



Canada's Species at Risk Act: An Opportunity to Protect "Endangered" Salmon

endangered species
feature

ABSTRACT

Canadian salmon are now eligible for protection under a federal Species at Risk Act proclaimed in June 2003 and fully implemented in June 2004. The act has four major steps dealing with species at risk of extinction: (1) an independent scientific committee assesses biological status and designates those at risk, (2) Federal Cabinet decides, following consideration of socioeconomic implications, which species to add to the legal list of species at risk, (3) legal protection, and (4) recovery planning and implementation. The committee has designated five distinct populations of salmon as endangered—one Atlantic salmon (*Salmo salar*), one coho salmon (*Oncorhynchus kisutch*), two sockeye salmon (*O. nerka*), and one Chinook salmon (*O. tshawytscha*). Only the Atlantic salmon is currently listed under the act; Cabinet decided not to list the two sockeye after considering socioeconomic implications and decisions on listing coho and Chinook are pending socioeconomic assessment. Both the Species at Risk Act in Canada and the Endangered Species Act in the United States use multiple criteria to assess the status of units that may be below the taxonomic species level. The Canadian act, in contrast to the act in the United States, mandates a non-governmental committee to assess status, separates biology from socioeconomics in the listing process, does not consider socioeconomic consequences when identifying critical habitat, and has specific timetables for the completion of recovery plans. Canadian salmon managers must now consider the effects of fisheries on salmon diversity, resulting in changes to the way fisheries are managed. The enactment of the act has introduced a new process for protecting salmon diversity in Canada, and its continued development and application will provide an interesting contrast to salmon conservation efforts in the United States.

Introduction

In June 2003, Canada's new Species at Risk Act (SARA) came into force, and the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) was given the legal mandate for scientific assessment of *species* (these and other key terms from SARA are italicized in the text and defined in Text Box 1) at risk of extinction. To date, COSEWIC has identified five Canadian salmon populations as *endangered*, and one is now legally protected under SARA. The purpose of this article is to inform the fisheries community about SARA, COSEWIC, the process whereby the salmon populations were listed, and the implications for protection of salmon diversity in Canada.

History of SARA, COSEWIC, and Salmon Listings

The road to SARA and listing of salmon has been a long one (Table 1). In 1992, Canada ratified the International Convention on Biological Diversity (Rio Accord) that obligates signatories to protect biodiversity. In 1996 the Canadian Parliament discussed an Endangered Species Protection Act but this was abandoned the following year when an election was called. In 2000, Parliament considered a Species at Risk Act (SARA), but this too was abandoned when an election was called. SARA was re-introduced in

modified form in 2001, passed in 2002, proclaimed in June 2003, and fully implemented in June 2004.

The purposes of SARA are "to prevent *wildlife species* from being *extirpated* or becoming extinct, to provide for the recovery of wildlife species that are extirpated, endangered or *threatened* as a result of human activity and to manage *species of special concern* to prevent them from becoming endangered or threatened" (CSAR 2004b, Section 2.[1]). Wildlife species include fish.

COSEWIC has operated since 1977, producing its first list of Canadian species at risk in 1978. COSEWIC was originally formed by provincial and federal government agreement on the need to provide a national perspective on the state of wildlife, and COSEWIC was later designated in SARA as the responsible committee to assess and recommend to the federal government species for legal listing.

Salmon were not assessed by COSEWIC until May 2001 when the inner Bay of Fundy (iBoF) Atlantic salmon (*Salmo salar*) population from Nova Scotia and New Brunswick was designated as endangered. Interior Fraser coho (*Oncorhynchus kisutch*) became the first Pacific salmon to be designated by COSEWIC as endangered (May 2002), and two other Pacific salmon, Sakinaw sockeye (*O. nerka*) and Cultus sockeye in British Columbia, were designated endangered by COSEWIC emergency assessment in November 2002 and by COSEWIC ratification in May 2003. (Following an emergency assessment in

James R. Irvine
Mart R. Gross
Chris C. Wood
L. Blair Holtby
Neil D. Schubert
Peter G. Amiro

Irvine, Wood, and Holtby are research scientists with the Canadian Department of Fisheries and Oceans (DFO) at the Pacific Biological Station in Nanaimo, British Columbia (BC). Irvine can be reached at irvinej@pac.dfo-mpo.gc.ca. Gross is professor of conservation biology and fisheries at the University of Toronto, Ontario, and co-chair of the Marine Fishes Subcommittee on the Committee on the Status of Endangered Wildlife in Canada (COSEWIC). Schubert is chief of DFO Stock Assessment for the Lower Fraser area and is based in Delta, BC. Amiro is a salmon assessment biologist with DFO in Dartmouth, Nova Scotia.

May 2005, Chinook salmon *O. tshawytscha* from the Okanagan region of British Columbia became the fifth salmon to be designated as endangered by COSEWIC; Okanagan Chinook are not considered further in this article.) In June 2003, when SARA was proclaimed, iBoF Atlantic salmon was automatically on the SARA list (Schedule 1) along with other species assessed earlier by COSEWIC. But in January 2005, the Federal Cabinet decided not to include Sakinaw sockeye and Cultus sockeye on the SARA list; Cabinet's decision on the Interior Fraser coho is not yet made.

A Primer on COSEWIC and SARA for Salmon

SARA has four major steps for dealing with salmon at risk: (1) the COSEWIC list—species assessed for biological risk and designated a status by COSEWIC, (2) the SARA (legal) list—species from the COSEWIC list that are designated by the Federal Cabinet, usually after socioeconomic consideration, (3) protection under the law, and (4) recovery planning and implementation.

Table 1. Chronology of significant events in the development of endangered species legislation in Canada and for the first listings of salmon by COSEWIC and the federal government (from Government of Canada 2004b unless otherwise indicated).

Date	Event
1975	Canada is 10th country (164 countries currently belong) to join the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES 2004).
1976	Conference of Federal-Provincial-Territorial Wildlife Directors recommends formation of COSEWIC.
1977	COSEWIC created.
1992	Canada is the first western nation to ratify the International Convention on Biological Diversity (www.biodiv.org/world/parties.asp), a commitment to "develop or maintain necessary legislation and/or other regulatory provisions for the protection of threatened species and populations" (Article 8, Convention on Biological Diversity, www.biodiv.org/convention/articles.asp).
1995	Public workshops to discuss the protection of species at risk.
1996	Accord for the Protection of Species at Risk accepted. Provincial, territorial, and federal ministers agree to develop laws and programs to protect species at risk and their habitat.
1996/1997	Canada Endangered Species Protection Act (Bill C-65) introduced/abandoned.
1999	COSEWIC updates assessment criteria based on those developed by the International Union for the Conservation of Nature (IUCN).
2000	Species at Risk Act (Bill C-33) introduced/abandoned.
2001	Species at Risk Act (SARA, Bill C-5) introduced. COSEWIC lists the Inner Bay of Fundy Atlantic salmon as endangered.
2002	SARA approved; COSEWIC lists Interior Fraser coho salmon as endangered.
2003	SARA proclaimed; two-thirds of its sections come into effect. iBoF Atlantic salmon included on SARA list (i.e., Appendix 1, legally listed). COSEWIC lists Cultus Lake and Sakinaw Lake sockeye as endangered.
2004	SARA fully in effect; legal listings trigger automatic prohibitions against harming individuals or their residences and the destruction of critical habitat.
2005	Government announces decision not to legally list Sakinaw and Cultus sockeye because of social and economic costs for the commercial and recreational fishing sectors, and some Aboriginal peoples and coastal communities (January). COSEWIC lists Okanagan Chinook as endangered (May). Canada-British Columbia Agreement on Species at Risk signed. Legal listing recommendation on interior Fraser coho expected in December.

Box 1. Important terminology from SARA (CSAR 2004b, Subsection 2.[1]).

<p>Critical habitat: the habitat that is necessary for the survival or recovery of a listed wildlife species and that is identified as the species' critical habitat in the recovery strategy or in an action plan for the species.</p> <p>Endangered species: a wildlife species that is facing imminent extirpation or extinction.</p> <p>Extirpated species: a wildlife species that no longer exists in the wild in Canada, but exists elsewhere in the wild.</p> <p>Residence: a dwelling-place, such as a den, nest, or other similar area or place, that is occupied or habitually occupied by one or more individuals during all or part of their life cycles, including breeding, rearing, staging, wintering, feeding, or hibernating.</p> <p>Species at risk: an extirpated, endangered, or threatened species or a species of special concern.</p> <p>Species of special concern: a wildlife species that may become a threatened or an endangered species because of a combination of biological characteristics and identified threats.</p> <p>Threatened species: a wildlife species that is likely to become an endangered species if nothing is done to reverse the factors leading to its extirpation or extinction.</p> <p>Wildlife species: a species, subspecies, variety, or geographically or genetically distinct population of animal, plant, or other organism, other than a bacterium or virus, that is wild by nature and (a) is native to Canada; or (b) has extended its range into Canada without human intervention and has been present in Canada for at least 50 years.</p>

COSEWIC

COSEWIC is a scientific body largely independent from government that is responsible for identifying and prioritizing candidate species at risk of extinction, assessing status, and making status reports and other information available to the public (www.cosewic.gc.ca/). It recommends the status of species at risk to the federal Minister of the Environment and to the joint provincial and federal Conservation Council (Government of Canada 2004a). The voting membership on COSEWIC is appointed by the Minister of the Environment, and consists of a representative from each provincial and territorial government wildlife agency, three federal agencies (Parks Canada, Canadian Wildlife Service, and Fisheries and Oceans Canada [DFO]), the National Biosystematics Partnership, three non-jurisdictional representatives, the co-chairs for the Aboriginal Traditional Knowledge Subcommittee, and the co-chairs for the Species Specialist Subcommittees that deal with the taxonomic groups.

Salmon are the responsibility of the two co-chairs of the Marine Fishes Subcommittee. This subcommittee consists of 12 marine fish experts from North America who volunteer to assist with the identification of marine fish at risk, preparation of status reports, assessment, and status recommendation. Drawing on numerous sources of information, the subcommittee determines which salmon (and other marine species) may be most at risk and are therefore candidates for the preparation of a COSEWIC status report. Priority candidate lists are updated as needed and publicly available on the COSEWIC web site (www.cosewic.gc.ca/eng/sct3/index_e.cfm). There is an annual call for proposals to prepare status reports and knowledgeable contractors are selected through a competitive process. Species previously determined to be at risk must be re-assessed at least every 10 years. The subcommittee may also consider unsolicited status reports if these contain valuable assessment information. Status reports go through an extensive review process and the penultimate draft is used by the subcommittee to determine the species' preliminary status. The co-chairs bring the recommendations of the subcommittee to COSEWIC and help lead the discussion that results in a designation.

To deal with wildlife species below the taxonomic species level, COSEWIC identifies Designatable Units (DU) based on (1) established taxonomy (e.g., subspecies, varieties in taxonomic references), (2) genetic distinction, (3) range disjunction (geographic isolation), or (4) biogeographic distinction (e.g., ecoregions). All of the salmon listed by COSEWIC are at the DU level, and this is the most likely direction for future assessment and designation of endangered salmon biodiversity.

COSEWIC uses World Conservation Union criteria (IUCN 2001; Gärdenfors et al. 2001) as guidelines when assessing risks of extinction (see Box 2). The criteria are not prescriptive, but provide a means for focusing on important elements in biological risk. The most frequently used criterion for salmon may be the rate of decline, but in small populations it may also be the number of individuals. The endangered risk category of COSEWIC corresponds to the critically endangered and endangered IUCN categories, and the threatened COSEWIC category corresponds to the IUCN vulnerable category.

In an emergency, COSEWIC can recommend to the Minister of the Environment that the species be protected under SARA even when the COSEWIC status report has not been completed (the report must be completed within one year). The Minister of the Environment may then choose to protect the species under SARA regulations without first seeking Federal Cabinet approval. Sakinaw sockeye and Cultus sockeye were both assessed as emergency cases.

SARA

Species are generally not protected under SARA until they are added by Federal Cabinet decision to the List of Wildlife Species at Risk in Schedule 1 (i.e., SARA or legal list). Within 90 days of receiving the annual recommendations from COSEWIC, the Minister of the Environment is required to publish a response statement on the Species at Risk Public Registry (www.sararegistry.gc.ca/). The Minister is also required to forward COSEWIC assessments to the Governor in Council (i.e., Federal Cabinet) along with recommendations for listing, but SARA does not specify a timeline, and delays can occur. Cabinet will not consider listing a species until the Minister of the Environment recommends it. The Minister of the Environment is also entitled to consider the social and economic benefits and costs of any regulatory changes that would be necessitated by listing, and to consult with affected parties. For aquatic species including salmon, the Minister of DFO advises the Minister of the Environment. The three salmon species that have been designated by COSEWIC since the passing of SARA, including the emergency assessed species, have faced delays of more than a year before the Minister of the Environment made his recommendation to Cabinet.

Following the Minister's recommendation, Cabinet has 9 months to either refer the matter back to COSEWIC for reassessment, or accept or modify the Minister's recommendation and accordingly amend the SARA list. If Cabinet takes no action within 9 months, the Minister of the Environment must, by order, amend the SARA list in accordance with COSEWIC's recommendation. The addition of a species to the list obligates the government of Canada to begin various measures for the protection and recovery of the species.

Box 2. COSEWIC endangered status designation criteria.

IUCN criteria modified by COSEWIC to aid in determining risk are found at: www.cosewic.gc.ca/eng/sct0/Assessment_process_tbl2_e.cfm. A DU is likely to be considered endangered if it has:

- (a) a declining total population size (by >70 % in the past 10 years or 3 generations, whichever is longer, where the causes of the reduction are clearly reversible and understood and ceased, or by >50 % in the recent past or projected future where the reduction or its causes may not have ceased or may not be understood or may not be reversible);
- (b) a small distribution (< 5,000 km² extent of occurrence or <500 km² area of occupancy) with declining or fluctuating abundance;
- (c) a small declining population size (<2,500 mature individuals);
- (d) a very small population (<250) or restricted distribution; or
- (e) a probability of extinction in the wild >20% in 20 years or 5 generations, whichever is longer.

Protection

Section 32 of SARA (CSAR 2004b) makes it illegal to kill, harm, harass, capture, or take an individual of a species that is listed in Schedule 1 of SARA as extirpated, endangered, or threatened (but see exceptions in Box 3). It is also illegal to damage or destroy their *critical habitat* or *residence*. Critical habitat is habitat that is necessary for the survival or recovery of the species, whereas a residence is a specific site that an individual returns to during its life cycle. SARA applies on federal lands, most freshwater habitats, and the oceans. Under the 1996 Accord on the Protection of Endangered Species, provincial and territorial governments are expected to protect legally listed species outside of federal lands, but if this does not take place, the Federal Cabinet on the recommendation of the Minister of the Environment can order that certain prohibitions will apply (termed the “Safety Net”). In 2005, the federal government signed an agreement with its provincial counterpart in British Columbia to coordinate and focus approaches to the delivery of species at risk protection and recovery through legislation, policies, and operational procedures.

In a sense, the protection of critical habitat for fishes in Canada is redundant. Fish habitat, defined as “spawning grounds and nursery, rearing, food supply and migration areas on which fish depend directly or indirectly to carry out their life processes,” which includes critical habitat, is already protected by Sections 35 to 43 of the Fisheries Act (CSAR 2004a).

Recovery

Recovery plans, consisting of a “recovery strategy” and an “action plan” are required within 1 year for SARA species listed as endangered (see Box 4). A recovery strategy is required even if survival is

thought not to be feasible, in which case it must include reasons why recovery is not feasible. Recovery strategies are to be updated every 5 years until the species is considered recovered. The Minister of DFO posts the recovery plans for fishes on the Species at Risk Public Registry. The recovery plan for the iBoF salmon is due in 2006, but DFO has been proactive in forming multi-stakeholder recovery teams and the iBoF Atlantic Salmon Team has already released its draft recovery strategy (DFO 2004a). Recovery strategies for interior Fraser coho, Sakinaw sockeye, and Cultus sockeye have also been drafted, even though these salmon are not on the SARA list.

Comparison to the US Endangered Species Act (ESA)

SARA was established 30 years after ESA, and there are important differences in how the two deal with salmon. Multiple criteria are used by both SARA and ESA in scientific assessments of the biological risk of extinction. SARA mandates a non-governmental scientific group (COSEWIC) to conduct the biological assessments of risk, without considering the regulatory or socioeconomic impacts. By contrast, ESA relies on a government agency (NOAA for salmon) that must also later deal with the implications of the listing. The independent assessment and two-step process of SARA that clearly separates biology from socioeconomic consequences could conceivably result in more species being “considered” for Canadian listing. Canada has two lists—the COSEWIC biological status list and the SARA legal list that may also consider socioeconomic consequences of listing—and some species may not receive legal protection even though they are biologically at risk. By contrast, the single-step process of ESA provides protection for all listed species. SARA does not specify a timeline for the Minister's recommendation to Cabinet of species at risk so delays can occur; ESA prescribes a timeline for

Box 3. Exceptions to prohibitions.

SARA allows potentially harmful activities to continue if:

- “(a) the activity is scientific research relating to the conservation of the species and conducted by qualified persons;
- (b) the activity benefits the species or is required to enhance its chance of survival in the wild; or
- (c) affecting the species is incidental to the carrying out of the activity.” (CSAR 2004b, Subsection 73[2]).

The third precondition, which allows incidental harm, will probably receive the greatest scrutiny because it can allow fisheries to continue. To be permitted however,

- “(a) all reasonable alternatives to the activity that would reduce the impact on the species have been considered and the best solution has been adopted,
- (b) all feasible measures will be taken to minimize the impact of the activity on the species or its critical habitat or the residences of its individuals, and
- (c) the activity will not jeopardize the survival or recovery of the species” (CSAR 2004b, Subsection 73[3]). In addition, Subsection 83(4) allows activities permitted by a recovery strategy, an action plan, or a management plan to be exempted from various prohibitions.”

A framework has been developed to document procedures to be used to determine under what conditions permits provided for in Section 73 can be issued (DFO 2004b). For activities to be permitted under Section 73, this framework states it is necessary and sufficient to demonstrate that the activity will not leave the DU under worse conditions at the end of the permitting period than it was at the start.

Box 4. Recovery strategies and action plans.

SARA-listed species require **recovery strategies** and **action plans**.

Recovery strategies will “identify the threats to the survival of the species and threats to its habitat and a description of the strategy to be taken to address those threats; describe the species' critical habitat, to the extent possible, and provide examples of activities that are likely to result in its destruction; and include a schedule of studies to identify critical habitat, where available information is inadequate, as well as a statement of the population and distribution objectives that will assist the recovery and survival of the species, and a general description of the research and management activities needed to meet those objectives” (CSAR 2004b, Subsection 41[1]). Stewardship incentives are to aid in recovery.

Action plans are “measures to implement the recovery strategy, including those that address the threats to the species and those that help to achieve the abundance and distribution objectives, as well as an indication as to when these measures are to take place; the methods to be used to monitor the recovery of the species and its long-term viability; activities that are likely to result in the destruction of a species' critical habitat; measures to preserve critical habitat; and an evaluation of the socioeconomic costs of the action plan and the benefits to be derived from its implementation” (CSAR 2004b, Subsection 41[1]).

receiving petitions for listing and NOAA taking actions to make scientific recommendations and final status decisions. In both SARA and ESA, socioeconomic impacts are considered in developing recovery plans. Both SARA and ESA provide for the protection of critical habitat, but in the United States, critical habitat designations must consider economic and other relevant impacts of such designations, and areas may be excluded from critical habitat if the costs outweigh the benefits of specifying such areas as part of the critical habitat.

Recovery teams in both countries are having difficulty applying the critical habitat concept to salmon. For example, in the United States, habitats that had been identified as critical for 19 salmon and steelhead Evolutionarily Significant Units (ESUs) in Washington, Oregon, Idaho, and California were withdrawn in 2002 and a revised list was released by NOAA Fisheries in August 2005 (NOAA Fisheries 2005). In Canada, critical habitat has not yet been designated for any salmon, although draft recovery plans identify proposed critical habitat. In contrast to SARA, there is no mandated timetable for ESA recovery plans and developing these has sometimes dragged on for many years. Under SARA, there is no provision for public comment or review of the incidental harm permitting process, unlike ESA. Finally, both SARA and ESA allow protection of salmon at the population level, however, COSEWIC requires only that they are genetically or geographically distinct (the DU), while the ESA requires a demonstration that a population is both distinct and “evolutionarily significant” (the ESU). Thus, a population may qualify as a DU but not as an ESU because of the latter’s emphasis on evolutionary heritage (Ford 2004). It is too early in the history of SARA to know whether it will be a more effective tool than ESA in preventing species extinctions. Amendments to SARA have already been suggested to deal with perceived weaknesses and loopholes (Vanderzwaag and Hutchings 2005).

COSEWIC Listed Salmon

Inner Bay of Fundy (iBoF) Atlantic salmon

Amiro submitted an unsolicited status report on iBoF Atlantic salmon in 1999 (Figure 1, Amiro 2003). The iBoF salmon was identified by COSEWIC as an acceptable unit for listing, and designated by COSEWIC in May 2001 as endangered. Provisional genetic data, including mitochondrial haplotypes, suggest that the iBoF Atlantic salmon is likely genetically distinct from all other Atlantic salmon populations (Table 2). Verspoor et al. (2002) suggest that a lineage of Atlantic salmon re-colonized this area post-glacially ~18,000 years ago. Initial colonists may have come from refugial populations on the now submerged George’s Bank, opposite the mouth of the Bay of Fundy, rather than from isolated and more distant refugial populations in non-glacial rivers south of modern day New York.

iBoF salmon once spawned in at least 32 rivers northeast of the Saint John River in New Brunswick and the Annapolis River in Nova Scotia (Figure 1). The number of returning adults perhaps averaged over 40,000, but by 1999 was likely less than 500. The mean 4-year (one generation) smoothed trend for the 2 largest residual populations, the Stewiacke River in Nova Scotia and the Big Salmon River in New Brunswick, indicated a 97% decline over 3 generations (Figure 2a), well in excess of IUCN guidelines for endangered status (see Text Box 2). These data (up to 1999), as well as abundance estimates for juvenile salmon from 8 iBoF rivers and catch data that were consistent with the observed declines in escapement (Amiro 2003), resulted in the endangered designation.

Declines in iBoF salmon appear to be primarily the result of reduced marine survival; recent marine survivals of 0.1% to 1.0% are below that required for maintenance of the DU (Amiro 2003).

The causes of declining marine survivals are not clear. Known impacts to the freshwater environment include forestry, farming, dams, and urban and industrial development, perhaps leading to a chronic loss in freshwater productivity. COSEWIC concluded that the threats to the DU included habitat alteration by forestry and agricultural practices, damming of rivers and estuaries, bycatch in shad and herring fisheries, impacts from farmed Atlantic salmon, and illegal fishing. Although salmon harvest in the Bay of Fundy was legislatively eliminated in 1985 for commercial fisheries and in 1990 for recreational fisheries, there is no evidence of recovery (Figure 2a).

Figure 1. Location of Atlantic salmon rivers in the inner Bay of Fundy (shaded region) in eastern Canada whose Atlantic salmon were designated by COSEWIC as endangered.

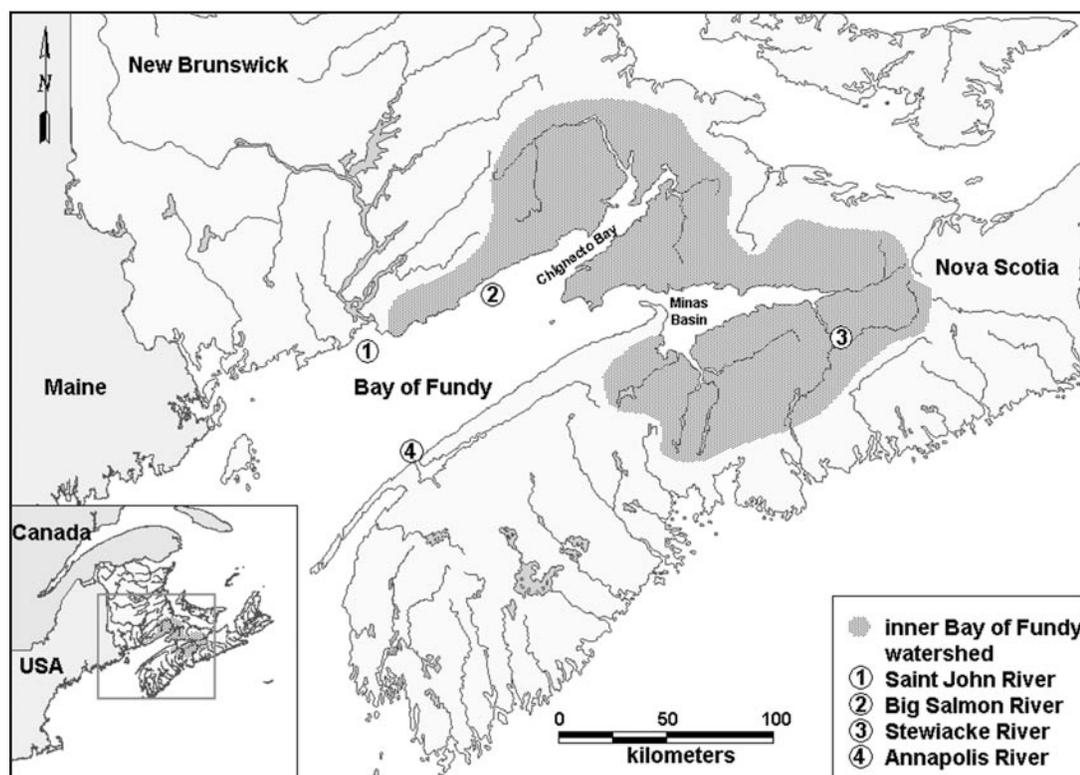


Table 2. Summary characteristics of four Canadian salmon populations listed by COSEWIC.

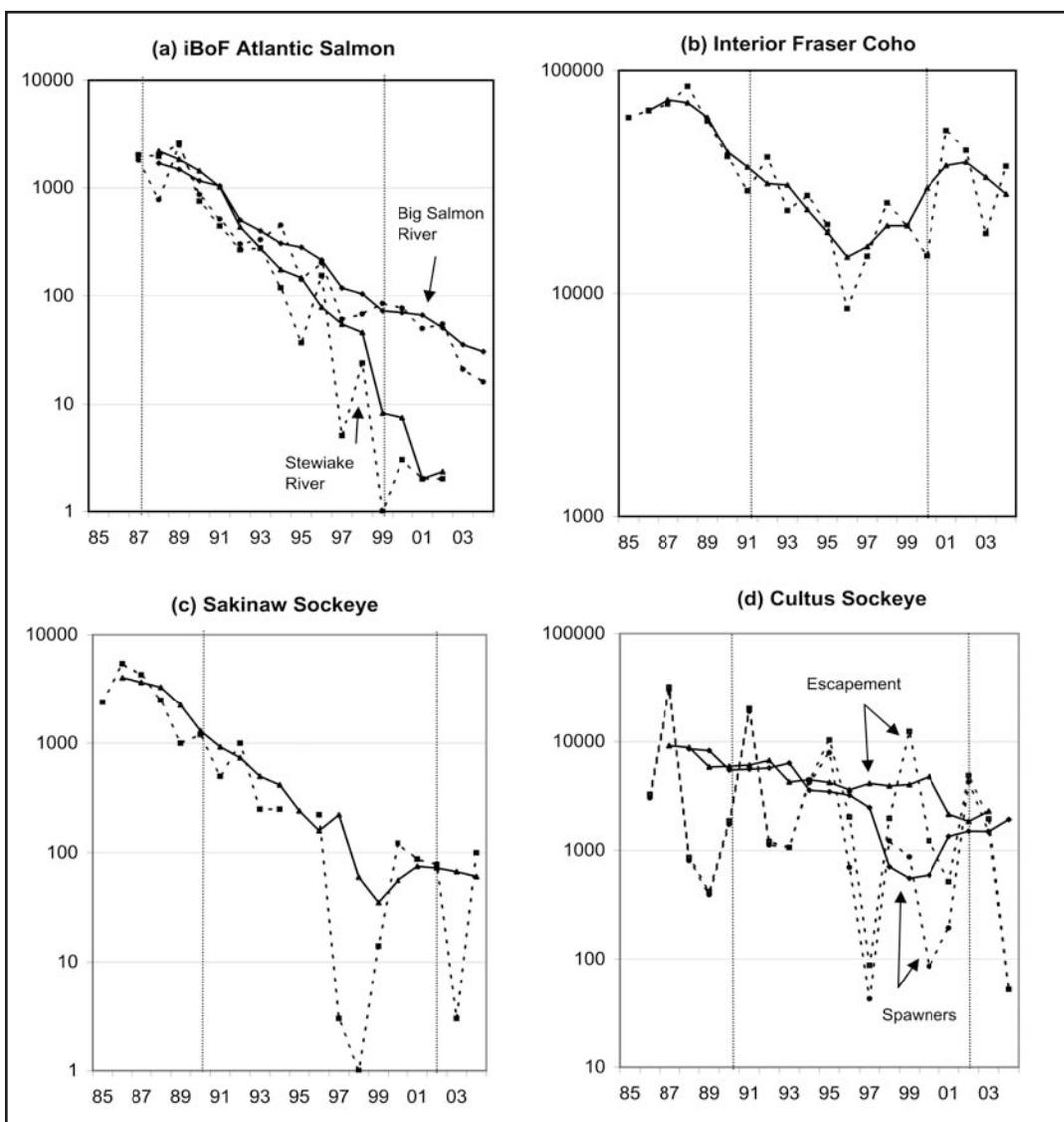
	Inner Bay of Fundy Atlantic salmon	Interior Fraser Coho	Sakinaw Sockeye	Cultus Sockeye
Escapement maxima	40,000	100,000–200,000	16,000	82,000
2004 escapement	<100	~38,000	100	52
Freshwater extent of occurrence (km ²)	~13,000	~140,000	6.9	6.3
Number of extant locations	~32 spawning streams	>75 spawning streams	1 (Sakinaw Lake)	1 (Cultus Lake)
Genetic distinctiveness (reproductive isolation)	Matrilineal phylogenetic divergence	Microsatellite and MHC data	Micro and mitochondrial DNA and allozyme data	Microsatellite and MHC data
Geographic distinctiveness (local adaptation)	Limited freshwater and marine distribution, early age at maturity and high survival between spawnings	Significant proportion of historical range within Canada, jacks rare	Unusual nursery lake, early and protracted adult run timing, adults small, low fecundity, large smolts	Migratory delays, protracted lake residence of spawners, spawning in lake, offshore movement of fry
COSEWIC 3 generation decline rate	97% (1987–1999)	~60% (1990–2000)	98% (1990–2002)	93% (1990–2002)
Major reasons for decline	Marine survival low but reasons not understood	Overfishing, changing marine conditions, freshwater habitat degradation	Overfishing, freshwater habitat degradation	Overfishing, recruitment failure, high pre-spawning mortality, depensation in freshwater

Figure 2. Time series' of escapement estimates for: (a) iBoF Atlantic salmon (2 index rivers), (b) interior Fraser coho (all streams combined), (c) Sakinaw sockeye, and (d) Cultus sockeye.

Annual escapement estimates and 1-generation smoothed escapement estimates for (a) Stewiacke River Atlantic salmon, (b) interior Fraser coho, (c) Sakinaw sockeye, and (d) Cultus sockeye are represented by squares connected by dashed lines and triangles connected by solid lines respectively.

Annual escapement estimates and 1-generation smoothed estimates for (a) Big Salmon River escapements and (d) Cultus sockeye spawners (i.e., escapement minus known pre-spawning mortalities) are represented by circles connected by dashed lines and triangles connected by solid lines respectively.

Vertical dashed lines represent periods for which COSEWIC 3 generation decline rates were computed.



The iBoF Recovery Team was formed in 2000 and comprises government employees as well as interested stakeholders and aboriginal peoples from the inner Bay of Fundy area. The short-term goal of the Recovery Strategy is to re-establish wild self-sustaining populations to preserve the remaining genetic diversity of the lineage of iBoF salmon, while the long-term goal is to re-establish wild iBoF salmon populations in all rivers and streams that produced salmon historically. Tagging and tracking of iBoF smolts has been ongoing since 1999 to measure abundance of the population, and try to identify the reasons and mitigate for poor marine survival. To prevent extinction, a gene-banking program was started and captive breeding programs initiated to produce broodstock (DFO 2004a). The status of iBoF Atlantic salmon is under current review.

Interior Fraser River Coho Salmon

Irvine submitted a solicited status report on the coho salmon of the interior Fraser River in 2001 (Figure 3, Irvine 2002). Interior Fraser coho were assessed by COSEWIC as an acceptable unit for listing, and designated in May 2002 as endangered (COSEWIC 2002). Coho from the interior Fraser River watershed, upstream of Hell's Gate, constitute a DU since they are genetically differentiated and substantially reproductively isolated from all other coho salmon (Table 2). These coho are believed to have originated from populations that survived glaciation in a Columbia River refuge. Since coho are now extinct in the upper Columbia, interior Fraser coho are distinct from all other coho salmon. Genetic data, including microsatellite loci and two major histocompatibility complex exons suggest that the interior Fraser coho unit is structured into five populations (North Thompson, South Thompson, lower Thompson/Nicola, Fraser Canyon, and upper Fraser; Irvine 2002).

Status was inferred chiefly from an analysis of trends in the estimated abundance of spawners. The longest time series of reliable abundance estimates was 25 years duration for coho from the North and South Thompson drainages. The mean 3-year (one generation) smoothed trend for North and South Thompson coho indicated a decline of ~60% over 3 generations (Figure 2b), within IUCN's endangered status criteria range. There were four years (1991, 1995, 1997, and 1998) when some populations may not have been able to replace themselves, even if fishing mortality had been zero.

COSEWIC (2002) concluded that interior Fraser River coho salmon are a unit of coho salmon biodiversity that declined by >60% in numbers of individuals due to changes in freshwater and marine habitats, overexploitation, and impacts relating to hatcheries. COSEWIC was concerned that reductions in fishing mortality that were begun by DFO in 1997 were insufficient or would not be maintained long enough to insure recovery, that marine survivorship might not improve, that habitat loss or deterioration in the watershed would continue, and that use of hatcheries threatened recovery. Interior Fraser coho appear to have responded positively to fishery closures, although escapements remain lower than they were historically (Figure 2b).

The goal of the draft recovery report is to secure the long-term viability of naturally spawning coho salmon within the interior Fraser River watershed. In the short term, this goal will be considered to have been achieved if there are one or more viable sub-populations (>1,000 naturally spawning coho salmon annually, excluding hatchery fish spawning in the wild) in each of the five populations.

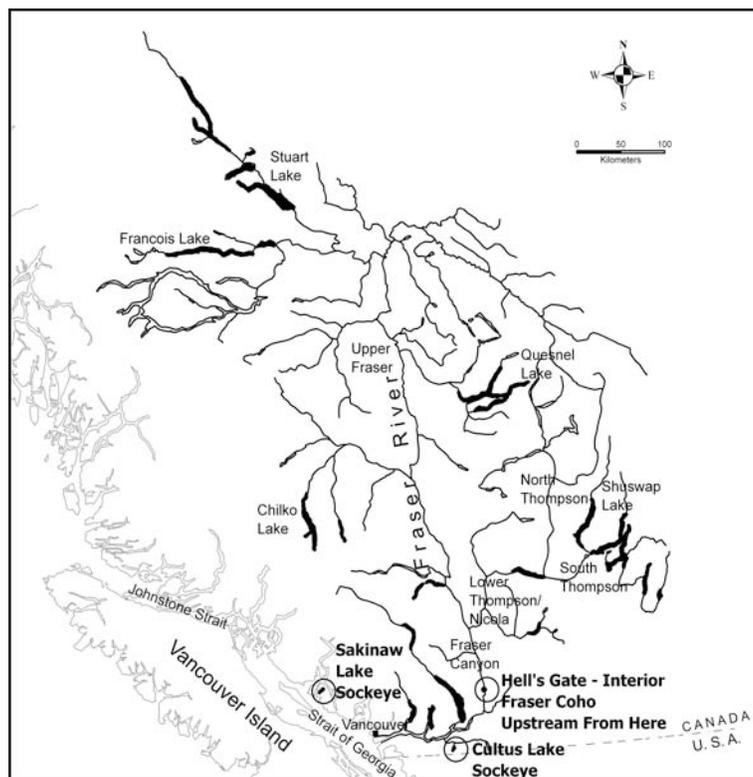
A response statement released in April 2004 (www.sararegistry.gc.ca/status/showHTML_e.cfm?ocid=769) confirmed that consultations would occur for 9 months before the Minister of the Environment forwarded the COSEWIC assessment to the Governor in Council. A legal listing recommendation is expected in December 2005, and the final decision whether to add this species to the SARA List, in April 2006.

Sakinaw Lake Sockeye Salmon

A request from a local biologist, Ken Wilson, initiated COSEWIC's emergency assessment of Sakinaw sockeye in October 2002. The COSEWIC Emergency Assessment Subcommittee reviewed the available information, including a report by Murray and Wood (2002), and concluded that this genetically unique and geographically distinct population had declined so drastically that the putative DU was at imminent risk of extinction. Subsequently, a commissioned status report by Wood (COSEWIC 2003b) was presented to the full COSEWIC membership and the endangered designation was confirmed in May 2003. COSEWIC (2003b) concluded that Sakinaw sockeye salmon are a listable unit of biodiversity because they are genetically distinct from all other sockeye populations based on analyses of protein-coding (allozyme), mitochondrial, and microsatellite DNA; they inhabit freshwater habitat that is unusual in its physical, chemical, and biological characteristics; and they possess local adaptations such as protracted adult run timing, extended lake residence prior to spawning, small body size, low fecundity, and large smolts (Table 2).

The 4-year (one generation) smoothed trend for Sakinaw Lake sockeye escapements indicates a decline of 98% over 3 generations (Figure 2c), greatly exceeding the threshold for endangered status. Three adults returned in 2003, 100 in 2004, and ~29 in

Figure 3. Locations of three designatable units (DUs) of Pacific salmon in British Columbia designated by COSEWIC as endangered.



2005, fewer than the number of parents that gave rise to these returning adults.

The decline of Sakinaw sockeye is probably due to factors in both marine and freshwater habitats. COSEWIC (2003b) concluded that the Sakinaw Lake population had collapsed primarily due to overfishing, exacerbated by reduced productivity due to freshwater habitat degradation, and that the unit was at high risk of extinction from fishing, poaching, natural predation, and impediments to spawning migration including low water flow. Sakinaw sockeye migrate through Johnstone and Georgia straits together with more abundant and productive populations of Fraser River sockeye salmon, exposing Sakinaw fish to significant mortality (i.e., bycatch). There is no evidence of recovery since COSEWIC listing (Figure 2c).

The goal of the draft recovery report is to stop the decline of the Sakinaw Lake sockeye salmon population and re-establish a self-sustaining and naturally spawning population, ensuring the preservation of the unique biological characteristics of this population. Various recovery objectives are proposed, including that by 2017, the mean population abundance in any 4-year period should exceed 1,000 naturally produced spawners, with no fewer than 500 naturally produced spawners in a year.

A response statement released in April 2004 (www.sararegistry.gc.ca/status/showHTML_e.cfm?ocid=787) indicated that the Minister of the Environment would immediately forward the COSEWIC assessment to the Governor in Council and consultations would take place whether or not to add this species should be added to the SARA List. In January 2005, the government announced its decision not to legally list Sakinaw sockeye because the automatic prohibitions of SARA would create unacceptable social and economic costs for the commercial fishing and recreational fishing sectors, some Aboriginal peoples, and coastal communities. Nevertheless, DFO committed to the protection and rebuilding of this population.

Cultus Lake Sockeye Salmon

Ken Wilson, together with Chief Doug Kelly of the Soowahlie First Nation, initiated COSEWIC's emergency assessment of Cultus Lake sockeye in October 2002. The Emergency Assessment Subcommittee, based largely on information in Schubert et al. (2002), concluded that this sockeye population was also a DU that faced imminent risk of extinction. A subsequently commissioned status report by Schubert (COSEWIC 2003a) was presented to the full COSEWIC membership and the endangered designation was confirmed in May 2003. COSEWIC (2003a) concluded that Cultus sockeye salmon are a listable unit of biodiversity because they are substantially reproductively isolated from other sockeye, including others in the Fraser River drainage (Figure 3). Cultus sockeye exhibit a variety of adaptive traits that further suggest they are distinct from other populations, including a migratory delay in the Fraser River estuary, a protracted period of lake residence prior to spawning, a spawning period that is among the latest in British Columbia sockeye, and an offshore movement of fry immediately after emergence that is possibly an adaptation to near-shore predators (Table 2, COSEWIC 2003a).

The 4-year (one-generation) smoothed trend for Cultus Lake sockeye escapements indicates a decline of 51% over 3 generations (Figure 2d). Beginning in 1995 heightened levels of pre-spawning mortality of adult sockeye, possibly caused by infestations of the Myxosporean parasite *Parvicapsula minibicornis* have resulted in declines of 93% over 3 generations in the number of effective spawn-

ers (Cooke et al. 2004; Fig. 2d), a decline that greatly exceeds the IUCN threshold for endangered status.

The principal factors responsible for the decline are believed to be excessive fishing harvest during most years from 1952–1995, and poor marine survival in the early to mid-1990s that resulted in production falling below the replacement line, exacerbated by high levels of pre-spawning mortality. COSEWIC (2003a) attributed the collapse to the long period of overexploitation, including directed catch and bycatch in mixed-stock fisheries, recruitment failure in the 1990s, and the high pre-spawn mortality associated with *Parvicapsula* infestation since 1995. There is no clear evidence of rebuilding since COSEWIC listing (Figure 2d).

The goal of the draft recovery report is to halt the population decline of Cultus sockeye so that they become a viable, self-sustaining and genetically robust wild population that will contribute to its ecosystems and have the potential to support sustainable use. In the short term, the population should exceed a 4-year arithmetic mean of 1,000 successful adult spawners with no fewer than 500 successful adult spawners on any one cycle, and continue to grow.

As with the Sakinaw sockeye, the Federal Cabinet decided in January 2005 not to list Cultus sockeye under SARA due to socioeconomic costs, but DFO committed to their protection and rebuilding.

Biodiversity, Salmon Management, and SARA

The development and management of Canadian salmon fisheries reflect a primary focus on fisheries that generate profits. During most of the twentieth century, Canada's Pacific salmon managers concentrated on the harvest of large productive salmon populations, and mixed stock fisheries where fish were abundant. However, in the late twentieth century, scientists and managers increasingly recognized that the long-term survival of salmon and salmon fisheries depended upon the store of genetic variation and local adaptation among salmon populations (NRC 1996). Also, in Canada legal decisions affirmed the constitutionally protected legal status of the traditional First Nations fisheries for food, social, and ceremonial purposes. These factors resulted in a shift in salmon fisheries management towards managing for a better mix among harvest, population conservation, and the maintenance of salmon diversity (Hyatt and Riddell 2000). How significant a shift are we seeing, and what role will SARA play in sustaining or furthering this change?

The evidence for a transition towards a management regime that considers salmon diversity is not entirely consistent. For instance, large sockeye salmon runs to Owikeno and Long lakes in central British Columbia collapsed in the mid-1990s. These populations were not assessed by COSEWIC, but both probably met the requirements to be considered endangered DUs. Terminal fisheries on these populations were closed. DFO also recognized and responded to conservation concerns for iBoF Atlantic salmon and interior Fraser coho salmon before COSEWIC listings. The situation is somewhat different for fisheries that catch Sakinaw and Cultus sockeye. Reductions and closures of fisheries were made following COSEWIC listings but fell short of those taken in the other examples provided, presumably because the biggest effects on Sakinaw and Cultus sockeye come from lucrative mixed stock fisheries for Fraser River sockeye. Closure or reductions in these fisheries would reduce impacts on the endangered DUs, but would also reduce catches on more productive, co-migrating Fraser sockeye salmon, resulting in social and economic impacts.

We see evidence that Canadian fishery managers are more willing to consider the impacts of mixed-stock fisheries on small salmon populations than they were before COSEWIC began listing salmon, and before SARA. Unfortunately, making trade-offs to conserve diversity raises socioeconomic issues that can lead to hesitancy to fully embrace the goal of protecting Canada's salmon diversity. It is not feasible to operate major fisheries and guarantee the preservation of all diversity. This is where the philosophy and process of SARA, COSEWIC, and a new policy to conserve wild salmon (DFO 2005) will need to find a common ground. The endangered designation of salmon by COSEWIC has served notice to DFO and other resource management ministries that such populations are important elements of Canada's biodiversity and warrant protection. Such protection requires that salmon populations be managed at finer geographic levels than has been done previously. SARA provides an opportunity and legal means for management to concentrate harvest at the point where it is biologically most appropriate. It highlights that harvest remains possible even if it is not where society has previously wished to operate. SARA requires that Canadians consider the economic and social implications of guaranteeing the protection of biodiversity at these fine levels by evaluating implications prior to making a decision to legally list. In the end, society will decide the level of salmon diversity that it will protect. 

Acknowledgements

We thank John Lombard for information on the US Endangered Species Act, and Lara Cooper, Carole Eros, Mary Hobbs, Don Lawseth, Tameezan Mawani, and Anne Phelps for providing unpublished documentation on the Species at Risk Act (Bill C-5), and NSERC for support given to Mart Gross. The article benefited from constructive comments provided by the reviewers and the science editor.

References

Amiro, P. G. 2003. Population status of inner Bay of Fundy Atlantic salmon (*Salmo salar*), to 1999. Canadian Technical Report Fisheries Aquatic Science 2488.

CITES (Convention on International Trade in Endangered Species of Wild Fauna and Flora). 2004. Member countries. Available at: www.cites.org/index.html; (September 2005).

Cooke, S. J., S. G. Hinch, A. P. Farrell, M. F. Lapointe, S. R. M. Jones, J. S. Macdonald, D. A. Patterson, M. C. Healey, and G. Van Der Kraak. 2004. Abnormal migration timing and high enroute mortality of sockeye salmon in the Fraser River, British Columbia. *Fisheries* 29(2): 22-33.

COSEWIC (Committee on the Status of Endangered Wildlife in Canada). 2002. COSEWIC assessment and status report on the coho salmon *Oncorhynchus kisutch* (Interior Fraser population) in Canada. COSEWIC, Ottawa. Available at: www.registrelep.gc.ca/virtual_sara/files/COSEWIC/sr%5Fcoho%5Fsalmon%5Fe%2Epdf; (September 2005).

_____. 2003a. COSEWIC assessment and status report on the sockeye salmon *Oncorhynchus nerka* (Cultus population) in Canada. COSEWIC, Ottawa. Available at: www.sararegistry.gc.ca/virtual_sara/files/COSEWIC/sr%5Fcultus%5Fsockeye%5Fsalmon%5Fe%2Epdf; (September 2005).

_____. 2003b. COSEWIC assessment and status report on the sockeye salmon *Oncorhynchus nerka* Sakinaw population in Canada. COSEWIC, Ottawa. Available at: www.sararegistry.gc.ca/virtual_sara/files/COSEWIC/sr%5Fsockeye%5Fsalmon%5Fe%2Epdf; (September 2005).

CSAR (Consolidated Statutes and Regulations). 2004a. Fisheries Act (R.S. 1985, c. F-14). Available at: <http://laws.justice.gc.ca/en/F-14/text.html>; (September 2005).

_____. 2004b. Species at Risk Act (2002, c. 29). Available at: <http://laws.justice.gc.ca/en/s-15.3/103526.html>; (September 2005).

DFO (Fisheries and Oceans Canada). 2004a. Inner Bay of Fundy Atlantic Salmon Conservation & Recovery Team. Available at: www.mar.dfo-mpo.gc.ca/masaro/english/Recovery_Teams/iBoF_Recovery.html; (September 2005). Dartmouth, Nova Scotia.

_____. 2004b. Revised framework for evaluation of scope for harm under Section 73 of the Species at Risk Act. Fisheries and Oceans Canada Science Advisory Secretariat Stock status report 2004/048. Ottawa, Ontario. Available at: www.dfo-mpo.gc.ca/csas/Csas/status/2004/SSR2004_048_REVISSED_e.pdf; (September 2005).

_____. 2005. Canada's policy for conservation of wild Pacific salmon. Available at: www.comm.pac.dfo-mpo.gc.ca/publications/wsp/default_e.htm; (September 2005). Vancouver, British Columbia.

Ford, M. J. 2004. Conservation units and preserving diversity. Pages 338-357 in A. Hendry and S. Stearns, eds. *Evolution illuminated: salmon and their relatives*, Oxford University Press, NY.

Gärdenfors, U., C. Hilton-Taylor, G. M. Mace, and J. P. Rodríguez. 2001. The application of IUCN Red List criteria at regional levels. *Conservation Biology* 15:1206-1212.

Government of Canada. 2004a. Committee on the Status of Endangered Wildlife in Canada. Available: www.cosewic.gc.ca/eng/sct5/index_e.cfm; (September 2005).

_____. 2004b. Species at Risk Act Public Registry. Available: www.sararegistry.gc.ca/default_e.cfm; (September 2005).

Hyatt, K. D., and B. E. Riddell. 2000. The importance of "stock" conservation definitions to the concept of sustainable fisheries. Pages 51-62 in E. E. Knudsen, C. R. Steward, D. D. MacDonald, J. E. Williams, and D. W. Reiser, eds. *Sustainable fisheries management: Pacific salmon*. Lewis Publishers, Boca Raton, Florida.

Irvine, J. R. 2002. COSEWIC status report on the coho salmon *Oncorhynchus kisutch* (Interior Fraser population) in Canada, in COSEWIC assessment and status report on the coho salmon *Oncorhynchus kisutch* (Interior Fraser population) in Canada. COSEWIC, Ottawa. Available at: www.registrelep.gc.ca/virtual_sara/files/COSEWIC/sr%5Fcoho%5Fsalmon%5Fe%2Epdf; (September 2005).

IUCN (World Conservation Union). 2001. IUCN Red List categories and criteria: version 3.1. IUCN Species Survival Commission. IUCN, Gland, Switzerland and Cambridge, UK.

Murray, C., and C. Wood. 2002. Status of Sakinaw Lake sockeye salmon (*Oncorhynchus nerka*). Fisheries and Oceans Canada Science Advisory Secretariat Research Document 2002/088: 100 p. Available at: www.dfo-mpo.gc.ca/csas/Csas/publications/ResDocs-DocRech/2002/2002_088_e.htm; (September 2005).

NOAA Fisheries. 2005. ESA critical habitat designations for west coast salmon and steelhead. Available at: www.nwr.noaa.gov/1salmon/salmesa/crithab/CHsite.htm#Proposal (September 2005).

NRC (National Resource Council). 1996. *Upstream: salmon and society in the Pacific Northwest*. Committee on Protection and Management of Pacific Northwest Anadromous Salmonids. National Academy Press, Washington, D.C.

Schubert, N. D., T. D. Beacham, A. J. Cass, T. E. Cone, B. P. Fanos, M. Foy, J. H. Gable, J. A. Grout, J. M. B. Hume, M. Johnson, K. F. Morton, K. S. Shortreed, and M. J. Staley. 2002. Status of Cultus Lake sockeye salmon (*Oncorhynchus nerka*). Fisheries and Oceans Canada Science Advisory Secretariat Stock Research Document 2002/064. Available at: www.dfo-mpo.gc.ca/csas/Csas/publications/ResDocs-DocRech/2002/2002_064_e.htm; (September 2005).

Verspoor, E., M. O'Sullivan, A. L. Arnold, D. Knox, and P. G. Amiro. 2002. Restricted matrilineal gene flow and regional differentiation among Atlantic salmon (*Salmo salar* L.) populations within the Bay of Fundy, Eastern Canada. *Heredity* 89:465-472.

Vanderzwaag, D. L., and J. A. Hutchings. 2005. Canada's marine species at risk: science and law at the helm, but a sea of uncertainties. *Ocean Development and International Law* 36: 219-259.