 41 mm.

Catch records and research data indicate that anchovy occur at low densities in bays and inlets of southern BC with recent northern occurrences reported near Fitz Hugh Sound in the central coast of BC (Therriault *et al.* 2002a) but historic observations indicate distribution ranging to near the Queen Charlotte Islands (Roach and Harrison 1948; McHugh and Fitch 1951; Hart 1973). A small seine fishery, mainly for bait, intermittently operated historically on the west coast of Vancouver Island since the 1930s. Various marketing strategies for the anchovy occurred through the 1940s, but most were unsuccessful. The lack of fish and markets resulted in the closure of the commercial fishery in BC in 2003.

Northern anchovy are daytime filter feeders, feeding indiscriminately on prey of suitable size rather than selecting specific prey species (Koslow 1981; as cited in Therriault *et al.* 2002a). Anchovy larvae feed primarily on copepods (Booman *et al.* 1991) while adult prey items include planktonic crustaceans, and fish eggs and larvae (Baxter 1967; Hunter and Kimbrell 1980). Anchovy are an important food source for piscivorous fish such as tuna, shark, chinook and coho salmon, as well as marine mammals and birds (Olesiuk *et al.* 1990; Emmett *et al.* 2001). In the southern stocks, the breeding success of California brown pelicans and elegant terns has been strongly correlated with anchovy abundance. Historically, the abundance of anchovy and sardines in the California Current system was inversely related but it is unclear whether the relationship continues to apply (Rodriguez-Sanchez *et al.* 2002; Baumgartner *et al.* 1992; Fisheries and Oceans Canada 2003a, and others). During periods of high abundance, either sardine or anchovy can be an important prey item.

10.0 AMERICAN SHAD

Alosa sapidissima (Wilson 1811)

American shad (*Alosa sapidissima*) was introduced from the Atlantic coast to the Sacramento River in California in the early 1870s (Hart 1973) and has spread rapidly throughout the Pacific. It is found from Kamchatka, Russia through Alaska and as far south as northern Baja Mexico. It ranges from the surface to depths of 250-375 m. In BC, shad have been captured incidentally in offshore trawl and seine gear. There are no directed commercial fisheries. Recently, shad have been captured by mid-water trawlers in significant quantities (several thousand pounds) as bycatch in the Pacific hake fishery off the lower west coast of Vancouver Island and in Juan de Fuca Strait (Venables 2005). Shad are rarely captured in the Fraser River or any other BC river. It is likely that many shad in southern BC waters originate from the Columbia River where a significant spawning population resides. Reports in the PNCIMA area are more sporadic, such as incidental catches in Queen Charlotte Sound and Central Coast inlets (*e.g.*, Rivers Inlet).

Adult shad range in size from 30-60 cm and 1-3 kg. In appearance, they have a broad, laterally compressed body similar to Pacific herring. Shad are distinguished by a deeper body and a single row of dark spots (3-23) along the side and saw-tooth scales or "scutes" along the abdomen (Hart 1973). Shad are anadromous but little is known of their life history in BC waters.

On the Atlantic coast, shad spawn in deep, swift areas of rivers and females release an average of 130,000 eggs annually, each measuring 2.5-3.5 mm in diameter. Fertilized eggs are non-adhesive and are carried downstream by the current. Hatching occurs quickly in 1-2 weeks, depending on river temperature (12-20 °C). Unlike eulachon, shad larvae are reared within the river and post-spawning adults rejoin the ocean migratory population. After hatching at approximately 10 mm in length, juvenile shad spend their first summer feeding in the river or estuary and then migrate offshore in autumn when river temperatures drop below 15 °C (Hart 1973). Shad mature at 4-5 years of age and, among Canadian populations, may spawn up to seven times and live up to 13 years. Adults feed mostly on copepods, mysids, euphausiids, and small fish. They are prey for sharks, tuna, sea lions, and other piscivores such as cod and dogfish. Shad are popular recreational fish and are prized for their roe. Due to their limited abundance within PNCIMA, it is unlikely that they will play a significant role in the ecosystem. The major threat to their populations has come from barriers to upstream migration such as dams or waterfalls.

11.0 ALBACORE TUNA

Thunnus alalunga (Bonnaterre 1788)

Albacore tuna (*Thunnus alalunga*) is a highly migratory pelagic species found in the Atlantic, Pacific, and Indian Oceans. In the eastern Pacific, albacore tuna range from Prince William Sound, Alaska to Chile. As sea surface temperatures rise, tuna migrate northward as much as 11 km per day, following the warm water. Migrating albacore concentrate along thermal discontinuities (ocean fronts) associated with waters of the Transition Zone in the North Pacific Ocean. Most albacore are caught in waters with a sea surface temperature ranging from 15-19 °C (Crone 2003). During the summer months, typically July and August, albacore appear erratically along the offshore coasts of BC (Hart 1973). Strong climatic changes, such as those caused by El Niño events, dramatically influence the feeding distribution of albacore tuna. The presence of tuna within the PNCIMA region is rare but could increase with increasing sea surface temperature associated with global warming.

Reproduction occurs in the spring, January to June, generally in the western part of the range from Japan to Hawaii. Juvenile albacore grow rapidly about 4 cm per month, and reach roughly 3 kg in their first year. Subsequent growth is 7-13 cm per year. They mature at 5-6 years of age, and can be 89-104 cm long and weigh an average of 16-24 kg. The maximum fork length is about 135 cm, averaging 125 cm. Off the Canadian coast, mature albacore rarely exceed 98 cm, averaging about 90 cm total length (Hart 1973). Ageing is difficult, but albacore are believed to reach a maximum age of 11-12 years (Crone 2003).

The Pacific-wide albacore tuna fishing effort is multi-national. Fishing fleets follow this highly migratory quarry as the waters and food sources dictate its feeding migrations. Canadian fishers have been pursuing albacore since the mid-1930s in the North Pacific, and recently (1980s) in the South Pacific. The North Pacific fishery lasts from May through October, and the South Pacific fishery runs from December through March. The Canadian fleet of smaller inshore fishing vessels range from the southern Oregon coast to the northern tip of Vancouver Island (Fisheries and Oceans Canada 2002c; Hart 1973). Since the 1950s, the total Pacific-wide albacore catches have ranged from 70,000-150,000 tonnes per year. Canada recently joined the Western and Central Pacific Fisheries Commission (WCPFC) which has responsibility for management of the albacore resource.

Albacore, like other tunas, lack the physical structures necessary to pump water over their gills to obtain oxygen. As a result, their respiration requires constant swimming, and combined with their ability to swim at high speeds, allows them to cover vast areas during their annual migration (Crone 2003). In order to sustain their physically demanding habits they have a high metabolic rate and require large quantities of food, at times consuming as much as 25% of their body weight each day. Albacore diet consists of sardines, herring, anchovy, myctophids, saury, small rockfish, squid and euphausiids. In addition to man, their predators may include blue marlin, striped marlin, wahoo, and larger species of billfish, tuna, and sharks (Fisheries and Oceans Canada 2002b; Crone 2003).

12.0 NORTHERN SMOOTHTONGUE

Leuroglossus schmidti (Rass 1955)

The northern smoothtongue belongs to the family Bathylagidae or deepsea smelts. The species occurs from southeastern Hokkaido to the Bering Sea on the Asian coast and south to southern Vancouver Island on the North American coast. The smoothtongue is a mesopelagic species that has been reported to depths of 1800 m, normally occurring to about 700 m but also observed at the surface. Night time diel migration patterns to the surface are observed in most areas and daytime occurrence has been observed in near shore surface waters of glacially turbid fjords (Abookire *et al.* 2002). Adults are observed infrequently, usually at night, from mid-water trawling with fine-mesh trawl liners or dropping from trawl meshes as nets break the surface. Smoothtongue often coexists with adult Pacific hake (*Merluccius productus*) and walleye pollock (*Theragra chalcogramma*) in the Strait of Georgia and in the deeper portions of inlets and fjords in the PNCIMA region. Northern smoothtongue are characterized by low fecundity, slow growth, and a short life span. Adults may reach 15 cm but are usually less than 7 cm in length, mature at 2 years of age, and live for 4-6 years (Mason and Phillips 1985).

Absolute abundance of smoothtongue is difficult to assess. In the Sea of Okhotsk off Russia, northern smoothtongue are relatively abundant, comprising 42-66% of the mesopelagic biomass (Dulepova and Radchenko 2003). During ichthyoplankton surveys (conducted at 0-20 m depth) in the central coastal inlets of PNCIMA, the northern smoothtongue larvae ranked third in abundance behind Pacific herring and eulachon (McCarter and Hay 1999). Surveys were conducted between April and June and larvae were found concentrated in surface waters (0-20 m) whenever bottom depths exceeded 400 metres, inside of most inlet sills and always within estuarine inlet circulation. Mason and Phillips (1985) encountered similar concentrations at slightly deeper depths in the Strait of Georgia basin during egg and larval surveys for Pacific hake and pollock.

Bathylagids have a small mouth, dense flat gill rakers, a small stomach and long intestine. They consume weak swimming soft-bodied animals such as pteropods, appendicularia, ctenophores, chaetognaths, polychaetes, and jellyfish. Bathylagids in the epipelagic zone can also feed on euphausiids and copepods at night when they are abundant (Gorelova and Kobylyanskiy 1985; Balanov *et al.* 1995). Seabirds nocturnally feed on abundant deepsea smelt (Abookire *et al.* 2002) and northern smoothtongues have been identified in the stomachs of herring, eulachon, sand lance, and chinook salmon (Hart 1973), and at times are an important food for fur seals. The mesopelagic distribution of this deepsea smelt species results in some predator avoidance, but seasonal trophic roles within the PNCIMA ecosystem remain unclear. Because of their relatively small size and depth distribution, it is difficult to assess the abundance and importance of bathylagids in the PNCIMA ecosystem.

13.0 SUMMARY

Most of the pelagic species discussed in this chapter are numerically abundant, schooling, migratory fishes that are relatively short-lived. Therefore, they are prone to dramatic natural fluctuations in population abundance, usually as a result of variations in environmental conditions that affect their survival. Pelagic species are the glue that holds the ecosystem together since they are a favoured and critical prey for many species at higher trophic levels. Pelagic species normally feed on plankton at lower trophic levels and consequently are usually high in lipid content.

The pelagic species as a group also have evolved a spawning modality that favours depositing their eggs and young in the inshore or in-river environment to minimize predation from abundant offshore predator populations. As a consequence, pelagic forage species are highly susceptible to anthropomorphic impacts on the nearshore environment from a variety of sources. Recognizing and mitigating these effects will be critical to the sustainability of many of the pelagic species and the long-term health of the PNCIMA and other ecosystems.

14.0 USEFUL INTERNET RESOURCES

Pacific fisheries management pelagic fish web page:
http://www.pac.dfo-mpo.gc.ca/ops/fm/herring/default_e.htm

Pacific science pelagic fish web page:
http://www.pac.dfo-mpo.gc.ca/sci/herring/default_e.htm

DFO Canadian Science Advisory Secretariat Research Documents:
http://www.dfo-mpo.gc.ca/CSAS/csas/publications/Pub_index_e.htm

DFO Science Stock Status Reports – pelagic fish:
http://www.pac.dfo-mpo.gc.ca/sci/psarc/SSRS/pelagic_ssrs_e.htm

Aboriginal fisheries:
http://www.pac.dfo-mpo.gc.ca/tapd/Default_e.htm

Pacific fisheries management consultations – Pelagic species:
http://www-ops2.pac.dfo-mpo.gc.ca/xnet/content/consultations/pelagics/default_e.htm

Integrated Fisheries Management Plans (IFMP) – all species:
http://www-ops2.pac.dfo-mpo.gc.ca/xnet/content/mplans/mplans.htm

Committee on the Status of Endangered Wildlife in Canada (COSEWIC):
http://www.cosewic.gc.ca/eng/sct5/index_e.cfm

BC Tidal Waters Sport Fishing Guide:
http://www.pac.dfo-mpo.gc.ca/recfish/default_e.htm

Sea Surface temperatures Pacific Region web page:
http://www.pac.dfo-mpo.gc.ca/sci/osap/data/sstarchive_e.htm#

Robards, M.D. *et al*. reviews of all six recognized species of sand lance:
http://www.fs.fed.us/pnw/pubs/rp_521.htm

Herring spawn and harvest information:
http://www.pac.dfo-mpo.gc.ca/sci/herring/herspawn/pages/default3_e.htm

Environment Canada - National set of indicators – Pacific herring:
http://www.ec.gc.ca/soer-ree/English/Indicators/Issues/Herring/Bulletin/ph_iss_e.cfm?accessible=on

Proceedings of the Sardine Symposium, 2000:
http://nsgl.gso.uri.edu/cuimr/cuimrw00001/cuimrw00001index.html

British Columbia Tuna Fisherman's Association:
http://www.bctfa.com/

Albacore Biology/Ecology:
http://swfsc.nmfs.noaa.gov/frd/HMS/Large%20Pelagics/Albacore/albie01.htm

15.0 GLOSSARY

Anadromous – Refers to species of fish that spawn in freshwater but live most of their lives in saltwater, returning to freshwater to spawn.

Estuary – An inlet or arm of the sea; especially the wide mouth of a river, where the tide meets the current.

Fecundity – The reproductive capacity of an individual or a population, generally measured by the number of eggs produced.

Metamorphosis – Refers to the change in the shape or form of an individual, usually associated with the conversion that takes place from the larval to juvenile phase in fishes.

Piscivorous – A species of fish that feeds primarily on other fishes.

Semelparous – Refers to a species of fish where the individuals all die soon after spawning.

Viviparous – Refers to a method of reproduction where the embryo develops within the female and from whom it receives nourishment. The female gives birth to highly developed, free-swimming offspring.

16.0 REFERENCE LIST

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