Chapter 4

The Salmonids of Bristol Bay

In 2010, over 40 million wild sockeye salmon returned from the ocean to spawn in the Bristol Bay basin. The 28.5 million sockeye harvested commercially in the bay that year produced an ex-vessel value of just under $150 million (ADFG 2011a), a figure that does not include the retail, recreational, or cultural value of the harvest (discussed in chapter 7). Over 11 million sockeye escaped the nets to spawn in 2010 (ADFG 2011a), ensuring the continued viability of the largest sustainable harvest of wild salmon on the planet.

> *[T]he net result of losing [Bristol Bay sockeye] population and life history diversity could be a tenfold increase in the frequency of fishery closures, generating considerable hardship for people who rely on consistent annual returns for their livelihoods.*
>
> —"Population Diversity and the Portfolio Effect in an Exploited Species" (Schindler et al. 2010)

4.1 Habitat and Adaptation

Salmon require several different types of freshwater habitat to successfully complete their lifecycles, including areas suitable for spawning, incubation, rearing, and migration (Meehan 1991). The unique richness and diversity of Bristol Bay's salmon populations are driven by the region's extraordinary abundance of varied, near-pristine, hydrologically well-connected, and productive freshwater habitats. The region's habitat complexity, coupled with salmon's strong natal homing tendencies, creates distinct, locally adapted populations with a high degree of adaptive specialization to individual stream conditions (Hilborn et al. 2003 , Ramstad et al. 2009).

The Kvichak River provides a good example of habitat-driven genetic adaptation for sockeye. At least 150 sockeye populations have been identified in the Kvichak watershed, 38 of which reside in Lake Clark and the upper Newhalen River (Demory et al. 1964, Young and Woody 2007). It is possible that as many as 200 to 300 discrete spawning aggregates occupy the Kvichak system alone (Habicht et al. 2004, Ramstad et al. 2004, Ramstad et al. 2009). Local genetic adaptations include size and age at maturity, which depends to a large degree on stream size, and timing of spawning (Hilborn et al. 2003, Woody 2004, Ramstad et al. 2009). Habicht et al. (2007) found that 97.2% of the genetic diversity of Bristol Bay sockeye salmon could be explained by differentiating among the spawning sites where they were collected.

This habitat-dependent population diversity limits the fluctuations in salmon runs commonly seen in systems with less complex and available habitats. In a recently published paper, Schindler et al. (2010) use 50 years of Bristol Bay sockeye population data to highlight the role that life history and population diversity play in sustaining a steady yield of a heavily exploited species. The research finds that "variability in annual Bristol Bay salmon returns is 2.2 times lower than it would be if the system consisted of a single population, rather than the several hundred discrete populations it currently consists of." Population and life history diversity reduce variability in production at the basin or stock scale (Bristol Bay has 15 discrete stocks) because the impacts of disturbance or unfavorable environmental conditions can be minimized. For example, juvenile sockeye exhibit a variety of strategies when migrating to or returning from the ocean. Some spend one year rearing in freshwater while others spend two; similarly, sockeye may remain in the ocean for one to three years before returning to spawn as adults. This complex age structure within a population increases the likelihood that temporally or spatially limited disturbances (i.e., environmental changes that do not impact the entire basin or persist over many years) do not impact all of the individuals in a particular cohort.

This dampening effect on the impact of disturbance is critical in maintaining the productivity of the entire system and allowing sustainable commercial, recreational, and subsistence harvests year after year. In fact, Schindler et al. (2010) found that if Bristol Bay produced just a single homogeneous population, the resulting increased variability in run size would "lead to ten times more frequent fisheries closures." In addition to the bounty enjoyed by humans, the benefits of sustained salmon runs are shared among numerous other species (discussed in section 4.2).

Although Bristol Bay's population diversity and population-level habitat specialization ensures that salmon can take advantage of a wide range of habitats and limits the impacts of environmental disturbance, it leaves them vulnerable to larger scale habitat alterations. For example, to sustain genetically adapted local populations, water quality characteristics must remain within a narrow range, and small changes, such as increases in dissolved copper concentrations, can be lethal or highly disruptive to survival (Eisler 2000, Baldwin et al. 2003, Sandahl et al. 2006, Hecht et al. 2007, Sandahl et al. 2007, Tierney et al. 2010). Once genetic diversity is lost from salmon populations through habitat destruction or degradation, the

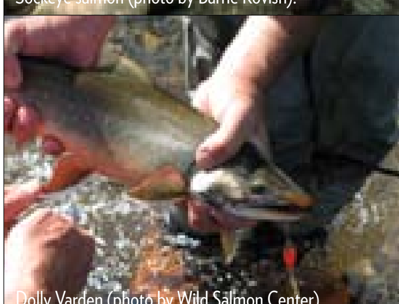
Table 2. Fish Species in Bristol Bay Drainages. All salmon spawn in fresh water. Anadromous fish (indicated by "ANA" in the table) spawn in fresh waters and migrate to marine waters to feed. Resident, non-anadromous fish ("NON") spawn and feed entirely in fresh water, often with substantial seasonal movements between habitats within a given drainage (Quinn 2004). These are known as potamodromous (POT). In amphidromous (AMP) populations, juveniles move from salt water to the lower rivers to feed.

In some Bristol Bay species (including salmon), essentially all individuals have anadromous life histories. In others, all individuals have nonanadromous life histories (lake trout, arctic grayling, and pygmy and round whitefish). And in yet other species, individual fish may exhibit either anadromous or nonanadromous life histories (rainbow trout/steelhead, Dolly Varden, Bering cisco, least cisco, humpback whitefish). Salmon are "semelparous", meaning they reproduce only once per lifetime and then die. Other Bristol Bay salmonids are "iteroparous" and can spawn multiple times during a lifetime (Morrow 1980, Stearns 1992, Mecklenburg et al. 2002, ADFG 2008b, Brown et al. 2009).


Chum salmon (photo by Paul Vecsei).


Coho salmon (photo by Barrie Kovish).


Sockeye salmon (photo by Barrie Kovish).


Dolly Varden (photo by Wild Salmon Center).


Rainbow trout (photo by Wild Salmon Center).

Family Name	Common Name	Scientific Name	Principal Life History
Petromyzontidae/lampreys	arctic lamprey	*Lethenteron camtschaticum*	ANA
Petromyzontidae	Alaskan brook lamprey	*Lethenteron alaskense*	NON
Petromyzontidae	Pacific lamprey	*Entosphenus tridentatus*	ANA
Clupeidae/herrings	Pacific herring	*Clupea pallasii*	AMP
Catostomidae/suckers	longnose sucker	*Catostomus catostomus*	NON
Esocidae/pikes	northern pike	*Esox lucius*	NON
Umbridae/mudminnows	Alaska blackfish	*Dallia pectoralis*	NON
Osmeridae/smelts	rainbow smelt	*Osmerus mordax*	ANA
Osmeridae	pond smelt	*Hypomesus olidus*	NON
Osmeridae	eulachon	*Thaleichthys pacificus*	ANA
Salmonidae/salmonids	Bering cisco	*Coregonus laurettae*	ANA and NON
Salmonidae	humpback whitefish	*Coregonus pidschian*	ANA and NON
Salmonidae	least cisco	*Coregonus sardinella*	ANA and NON
Salmonidae	pygmy whitefish	*Prosopium coulteri*	NON
Salmonidae	round whitefish	*Prosopium cylindraceum*	NON
Salmonidae	coho salmon	*Oncorhynchus kisutch*	ANA
Salmonidae	Chinook salmon	*Oncorhynchus tshawytscha*	ANA
Salmonidae	sockeye salmon	*Oncorhynchus nerka*	ANA
Salmonidae	chum salmon	*Oncorhynchus keta*	ANA
Salmonidae	pink salmon	*Oncorhynchus gorbuscha*	ANA
Salmonidae	rainbow trout	*Oncorhynchus mykiss*	POT and ANA
Salmonidae	arctic char	*Salvelinus alpinus*	POT
Salmonidae	Dolly Varden	*Salvelinus malma*	ANA and POT
Salmonidae	lake trout	*Salvelinus namaycush*	NON
Salmonidae	arctic grayling	*Thymallus arcticus*	POT
Gadidae/cods	burbot	*Lota lota*	POT
Gadidae	Pacific cod	*Gadus macrocephalus*	AMP
Gadidae	saffron cod	*Eleginus gracilis*	AMP
Gasterosteidae/sticklebacks	threespine stickleback	*Gasterosteus aculeatus*	NON and ANA
Gasterosteidae	ninespine stickleback	*Pungitius pungitius*	NON
Cottidae/sculpins	coastrange sculpin	*Cottus aleuticus*	NON
Cottidae	slimy sculpin	*Cottus cognatus*	NON
Cottidae	Pacific staghorn sculpin	*Leptocottus armatus*	AMP
Pleuronectidae/ flounders	arctic flounder	*Pleuronectes glacialis*	AMP
Pleuronectidae	starry flounder	*Platichthys stellatus*	AMP

likelihood of the species surviving over the long term is diminished (Rich 1939, Nehlsen et al. 1991, Spence et al. 1996, Hilborn et al. 2003, Schindler et al. 2010). This fact has been demonstrated repeatedly. Salmon populations prospered in cold waters throughout large regions of North America for thousands of years, but over the last century they have been extirpated from substantial portions of their ranges as a result of human changes to their habitats (Nehlsen et al. 1991). Decades of resource extraction, construction of migration barriers, hatchery production, and harvest have caused the decline and extinction of many populations (Nehlsen et al. 1991, Frissell 1993, Huntington et al. 1996).

If a major disturbance, such as a flood, volcano, freeze, disease, or tailings dam failure eliminates all salmon from a system, populations in other watersheds can remain productive and eventually re-colonize the disrupted system once the affected habitat has recovered (Waples et al. 2008). However, the genetic diversity can only be replaced through genetic mutation or individual straying, both long term processes that make recovery difficult. The straying rate for sockeye is the lowest among all of the Pacific salmon, estimated at less than 3% per year (Quinn et al. 1987).

4.2 Ecological Importance of Bristol Bay Salmon

Anadromous salmon and steelhead have evolved into seven distinct species across the north Pacific Ocean, adapting to the varied environments of hundreds of thousands of rivers and streams. Throughout their ranges, these species play a vital role in increasing the productivity of a variety of terrestrial and aquatic ecosystems by delivering marine nutrients inland to headwater streams (Kline et al. 1993, Schindler et al. 2003, Wipfli and Baxter 2010). Pacific salmon leave freshwater as 6 to 19 gram (0.2 to 0.4 ounce) smolts and attain more than 98% of their final mature weight at sea (Quinn 2004). When they return to freshwater to spawn, they transport and distribute tons of marine-derived nutrients to Alaska's nutrient-poor freshwaters (Kline et al. 1993, Schindler 2003, Stockner 2003). Donaldson (1967) estimated that a record escapement of 24.3 million sockeye to the Kvichak River in 1965 deposited, after death, 169.3 metric tons of phosphorus, a nutrient essential to the health and productivity of the watershed.

Such annual nutrient influxes by salmon maintain the productivity of lakes, streams, and riparian areas while supporting a diversity of wildlife (Naiman et al. 2002). Salmon and salmon carcasses are a major food source for terrestrial and avian predators and scavengers, including bears, wolves, foxes, mink, mice, ducks,

Bristol Bay's resident salmonids and ocean-going species, such as this coho, are genetically adapted to live within a relatively narrow range of physical, chemical, and biological habitat conditions during their freshwater life cycles (photo by Wild Salmon Center).

wrens, hawks and eagles (Willson and Halupka 1995). When these and other species drag and carry carcasses from the beaches and rivers into riparian zones, they deliver critical nutrients to a variety of plant and other animal species. In some areas, carcass densities have been measured as high as 4000 kg/ha within riparian areas, and salmon-derived nutrients have accounted for 20% of tree metabolism (Reimchen 1994, Hilderbrand et al. 1999). In coastal Alaska, brown bears obtain virtually all of their carbon and nitrogen from salmon (94% ± 9% of total), while the timing of mink reproduction can be influenced by the timing of salmon spawning (Hilderbrand et al. 1996, Ben-David 1997). Phosphorus and calcium from bones are especially important in oligotrophic waters and acidic soils, where these nutrients are naturally in low concentrations. Gende et al. (2002) describe major dispersal pathways for salmon-derived nutrients during and after spawning (Figure 14).

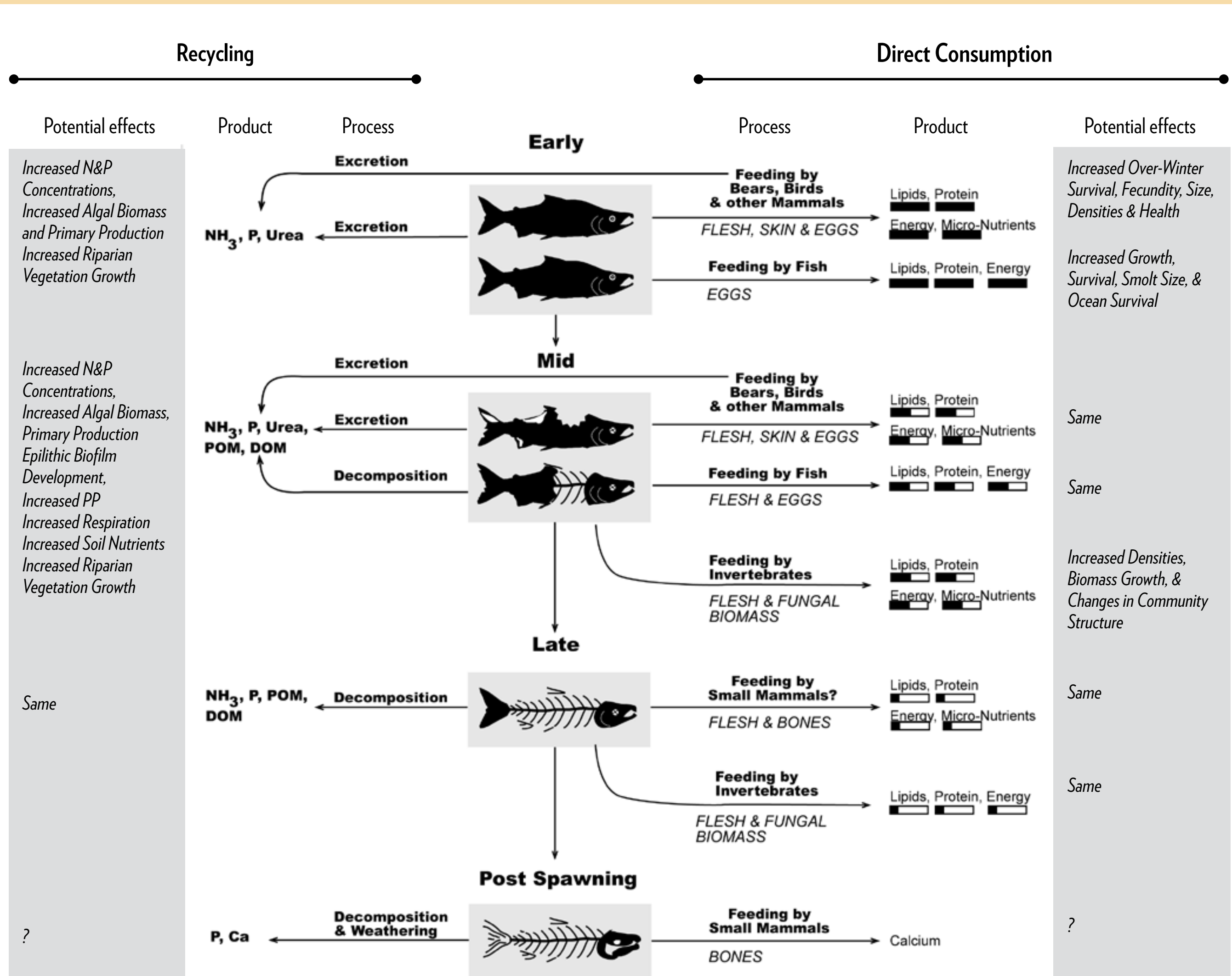
Healthy salmon returns also directly support the continued productivity of fish populations (Koenings and Burkett 1987). Carcasses of spawned-out adults and eggs from spawning fish are important seasonal parts of the diet of rearing juvenile salmon, rainbow trout, Dolly Varden, and arctic grayling (Bilby et al. 1998, Lang et al. 2006). Wipfli et al. (2003) found that salmon carcasses increased growth rates of stream-dwelling salmonids and that more carcasses translated into greater growth. Juvenile salmon and smolts are an important food source for the large populations of resident fish species, such as rainbow trout, Dolly Varden, and arctic grayling, found in Bristol Bay streams. In this way, salmon provide a rich food source up and down Bristol Bay rivers across many months of the year and are key to the success of trout, char, and grayling populations. Without large salmon escapements and the associated input of marine nutrients, the productivity of the region and the numbers of freshwater and terrestrial species would decline in Bristol Bay as they have in the western conterminous United States and elsewhere (Gresh et al. 2000, Wipfli and Baxter 2010).

4.3 *Salmon Species of Bristol Bay*

As listed in Table 2, Bristol Bay river systems support diverse and robust populations of fish, representing at least 11 families, 22 genera, and 35 species. The 15 extant salmonid species (family *Salmonidae*) dwarf most Bristol Bay freshwater fish assemblages in abundance, diversity, ecosystem function, and human use and interest. The salmonid family comprises three subfamilies, each with representatives in Bristol Bay: salmon, trout, and char (*Salmoninae*), grayling (*Thymallinae*), and whitefish (*Coregoninae*) (Mecklenburg et al. 2002). The following provides general information on the life histories and commercial value of the five salmon species present in Bristol Bay.

Salmon are genetically adapted to a relatively narrow and unique range of habitat and water quality parameters within their natal streams. The extraordinary productivity of the Bristol Bay is attributable, in part, to the adaptation of sockeye to the diverse and complex array of habitats and environmental conditions in the Bristol Bay basin (Hilborn et al. 2003, Schindler et al. 2010). These adaptations have produced a unique diversity of sockeye populations and life histories within Bristol Bay sockeye. This diversity mitigates population fluctuations in the event of environmental disturbances (Schindler et al. 2010) (photo by Wild Salmon Center).

Figure 14. Major dispersal pathways for salmon-derived materials during spawning (Gende et al. 2002).

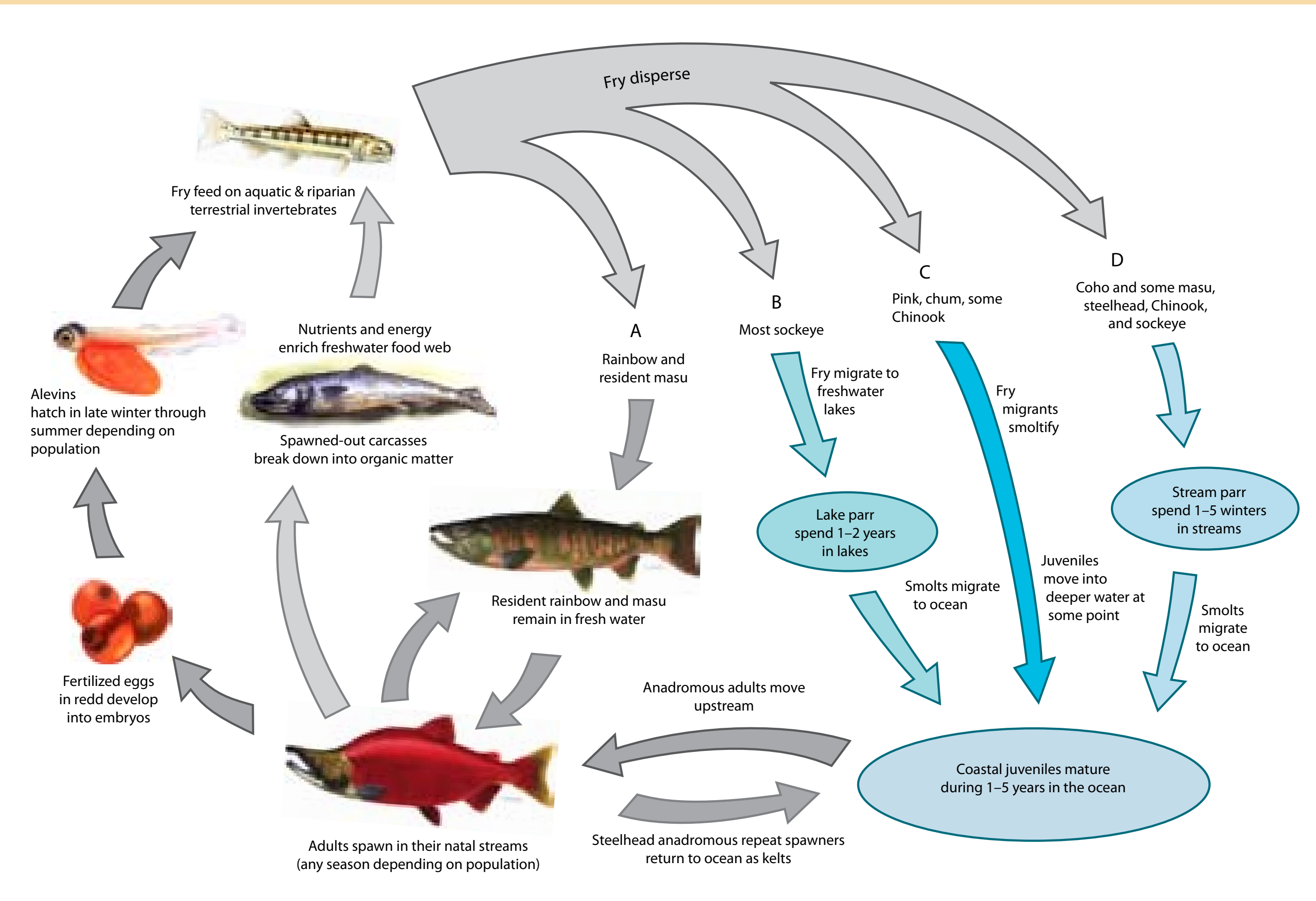


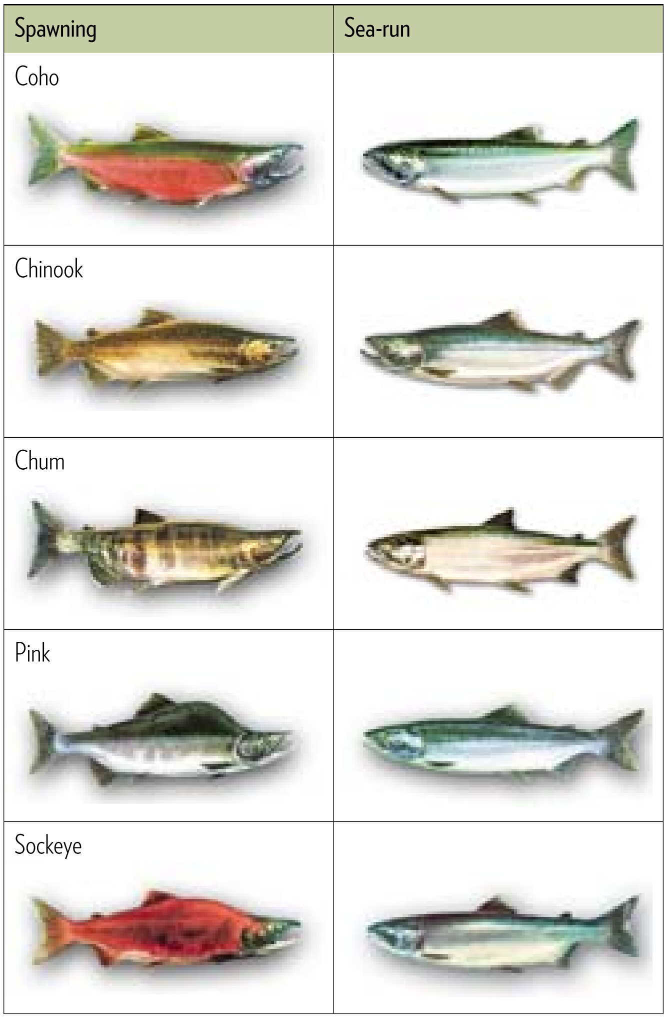
The details of salmon life history (e.g., age and size at seaward migration, age and size at maturity, timing of migration and reproduction) vary among species, years, and within and across watersheds. In Bristol Bay, essentially all salmon spawning occurs in the last half of the calendar year, when eggs are deposited and immediately fertilized in *redds* (depressions) excavated by the adult female in stream or lake substrates. The eggs incubate until mid-winter and then hatch into alevin (fry with large attached yolk sacs) (Figure 15). The alevins remain in the spawning gravels through spring to early summer of the following year, absorbing their yolk sacs, before emerging as free-swimming juveniles (fry). The length of time between spawning and fry emergence varies with species, population, and water temperature (Murray and McPhail 1988, Quinn 2004).

After emergence, chum and pink salmon migrate directly to marine waters, meaning they have short freshwater residencies (measured in days) as juvenile fry (Quinn 2004). However, almost all Bristol Bay coho, Chinook, and sockeye salmon rear in lakes and streams for a year or more before migrating to the ocean as smolts (Yuen and Nelson 1984). For juveniles of these three species, summer feeding and overwintering habitats may be in different locations, requiring migrations between seasonal freshwater habitats.

Newly hatched alevin will remain in streambed cobbles through the winter to emerge as free-swimming fry the following spring or early summer (photo by Rich Grost).

Figure 15. Salmon life cycle. Although Pacific salmon share a common life cycle, considerable variation exists across both the different species and the many unique populations that can be found within a species. (© Kate Spencer).





Salmon Species in Bristol Bay Drainages. All Bristol Bay salmon species have a noticeable change in color moving from ocean back to freshwater to spawn (© Fisheries and Oceans Canada).

<u>Sockeye Salmon (Oncorhynchus nerka)</u>

With minor exceptions in lakes where egress has become blocked (USNPS 2006), or as a very small component of an otherwise anadromous stock (Hodgson and Quinn 2002), all Bristol Bay sockeye salmon are anadromous. In Bristol Bay, adult run timing varies between drainages, but commercial harvest generally occurs from mid-June through early August, peaking in early July (Yuen et al. 1984). Between 1990 and 2009, the Bristol Bay commercial harvest averaged 25.8 million fish, which supported $114.7 million of the $116.7 million Bristol Bay commercial salmon fishery (ex-vessel value). Subsistence harvest during this same time period averaged 141,000 fish (ADFG 2011a). In total, the average production of Bristol Bay sockeye during this 20-year period was 37.49 million fish; in 2010, this number exceeded 40.1 million (ADFG 2011a).

Sockeye spawning occurs from July into January (Russell 1980, Hodgson and Quinn 2002, Woody et al. 2003). Most Bristol Bay sockeye populations spawn along the beaches of large glacially-carved lakes or in streams flowing to, or draining out of these lakes, and these lakes serve as nurseries for rearing juveniles. However, in some river systems, particularly in the Nushagak—Mulchatna drainage, sockeye salmon spawn and rear in larger, often braided, rivers (ADFG 2008b). The many large lakes in the region provide ideal sockeye salmon habitat, and sockeye are well-distributed throughout the basin, except in the slow-moving streams draining the broad coastal plain of inner Bristol Bay.

After fry emerge in the spring, most juvenile sockeye salmon rear in fresh water for one to two years. The production of juvenile sockeye salmon in Bristol Bay's large rearing lakes is phenomenal. The migration of juvenile sockeye leaving Iliamna Lake in late May and early June just after lake ice-melt has been estimated at over 200 million fish in a three-week period (Bill 1984). Sockeye live in the ocean for two to three years before returning to spawn (Yuen et al. 1984, Stratton and Cross 1990).

<u>Coho Salmon (Oncorhynchus kisutch)</u>

Bristol Bay coho salmon populations are all anadromous, with possible minor exceptions in local freshwater habitats that suddenly become inescapable. The adult coho salmon spawning return occurs later in the year than the returns of the other four Bristol Bay salmon species. The inshore commercial harvest of returning adults occurs from late July through September (Yuen et al. 1984), but the end of the harvest probably reflects the loss of fishing interest rather than the absence of fresh fish. Between 1990 and 2009, an average of 88,000 coho were commercially harvested annually (ADFG 2011a).

Spawning occurs from September through October (Russell 1980), and may continue in specific areas well into winter. Coho spawn and rear from headwater streams to moderate-sized rivers. They generally do not use the sluggish streams draining the flat coastal plain. Coho salmon eggs and alevins incubate in spawning substrates through the winter, and fry emerge in spring to early summer. After they emerge, juvenile Bristol Bay coho salmon typically rear in fresh water for one to three years before migrating to sea, and different juvenile age classes may occupy different microhabitats (ADFG 2008b). Bristol Bay coho salmon fry rear in diverse habitats ranging from spring-fed headwater springs, to beaver ponds, to side-channels and sloughs of large rivers. In surveyed regions of Bristol Bay, coho salmon are documented throughout the Nushagak-Mulchatna watershed, and the Kvichak watershed (Woody and O'Neal 2010, ADFG 2011b). Most

Bristol Bay coho salmon spend slightly more than one year feeding in the ocean before returning to spawn (Yuen et al. 1984, Stratton and Cross 1990, Edwards and Larson 2003).

Chinook Salmon (Oncorhynchus tshawytscha)

Bristol Bay Chinook salmon populations are anadromous, with minor exceptions where local habitats become inescapable (Nelle 2002). In Bristol Bay, Chinook are the first salmon to return each year to spawn. Commercial harvest of the run occurs from late May through early August, peaking in June (Yuen et al. 1984). The commercial Chinook harvest throughout Bristol Bay between 1990 and 2009 averaged 64,000 fish. The vast majority of these were produced in the Nushagak watershed with an average of 53,000 fish harvested in the Nushagak District (ADFG 2011a).

Most Chinook spawning occurs from late July through early September (ADFG 2008b). Chinook spawn and rear from high in stream networks to large-sized mainstem rivers. They generally do not use streams draining the flat coastal plain. After fry emerge from spawning gravels in the spring, most rear in fresh water for one year before migrating to the ocean where they feed for two to five years before returning to spawn (Yuen et al. 1984, Stratton and Cross 1990). Within their general range, juveniles typically seek areas immediately adjacent to cut banks and next to faster flowing water. Chinook salmon occur throughout the Nushagak—Mulchatna drainage, but are seldom encountered in the Lake Clark portion of the Kvichak River drainage.

Chum Salmon (Oncorhynchus keta)

All Bristol Bay chum salmon populations are anadromous. In Bristol Bay, adult run timing varies between drainages, but commercial chum salmon harvest generally occurs from mid-June through August, peaking in late July and early August (Yuen et al. 1984). The commercial chum harvest over the 20-year period from 1990 through 2009 numbered 986,530 fish (ADFG 2011a). Spawning occurs from July into September in moderate-sized streams and rivers (ADFG 2008b).

After fry emerge from spawning gravels in spring, juvenile chum salmon migrate immediately to marine waters; they have no extended fresh water rearing period. Most Bristol Bay chum salmon feed three to four years in the ocean before returning to spawn (Yuen et al. 1984, Stratton and Cross 1990). Chum salmon occur throughout Bristol Bay, but are seldom encountered in the Lake Clark portion of the Kvichak River drainage or in the slow-moving streams draining the broad, flat coastal plain.

Pink salmon (photo by Barrie Kovish).

Pink Salmon (Oncorhynchus gorbuscha)

All Bristol Bay pink salmon populations are anadromous. In Bristol Bay, adult run timing varies between drainages, but commercial pink salmon harvest generally occurs from mid-July through mid-August (Yuen et al. 1984), and spawning occurs from July into September (ADFG 2008b). Among the five salmon species of Bristol Bay, pink salmon have the most limited freshwater distribution. They spawn in relatively few moderate-sized streams and rivers. Because juveniles migrate to the ocean immediately after emergence, they have no extended freshwater rearing period and do not use freshwater rearing habitat.

All Bristol Bay pink salmon feed a little more than a year in the ocean before returning to spawn. This unwavering life history pattern of no fresh water residency and only one year of ocean feeding produces a strong biannual run cycle. In Bristol Bay, strong returns of pink salmon occur in even years and essentially no pink salmon return in odd years (Yuen et al. 1984). Commercial interest in pink salmon has been relatively small with an average of only 182,000 fish harvested every other year. A significant market in the Nushagak District in 2010 increased the commercial harvest of pink salmon to 1.3 million fish (ADFG 2011a).

Pink salmon are infrequently encountered far up the major drainages. While they are mapped high in the Nushagak and Mulchatna Rivers, they are not frequently observed in these areas (ADFG 2008b). In the Kvichak system, the Alagnak River is the species' most important spawning stream (Yuen et al. 1984). In the Nushagak-Mulchatna drainage, the Nuyakuk and Tikchik Rivers provide most of the pink salmon spawning habitat (Nelson 1965).

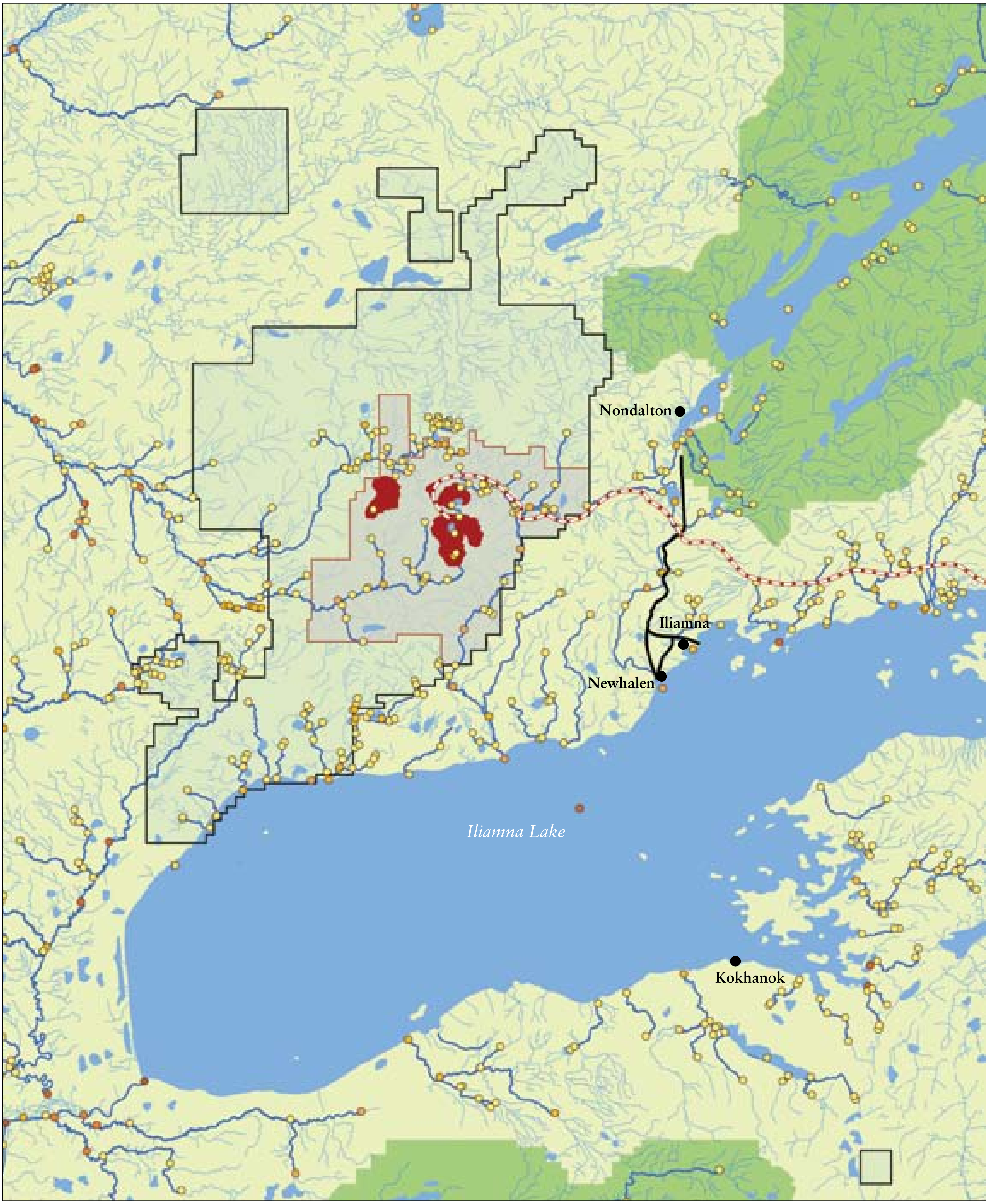

Nondalton
Iliamna
Newhalen
Iliamna Lake
Kokhanok

Figure 16. Anadromous Fish Catalog Surveys* Superimposed on Proposed Pebble Mine, Mining District, and Facilities (Woody 2009, Woody and O'Neal 2010, Ghaffari et al. 2011).

KEY

- Mining District Claims
- Pebble Mine Claim
- Pebble Mine Footprint
- Proposed Mining Road and Pipeline Route
- Existing Roads
- National Park
- Anadromous Catalog Streams
- Other Streams

*Species documented include sockeye, pink, chum, coho, Chinook, steelhead, and Dolly Varden.

Salmonid species documented per stretch of body of water*

6, 5, 4, 3, 2, 1

ANADROMOUS WATERS CATALOG

The Anadromous Fish Act (ALASKA STAT. §16.05.871) mandates that the ADFG Commissioner specify the "various... streams or parts of them that are important for the spawning, rearing, or migration of anadromous fish." However, only about half of the "waters" in Alaska that are important for anadromous fish are identified in the Anadromous Waters Catalog (AWC) (Buckwalter 2009). This is largely due to the fact that they have never been surveyed due to their remoteness, and in addition the statutory standards are vague and without statutory definition as to when, how, and under what circumstances the commissioner may make this designation (Parker et al. 2008).

In August 2008, over a period of just one week, a team of independent fishery biologists conducted salmon surveys in 37 water bodies within and adjacent to the mine permit boundary and found salmon in 20 streams, resulting in the nomination of 28 miles of additional salmon-bearing streams to the AWC (Woody 2009). In subsequent surveys conducted in 2009 and 2010, an additional 76 miles were documented (Woody and O'Neal 2010). Once a stream is added to the AWC, the commissioner of ADFG can require a developer whose plans will affect the designated waters to provide complete "specifications for the proper protection of fish... in connection with the construction or work, or in connection with the use." If such plans are deemed "insufficient for the protection of fish," the commissioner can deny approval.

The proposed road and pipelines from the Pebble Mine site to the deepwater port in Cook Inlet would cross approximately 89 creeks and rivers with permanent flows, 14 of which have already been designated as "anadromous waters" under the Catalog of Waters Important for the Spawning, Rearing or Migration of Anadromous Fish (Ecology and Environment, Inc. 2010). Many of these streams provide spawning and rearing habitat for one or more of the five Alaskan salmon species plus highly valued species such as rainbow trout, Dolly Varden, and arctic grayling. To meet the intent of the Anadromous Fish Act, increased monitoring is required to determine the full distribution of populations within this region and to ensure their conservation.

Since 2008, biologists have been surveying streams within and adjacent to the Pebble Mine boundary to determine the presence or absence of anadromous fish (photo by Steve Baird).