

Canadian species at risk (2006–2008), with particular emphasis on fishes

Jeffrey A. Hutchings and Marco Festa-Bianchet

Abstract: In accordance with the Species at Risk Act (SARA), the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) is nationally responsible for assessing wildlife species considered to be at risk of extinction. A parliamentary review of SARA provides impetus for an up-to-date summary of recent assessments (2006–2008) and a spatiotemporal analysis of the status of Canada's largest vertebrate group of species at risk, fishes. From April 1978 through December 2008, COSEWIC had assessed 13 wildlife species as extinct and 564 at some level of risk (extirpated, endangered, threatened, special concern). Among these 577 assessments, 112 are for fishes (76% freshwater and diadromous; 24% marine). Slightly more than one-quarter (27%) of Canada's 205 freshwater and diadromous species of fishes, many of which are in southwestern Ontario and southeastern Quebec, have been assessed as being at risk throughout all or parts of their ranges. The percentage of Canadian freshwater and diadromous fish species assessed by COSEWIC as endangered or threatened (16%) is similar to the percentage of freshwater and diadromous fishes in the US that have been listed under the Endangered Species Act (12%). The proportion of wholly freshwater fishes assessed by COSEWIC that have been added to SARA's legal schedule is somewhat lower than that of other taxa. However, whereas the US listed its first marine fish in 2005, the Canadian government has to date not accepted COSEWIC's advice to list an endangered or threatened marine fish since the proclamation of SARA in 2003.

Résumé : Comme établi par la Loi sur les Espèces en Péril (LEP), le Comité sur la Situation des Espèces en Péril au Canada (COSEPAC) est responsable au niveau national de l'évaluation des espèces considérées à risque d'extinction. La révision parlementaire prochaine de la LEP nous a incité à rédiger une mise à jour des évaluations récentes (2006–2008) et à faire une analyse spatio-temporelle de la situation des poissons, le groupe de vertébrés avec le plus grand nombre d'espèces à risque au Canada. Entre avril 1978 et décembre 2008, le COSEPAC a déterminé que 13 espèces sauvages se sont éteintes et 564 sont à différents niveaux de risque (disparues du Canada, en voie de disparition, menacées, ou préoccupantes). Parmi ces 577 évaluations, on retrouve 112 espèces de poissons (76 % d'eau douce ou diadromes; 24 % marines). Un peu plus d'un quart (27 %) des 205 espèces de poissons d'eau douce ou diadromes du Canada, dont de nombreuses se situent dans le sud-ouest de l'Ontario ou le sud-est du Québec, ont été évaluées comme étant à risque sur l'ensemble ou dans certaines parties de leur distribution géographique. Le pourcentage des espèces de poissons d'eau douce ou diadromes du Canada que le COSEPAC a évalué comme étant en voie de disparition ou menacées (16 %) est semblable au pourcentage de poissons d'eau douce ou diadromes inscrits dans le 'Endangered Species Act' aux États-Unis (12 %). Parmi les espèces entièrement d'eau douce évaluées par le COSEPAC, la proportion qui a été inscrite à la liste légale de la LEP est un peu plus faible que pour les autres groupes taxonomiques. Par contre, alors que la première espèce de poisson marin a été ajouté aux espèces protégées aux États-Unis en 2005, le gouvernement Canadien n'a pas encore accepté l'avis du COSEPAC d'inscrire sur la liste de la LEP aucune des espèces de poissons marins évaluées comme étant en voie de disparition ou menacée depuis la proclamation de cette loi en 2003.

Introduction

Despite worldwide declines in biodiversity, surprisingly few countries have enacted national endangered species legislation. The United States was the first, establishing the Endangered Species Preservation Act in 1966, before replacing it with the Endangered Species Act (ESA) in 1973. In 1999, Australia passed the Environment Protection and Biodiversity Conservation Act to protect Australia's threatened

species and the ecological communities of which they are a part. In Canada, the primary impetus for national legislation was the Convention on Biological Diversity (CBD), an international agreement signed in 1992 to promote sustainable development. Recognizing their responsibilities to the protection and recovery of global biota, all countries (with the exception of Andorra, Brunei, Iraq, Somalia, Timor-Leste, United States of America, and The Vatican) have signed the CBD. Canada was the first industrialized nation to sign, and passage of the Species at Risk Act (SARA) in December 2002 (proclaimed in 2003) — following nine years of legislation development, parliamentary debate, and national discussion — fulfilled a key obligation. Under the auspices of SARA, the scientific framework for the assessment of species at risk was formally recognized by legislation. Section 14 of SARA establishes the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) as the body responsible for the assessment of Canadian species at risk.

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The Act has three legislated objectives: (1) prevent extinction; (2) secure recovery of extirpated, endangered, and threatened species; and (3) manage species of special concern and prevent them from becoming further at risk. SARA is not intended to be solely a heavily-proscriptive, last-minute legislative tool for species on the brink of extinction. Rather, as articulated by the third objective, the Act acknowledges the importance of taking action to mitigate threats before species reach that brink.

SARA is to provide for the legal protection and recovery of *wildlife species*, defined by the Act as,

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 is either native to Canada or has extended its range into Canada without human intervention and has been present in Canada for at least 50 years.

Thus, SARA provides for the assessment of populations, or groups of populations, acknowledging implicitly that such designatable units (DUs) (Green 2005) can represent irreplaceable units of biodiversity critical to the persistence of biological species (i.e., those assigned a Latin binomial by a recognized authority). COSEWIC identifies discreteness and evolutionary significance as the primary criteria for recognizing DUs (www.cosewic.gc.ca/eng/sct2/sct2_5_e.cfm). A wildlife species as defined by SARA can be considered functionally equivalent to a DU. Unless identified otherwise, our use of the word “species” hereafter is equivalent to a wildlife species, or DU.

Annually, COSEWIC submits a report to the federal Minister of the Environment that details species status assessments undertaken during the previous year. Receipt of this report triggers the beginning of a 90-day period at the end of which the Minister must detail how he or she will initially respond to COSEWIC’s advice. These response statements outline how the Minister intends to consult and they provide timelines for the listing process. Listed species for which a COSEWIC review has reaffirmed status remain on Schedule 1 of SARA. Newly assessed species and species for which status has been upgraded are subject to either normal or extended consultations prior to the submission of the COSEWIC assessments to the Governor in Council (GIC), the subcommittee of the federal Cabinet responsible for rendering legal listing decisions on each species assessed by COSEWIC to be *at risk* (i.e., extirpated, endangered, threatened, special concern). Upon receipt of COSEWIC’s assessments from the Minister of the Environment, GIC has 9 months to decide whether to (a) accept the assessment and add the species to the legal list (i.e., Schedule 1 of SARA); (b) decide not to add the species to the list; or (c) refer the assessment back to COSEWIC for further information or consideration. The period of normal consultations is typically 3 months after the issuance of the response statement. The second option that has been exercised by the Minister, particularly for aquatic and northern species (Mooers et al. 2007), is to declare that a period of extended consultations, involving those who might be affected by a listing decision, will precede the submission of COSEWIC’s assessments to GIC. Because neither the pre-listing period of extended consultations nor its length are mentioned in SARA, the time preceding the submission of COSEWIC’s assessments by

the Minister to GIC has been lengthened by 12 to 24 months and, in some cases (described below), even longer.

The present review has two primary objectives. The first is to update summary statistics on Canadian species at risk during a time period not encompassed by previous work. Shank (1999) summarized COSEWIC species assessments to 1999 (see also Alvo and Oldham (2000) for amphibians and reptiles, and Campbell (2001) for fishes and marine mammals). Terrestrial species assessed by January 2001 were the focus of Kerr and Cihlar’s (2004) study of patterns and causes of species endangerment. Dextrase and Mandrak (2006) used COSEWIC assessments through 2003 to explore the impacts of species introductions on Canadian freshwater fishes and molluscs. Two separate studies included species assessed through May 2005: VanderZwaag and Hutchings’ (2005) examination of legal and scientific implications of SARA for marine species, and Venter et al.’s (2006) analysis of threats experienced by Canada’s biota. The most recent study of Canadian species at risk is Mooers et al.’s (Mooers et al. 2007) identification of taxonomic, geographical and jurisdictional biases in SARA listing decisions, based on species assessed as of August 2006. We used this date as a starting point, examining species assessed by COSEWIC at its meetings from November 2006 to November 2008 (COSEWIC 2007, 2008a, 2008b). This first objective provides an opportunity to highlight some of the species considered to be at greatest risk of extinction in Canada. Although separate species status reports are available at www.sararegistry.gc.ca, the data are not summarized in any single document. Our second objective is to provide a spatial and temporal analysis of status assessments undertaken by COSEWIC on fishes, Canada’s most speciose group of vertebrates and the one with the greatest number of species at risk.

Our purpose here is not to provide a scientific examination of SARA and its potential value to the protection and recovery of Canadian species at risk. Others have initiated this discussion (e.g., VanderZwaag and Hutchings 2005; Mooers et al. 2007) and we anticipate that many others will follow.

COSEWIC: A brief history

A national symposium organized by the Canadian Nature Federation and World Wildlife Fund (WWF) Canada in May 1976, and entitled, “Canada’s Threatened Species and Habitats”, recommended “that the Federal Provincial Wildlife Conference strike a standing committee consisting of representatives of the Federal and Provincial governments and appropriate conservation and scientific organizations for the purpose of establishing the status of endangered and threatened species and habitats in Canada” (Shank (1999) gives a comprehensive history of COSEWIC; VanderZwaag and Hutchings (2005) provide additional details subsequent to the passage of SARA). A resolution to this effect was passed in July 1976 at the 40th annual meeting of federal and provincial wildlife directors in Fredericton, leading to the formation of a temporary committee in March 1977.

The committee first met in Hull (now Gatineau), Quebec, on 27 September 1977. The initial species status assessments made by COSEWIC at its April 1978 meeting were restricted to birds (e.g., Eskimo curlew, *Numenius borealis*; peregrine falcon, *Falco peregrinus anatum/tundrius*) and

Table 1. Status assessments for wildlife species undertaken by COSEWIC between August 2006 and December 2008 (Abbreviations: DU, designatable unit; GL/StL, Great Lakes/St. Lawrence; GL/USL, Great Lakes/Upper St. Lawrence).

Species		DU Range	Status
Amphibians			
Allegheny Mountain dusky salamander	<i>Desmognathus ochrophaeus</i>	Carolinian GL/StL	Endangered (2007) Threatened (2007)
Great basin spadefoot	<i>Spea intermontana</i>	Canada	Threatened (2007)*
Western chorus frog	<i>Pseudacris triseriata</i>	GL/StL – Canadian Shield Carolinian	Threatened (2008) Not at risk (2008)
Coeur d’Alene salamander	<i>Plethodon idahoensis</i>	Canada	Special concern (2007)*
Arthropods			
Dusky dune moth	<i>Copablepharon longipenne</i>	Canada	Endangered (2008)
Rapids clubtail	<i>Gomphus quadricolor</i>	Canada	Endangered (2008)
Cobblestone tiger beetle	<i>Cicindela marginipennis</i>	Canada	Endangered (2008)
Pygmy snaketail	<i>Ophiogomphus howei</i>	Canada	Special concern (2008)
Pale yellow dune moth	<i>Copablepharon grandis</i>	Canada	Special concern (2008)
Birds			
Greater sage-grouse	<i>Centrocercus urophasianus phaios</i>		Extirpated (2008)*
	<i>C. u. urophasianus</i>	Canada	Endangered (2008)*
Kirtland’s warbler	<i>Dendroica kirtlandii</i>	Canada	Endangered (2008)*
Spotted owl caurina subspecies	<i>Strix occidentalis caurina</i>	Canada	Endangered (2008)*
Prothonotary warbler	<i>Protonotaria citrea</i>	Canada	Endangered (2007)*
Red knot	<i>Calidris canutus rufa</i>	Canada	Endangered (2007)
	<i>C. c. roselaari</i>	Canada	Threatened (2007)
	<i>C. c. islandica</i>	Canada	Special concern (2007)
Chimney swift	<i>Chaetura pelagica</i>	Canada	Threatened (2007)
Common nighthawk	<i>Chordeiles minor</i>	Canada	Threatened (2007)
Olive-sided flycatcher	<i>Contopus cooperi</i>	Canada	Threatened (2008)
Canada warbler	<i>Wilsonia canadensis</i>	Canada	Threatened (2008)
Ferruginous hawk	<i>Buteo regalis</i>	Canada	Threatened (2008)
Red-headed woodpecker	<i>Melanerpes erythrocephalus</i>	Canada	Threatened (2007)
Ross’s gull	<i>Rhodostethia rosea</i>	Canada	Threatened (2007)*
Black-footed albatross	<i>Phoebastria nigripes</i>	Canada	Special concern (2007)
Peregrine falcon	<i>Falco peregrinus pealei</i>	Canada	Special concern (2007)
	<i>F. p. anatum/tundrius</i>	Canada	Special concern (2007)
Great blue heron fannini subspecies	<i>Ardea herodias fannini</i>	Canada	Special concern (2008)*
Short-eared owl	<i>Asio flammeus</i>	Canada	Special concern (2008)
Band-tailed pigeon	<i>Patagioenas fasciata</i>	Canada	Special concern (2008)
Fishes			
Gravel chub	<i>Erimystax x-punctatus</i>	Canada	Extirpated (2008)*
Paddlefish	<i>Polyodon spathula</i>	Canada	Extirpated (2008)*
Basking shark	<i>Cetorhinus maximus</i>	Pacific	Endangered (2007)
Nooksack dace	<i>Rhinichthys cataractae</i> ssp.	Canada	Endangered (2007)*
Redside dace	<i>Clinostomus elongatus</i>	Canada	Endangered (2007)
Misty Lake stickleback	<i>Gasterosteus</i> sp.	Lentic Form	Endangered (2007)
		Lotic Form	Endangered (2007)
Lake sturgeon	<i>Acipenser fulvescens</i>	Winnipeg/English River	Endangered (2007)
		Nelson River	Endangered (2007)
		Saskatchewan River	Endangered (2007)
		Western Hudson Bay	Endangered (2007)
		Red/Assiniboine Rivers and Lake Winnipeg	Endangered (2007)
		GL/USL	Threatened (2007)
		Lake of the Woods – Rainy River	Special concern (2007)
		Southern Hudson Bay – James Bay	Special concern (2007)
Western silvery minnow	<i>Hybognathus argyritis</i>	Canada	Endangered (2008)
Lake chubsucker	<i>Erimyzon sucetta</i>	Canada	Endangered (2008)
Roundnose grenadier	<i>Coryphaenoides rupestris</i>	Canada	Endangered (2008)
Canary rockfish	<i>Sebastes pinniger</i>	Canada	Threatened (2008)

Table 1 (continued).

Species		DU Range	Status
Rainbow smelt	<i>Osmerus mordax</i>	L Utopia large-bodied L Utopia small-bodied	Threatened (2008) Threatened (2008)*
Vancouver lamprey	<i>Lampetra macrostoma</i>	Canada	Threatened (2008)*
Westslope cutthroat trout	<i>Oncorhynchus clarkii lewisi</i>	Alberta British Columbia	Threatened (2007) Special concern (2007)
Bluntnose sixgill shark	<i>Hexanchus griseus</i>	Canada	Special concern (2007)
Longspine thornyhead	<i>Sebastolobus altivelis</i>	Canada	Special concern (2007)
Northern brook lamprey	<i>Ichthyomyzon fossor</i>	GL/USStL Saskatchewan–Nelson	Special concern (2007) Data deficient (2007)
Rougheye rockfish	<i>Sebastes</i> sp. type I	Canada	Special concern (2007)
	<i>Sebastes</i> sp. type II	Canada	Special concern (2007)
Yelloweye rockfish	<i>S. ruberrimus</i>	Pacific outside waters Pacific inside waters	Special concern (2008) Special concern (2008)
Roughhead grenadier	<i>Macrourus berglax</i>	Canada	Special concern (2007)
Tope	<i>Galeorhinus galeus</i>	Canada	Special concern (2007)
Big skate	<i>Raja binoculata</i>	Canada	Not at risk (2007)
Bigmouth buffalo	<i>Ictiobus cyprinellus</i>	GL/USStL	Not at risk (2008)
Longnose skate	<i>R. rhina</i>	Canada	Not at risk (2007)
Sandpaper skate	<i>Bathyraja interrupta</i>	Canada	Not at risk (2007)
Greenside darter	<i>Etheostoma blennioides</i>	Canada	Not at risk (2007)
Black buffalo	<i>Ictiobus niger</i>	Canada	Data deficient (2007)
Blackfin cisco	<i>Coregonus nigripinnis</i>	Canada	Data deficient (2007)
Brown cat shark	<i>Apristurus brunneus</i>	Canada	Data deficient (2007)
Flathead catfish	<i>Pylodictis olivaris</i>	Canada	Data deficient (2007)*
Redbreast sunfish	<i>Lepomis auritus</i>	Canada	Data deficient (2008)
Lichens			
Seaside bone	<i>Hypogymnia heterophylla</i>	Canada	Threatened (2008)
Mammals			
Vancouver Island marmot	<i>Marmota vancouverensis</i>	Canada	Endangered (2008)*
Harbour seal	<i>Phoca vitulina mellonae</i>	Lac des Loups Marins	Endangered (2008)
	<i>P. v. concolor</i>	Atlantic – Arctic	Not at risk (2008)
Killer whale	<i>Orcinus orca</i>	Southern Resident Northern Resident West Coast Transient Offshore NW Atlantic – E Arctic	Endangered (2008)* Threatened (2008)* Threatened (2008)* Threatened (2008) Special concern (2008)
Western harvest mouse	<i>Reithrodontomys megalotis dychei</i>	Canada	Endangered (2007)
	<i>R. m. megalotis</i>	Canada	Special concern (2007)
American marten	<i>Martes americana atrata</i>	Newfoundland	Threatened (2007)
Sea otter	<i>Enhydra lutris</i>	Canada	Special concern (2007)
Sowerby's beaked whale	<i>Mesoplodon bidens</i>	Canada	Special concern (2007)*
Polar bear	<i>Ursus maritimus</i>	Canada	Special concern (2008)*
Bearded seal	<i>Erignathus barbatus</i>	Canada	Data deficient (2007)
Molluscs			
Eastern pondmussel	<i>Ligumia nasuta</i>	Canada	Endangered (2007)
Mosses			
Nugget moss	<i>Microbryum vlassovii</i>	Canada	Endangered (2007)
Fawnsfoot	<i>Truncilla donaciformis</i>	Canada	Endangered (2008)
Banff springs snail	<i>Physella johnsoni</i>	Canada	Endangered (2008)*
Hotwater physa	<i>P. wrighti</i>	Canada	Endangered (2008)*
Reptiles			
Pygmy short-horned lizard	<i>Phrynosoma douglasii</i>	Canada	Extirpated (2007)*
Greater short-horned lizard	<i>P. hernandesi</i>	Canada	Endangered (2007)
Eastern foxsnake	<i>Elaphe gloydi</i>	Carolinian GL/StL	Endangered (2008) Endangered (2008)
	<i>E. spiloides</i>	Carolinian GL/StL	Endangered (2007) Threatened (2007)

Table 1 (concluded).

Species		DU Range	Status
Five-lined skink	<i>Eumeces fasciatus</i>	Carolinian GL/StL	Endangered (2007) Special concern (2007)
Eastern hog-nosed snake	<i>Heterodon platirhinos</i>	Canada	Threatened (2008)*
Wood turtle	<i>Glyptemys insculpta</i>	Canada	Threatened (2008)
Snapping turtle	<i>Chelydra serpentina</i>	Canada	Special concern (2008)
Vascular plants			
Oregon lupine	<i>Lupinus oreganus</i>	Canada	Extirpated (2008)
Eastern flowering dogwood	<i>Cornus florida</i>	Canada	Endangered (2007)
Ogden's pondweed	<i>Potamogeton ogdenii</i>	Canada	Endangered (2007)
California buttercup	<i>Ranunculus californicus</i>	Canada	Endangered (2008)
Foothill sedge	<i>Carex tumulicola</i>	Canada	Endangered (2008)
Fragrant popcornflower	<i>Plagiobothrys figuratus</i>	Canada	Endangered (2008)
Lindley's false silverpuff	<i>Uropappus lindleyi</i>	Canada	Endangered (2008)
Muhlenberg's centaury	<i>Centaurium muehlenbergii</i>	Canada	Endangered (2008)
Rayless goldfields	<i>Lasthenia glaberrima</i>	Canada	Endangered (2008)
Golden paintbrush	<i>Castilleja levisceta</i>	Canada	Endangered (2008)*
Wood-poppy	<i>Stylophorum diphyllum</i>	Canada	Endangered (2008)*
Yellow montane violet	<i>Viola praemorsa praemorsa</i>	Canada	Endangered (2008)
Round-leaved greenbrier	<i>Smilax rotundifolia</i>	Great Lakes Plains Atlantic	Threatened (2008) Not at risk (2008)
Blunt-lobed woodsia	<i>Woodsia obtusa</i>	Canada	Threatened (2007)
Gray's desert-parsley	<i>Lomatium grayi</i>	Canada	Threatened (2008)
Mexican mosquito-fern	<i>Azolla mexicana</i>	Canada	Threatened (2008)*
Slender popcornflower	<i>Plagiobothrys tenellus</i>	Canada	Threatened (2008)
Beach pinweed	<i>Lechea maritima</i>	Canada	Special concern (2008)
Okanogan stickweed	<i>Hackelia ciliata</i>	Canada	Not at risk (2008)
Parker's pipewort	<i>Eriocaulon parkeri</i>	Canada	Not at risk (2007)
Scouler's corydalis	<i>Corydalis scouleri</i>	Canada	Not at risk (2007)

*Affirmation of the same status for the same DU.

mammals (e.g., Vancouver Island marmot, *Marmota flaviventris*; wood bison, *Bison bison athabascae*). The taxonomic breadth of assessments expanded in 1980 to fishes (e.g., shortnose sturgeon, *Acipenser brevirostrum*; speckled dace, *Rhinichthys osculus*) and vascular plants (e.g., Furbish's lousewort, *Pedicularis furbishiae*); in 1981 to reptiles (e.g., leatherback sea turtle, *Dermochelys coriacea*); in 1989 to amphibians (e.g., Prairie skink, *Eumeces septentrionalis*); in 1995 to lichens (e.g., cryptic paw, *Nephroma occultum*); in 1996 to molluscs (e.g., eelgrass limpet, *Lottia alveus alveus*); and in 1997 to mosses (e.g., rigid apple moss, *Bartramia stricta*) and to arthropods (e.g., Karner blue, *Lycaeides melissa samuelis*).

Assessments are based on reports that detail the best available information (including scientific information, Aboriginal traditional knowledge (ATK; e.g., Inuit Qaujimanitugangit), community knowledge) that pertains to the status of a wildlife species. These reports are subjected to extensive external review by jurisdictional (government, wildlife management boards), independent and university biologists over 1.5–2.0 years. The status assigned to each species is based on a two-thirds majority of the votes cast at a COSEWIC species assessment meeting. At present, a maximum of 31 votes can be cast: (i) one for each of four federal government agencies; (ii) one for each of the 10 provinces and 3 territories; (iii) one for each of the 10 Species Specialist Subcommittees; (iv) one for the ATK Subcommittee; and (v) one for each of 3 non-government science members.

In accordance with SARA, each member of COSEWIC is required by law to be a knowledgeable biologist and to exercise his or her discretion in an independent manner, meaning that votes on species status are not to be based on affiliation (e.g., government, university, research programme, non-governmental organization). Thus, although COSEWIC is inclusive of government (jurisdictions are allocated membership on the Committee), status assessments are made independently of government (members are biologists who convey knowledge but do not represent their jurisdictions). Importantly, the status assessment advice provided to the federal government is based only on the best available scientific information, irrespective of any perceived socio-economic or political consequences of that advice.

As of December 2008, COSEWIC had assessed the status of 787 wildlife species, finding 577 of them to either be extinct (13 wildlife species) or at risk (23 extirpated species, 238 endangered species, 146 threatened species, 157 species of special concern); there has been insufficient information to assess the status of an additional 44 species and 166 others have been deemed not at risk (COSEWIC 2008a).

Species status assessments (2006–2008)

Summary

At five meetings held between August 2006 and December 2008, COSEWIC had assessed the status of 130 wildlife species (Table 1). Among these, several were re-assess-

ments. (COSEWIC is required by SARA to review its classifications every 10 years, or earlier if it has reason to believe that the status of a wildlife species has changed significantly.) Among the 106 species assessed to be at risk between 2006 and 2008, 77% ($n = 82$) represented new status designations either for previously identified DUs or for DUs that had not previously been assessed. During this period, the proportion of assessed species at risk comprised of fishes (31%) was greatest among the taxonomic groups, followed by birds (20%), vascular plants (17%), mammals (12%), reptiles (10%), arthropods (5%), and amphibians (5%). Of the four at-risk categories, 36% of the 130 assessments were for endangered species; the remaining assessments were threatened (23%), special concern (23%), and extirpated (4%). Eleven species (8%) were determined to be not at risk and there were insufficient data to assess the status of an additional 7 species.

Extirpation from Canada and extinction are clearly the most serious of the status categories. Of the five extirpated species assessed by COSEWIC between August 2006 and December 2008, the vascular plant Oregon lupine, *Lupinus oregonus*, was assessed for the first time, whereas the other four (gravel chub, *Erimystax x-punctatus*; paddlefish, *Polyodon spathula*; pygmy short-horned lizard, *Phrynosoma douglasii*; the British Columbia subspecies of greater sage grouse, *Centrocercus urophasianus phaios*) confirmed previous assessments. Among the 77 endangered or threatened species, 56 were new assessments.

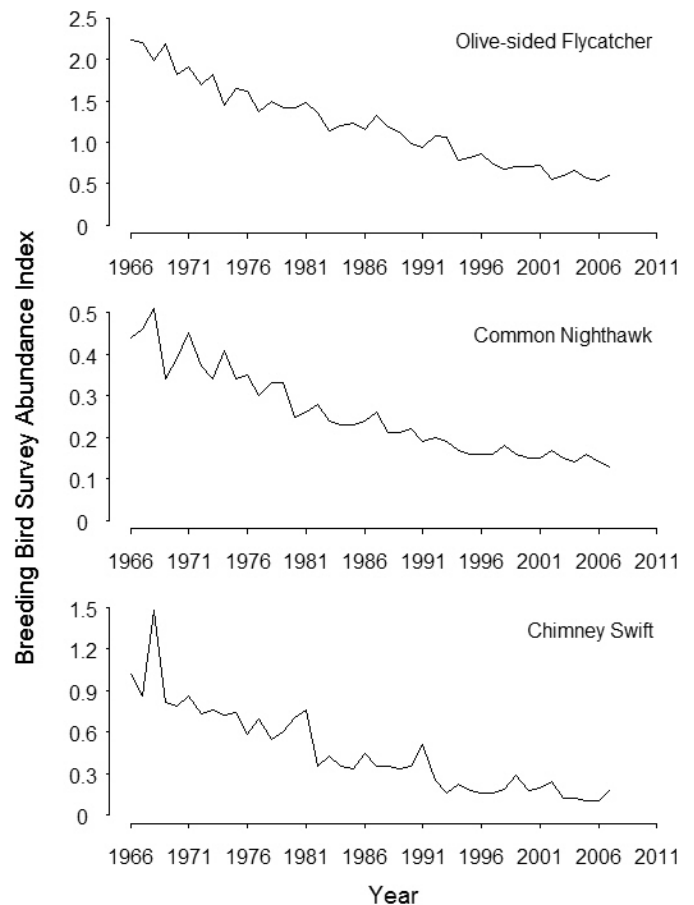
Focussing on a subset of species assessed as being at risk between 2006 and 2008, we highlight below some of the current threats to Canada's biodiversity (Venter et al. 2006). All information presented here was obtained from the status reports for each species, available from the SARA Public Registry (www.sararegistry.gc.ca).

Threat: Intentional mortality

The basking shark, *Cetorhinus maximus*, is Canada's largest fish, reaching 12 m in length. Its recovery potential is among the lowest of Canada's biota because of its lengthy gestation period (2.5–3.6 years) and late age at maturity (16–20 years for females). Although large aggregations comprising tens or hundreds of individuals were once seasonally common off British Columbia in the first half of the 20th Century, only 6 of these sharks have been sighted since 1996. The Pacific population, estimated to have declined more than 90% within the past two generations (i.e., 44–66 years), was assessed as endangered. This reduction in abundance can be attributed to a fishery for liver oil in the 1940s and to an eradication programme by the federal fisheries department. From 1954 to 1970, a patrol boat fitted with a large blade on its bow was used to ram and kill basking sharks to reduce the probability that they would be entangled in fishing gear set to capture Pacific salmon, *Oncorhynchus* spp. (Wallace and Gisborne 2006). Another species for which declines can be primarily attributed to direct, human-induced removals is the wood turtle, *Glyptemys insculpta*, a threatened species extremely vulnerable to collection for the pet trade.

Over-exploitation is the primary threat to marine fishes at risk. The endangered roundnose grenadier, *Coryphaenoides rupestris*, is a long-lived (60 years), late-maturing (10 years)

Fig. 1. Trends in the abundance of olive-sided flycatcher, common nighthawk, and chimney swift throughout Canada from 1966 to 2007, based on data obtained from breeding bird surveys.



fish, of the same taxonomic order as Atlantic cod (*Gadus morhua*), which inhabits deep waters off Newfoundland and Labrador. Its abundance is estimated to have declined more than 98% between 1978 and 2003. Overfishing of threatened canary rockfish, *Sebastes pinniger*, off British Columbia is the primary cause of its 80 to 96% decline in approximately one generation (20–30 years). Recovery of this species is anticipated to be slow because of life-history attributes associated with low resilience (Reynolds et al. 2005): late maturity (13 years for females), high longevity (84 years), and long generation time (20–30 years). Other species threatened by unsustainable fishing mortalities included lake sturgeon, *Acipenser fulvescens*, westslope cutthroat trout, *Oncorhynchus clarkii lewisi*, and longspine thornyhead, *Sebastolobus altivelis*.

Threat: Habitat alteration and destruction

Habitat loss is implicated in the decline of several birds. The reduction in abundance of aerial insectivores has been particularly noteworthy, as reflected by the threatened status assigned to formerly abundant species such as olive-sided flycatcher, *Contopus cooperi*, common nighthawk, *Chordeiles minor*, and chimney swift, *Chaetura pelagica* (Fig. 1). Breeding bird survey data estimate that the olive-sided flycatcher declined by 79% since the late 1960s and by 29% in the past decade. The common nighthawk has de-

clined approximately 50% over the last three generations (10 years) and approximately 80% since the late 1960s/early 1970s. Chimney swifts have declined more than 95% since the late 1960s.

Habitat degradation resulting from urban and agricultural development is a threat to many species. The endangered reaside dace, *Clinostomus elongatus*, a fish particularly sensitive to alterations of stream flow regimes, has been lost from 5 to 10 of 24 historic locations in southern Ontario and has experienced declines in 8 of 14 remaining locations, primarily because of habitat destruction through urban development. Habitat fragmentation also threatens the coeur d'Alene salamander, *Plethodon idahoensis*, and great basin spadefoot, *Spea intermontana*, in southern British Columbia; eastern hognose snake, *Elaphe gloydi*, in Ontario; and two species of dune moth (*Copablepharon longipenne*, *C. grandis*) in the southern Prairies. Ever-expanding road networks have increased anthropogenic-induced mortality for many reptiles, such as the gray ratsnake, *Elaphe spiloides*, five-lined skink, *Eumeces fasciatus*, and greater short-horned lizard, *Phrynosoma hernandesi*, all of which have been assessed as endangered. Future road development threatens the nugget moss, *Microbryum vlassovii*, in south-central British Columbia.

Habitat losses attributable to forestry have figured prominently in the declines of terrestrial mammals (e.g., American marten, *Martes americana atrata*, in Newfoundland and woodland caribou, *Rangifer tarandus caribou*, in the boreal forest from Labrador to southern Yukon) and birds such as the spotted owl, *Strix occidentalis caurina*, a subspecies that has declined from an estimated historic abundance of 500 individuals to 19, only 10 of which are in breeding condition. In the absence of successful recruitment, the spotted owl will likely disappear from Canada within 10 years.

Threat: Invasive species

Intentional and unintentional introductions of exotic species increasingly threaten Canada's native biota. The late-1980s invasion of the Great Lakes by the zebra mussel, *Dreissena polymorpha*, for example, increased the extinction probability of many native species. The threat is particularly acute for freshwater molluscs, upon which zebra mussels attach in the hundreds and thousands, suffocating or starving the native species. Today, approximately 86% and 90% of the habitat of Ontario's fawnsfoot, *Truncilla donaciformis*, and eastern pondmussel, *Ligumia nasuta*, respectively, has been invaded by zebra mussels. Habitat losses predicated COSEWIC's assessments of endangered for these two formerly common species.

Vascular plants are at great risk from invasive species. Endangered species assessed between 2006 and 2008 for which invasions have been identified as a threat include British Columbia's foothill sedge, *Carex tumulicola*, fragrant popcornflower, *Plagiobothrys figuratus*, Lindley's false silverpuff, *Uropappus lindleyi*, Muehlenberg's centauray, *Centaureium muehlenbergii*, and rayless goldfield, *Lasthenia glaberrima*. Southern Ontario's eastern flowering dogwood, *Cornus florida*, a native of Carolinian forests, has been assessed as endangered because of an 80% decline in the past decade, a reduction attributable to the spread of the fungal disease dogwood anthracnose, *Discula destructiva*, an inva-

sive species thought to have originated in the Orient, first reported in the US in 1978, and documented in Ontario in 1998.

Although the predominant ecological consequences of species invasions are parasitism, interspecific competition and predation, native species can also be at risk from interspecific hybridization. Perhaps the best current example of a species threatened by hybridization is westslope cutthroat trout. In Alberta, and to a lesser extent in southeastern British Columbia, the species has declined in part because of recreational over-fishing but also because of hybridization with non-native rainbow trout, *Oncorhynchus mykiss*, introduced for recreational angling. These government-sanctioned, exotic-species introductions have led to a proliferation of interspecific hybrids that has contributed to a reduction in native westslope cutthroat trout genomes in western Canada.

Threat: Climate change

Since the early 2000s, climate change has increasingly been recognized by COSEWIC as a threat. Species inhabiting the Arctic are most likely to be affected, and prominent amongst these is the endangered Peary caribou, *Rangifer tarandus pearyi*. From nearly 50 000 animals in the early 1960s, this High Arctic species has declined 84%, with a 72% decline occurring since 1980. By increasing the amount of freezing rain and snow, climate warming has reduced access to the vegetation on which Peary caribou depend for food, leading to episodes of mass starvation. Polar bear, *Ursus maritimus*, a species dependent on sea ice, is another mammalian species at risk (special concern) whose numbers are likely to decline because of reductions in sea ice attributable to global warming (Hutchings and Festa-Bianchet 2009).

Climate change has also been associated with increased environmental variability. Increased frequency and intensity of ocean storm surges, notably during winter, threaten the persistence of a lichen (seaside bone, *Hypogymnia heterophylla*) on southwest Vancouver Island and of the beach pinweed, *Lechea maritima*, a species restricted to stabilized sand dunes along coastal regions of New Brunswick and Prince Edward Island.

North America's vertebrates at greatest risk of extinction

Assessment and legal listing of fishes in Canada

Few spatiotemporal analyses of the status assessments of Canadian species have been undertaken. To date, the sole examination of temporal patterns is provided by Shank (1999) who focussed primarily on numbers of terrestrial mammal assessments and secondarily on the proportional representation of assessments by major taxonomic group from 1978 to 1998. Here, we provide an examination of trends in COSEWIC's assessments of fishes from the first undertaken in April 1980 to the most recent in November 2008.

Among the 577 species assessed by COSEWIC as being either extinct or at risk (extirpated, endangered, threatened, species concern), 19% are fishes, the highest proportional representation amongst vertebrates and second only to vascular plants (which comprise ~30% of the total assessments

Table 2. Status assessment summary (as of December 2008) for wildlife species assessed by CO-SEWIC as being extinct or at risk (extirpated, endangered, threatened, special concern).

Taxon	Extinct or extirpated	Endangered	Threatened	Special concern	Total
All species	36	238	146	157	577
Freshwater and diadromous fishes	9	30	18	28	85
Marine fishes	0	6	8	13	27
All fishes	9	36	26	41	112

Table 3. Taxonomic species of fishes assessed to be at risk (extirpated, endangered, threatened, special concern) throughout all or parts of their geographical ranges, as of December 2008. Abbreviations: AB, Alberta; ATL, Atlantic; ARC, Arctic; BC, British Columbia; MB, Manitoba; NB, New Brunswick; NL, Newfoundland and Labrador; NS, Nova Scotia; NT, Northwest territories; ON, Ontario; PAC, Pacific; PE, Prince Edward Island; QC, Quebec; SK, Saskatchewan; YK, Yukon.

Species	Locations
Freshwater and diadromous fishes	
Chestnut lamprey	<i>Ichthyomyzon castaneus</i> SK, MB
Northern brook lamprey	<i>I. fossor</i> ON, QC
Morrison creek lamprey	<i>Lampetra richardsoni</i> BC
Vancouver lamprey	<i>L. macrostoma</i> BC
Paddlefish	<i>Polyodon spathula</i> ON
Green sturgeon	<i>Acipenser medirostris</i> BC
Lake sturgeon	<i>A. fulvescens</i> AB, SK, MB, ON, QC
Shortnose sturgeon	<i>A. brevirostrum</i> NB
White sturgeon	<i>A. transmontanus</i> BC
Spotted gar	<i>Lepisosteus oculatus</i> ON
American eel	<i>Anguilla rostrata</i> ON, QC, NB, NS, PE, NL
Bigmouth buffalo	<i>Ictiobus cyprinellus</i> SK, MB, ON
Salish sucker	<i>Catostomus catostomus</i> ssp. BC
Spotted sucker	<i>Minytrema melanops</i> ON
Black redbhorse	<i>Moxostoma duquesnei</i> ON
Copper redbhorse	<i>M. hubbsi</i> QC
River redbhorse	<i>M. carinatum</i> ON, QC
Carmine shiner	<i>Notropis percobromus</i> MB
Bridle shiner	<i>N. bifrenatus</i> ON, QC
Silver shiner	<i>N. photogenis</i> ON
Pugnose shiner	<i>N. anogenus</i> ON
Nooksack dace	<i>Rhinichthys cataractae</i> ssp. BC
Umatilla dace	<i>R. umatilla</i> BC
Speckled dace	<i>R. osculus</i> BC
Redside dace	<i>Clinostomus elongatus</i> ON
Lake chubsucker	<i>Erimyzon sucetta</i> ON
Gravel chub	<i>Erimystax x-punctatus</i> ON
Silver chub	<i>Macrhybopsis storeriana</i> MB, ON
Western silvery minnow	<i>Hybognathus argyritis</i> AB
Pugnose minnow	<i>Opsopoeodus emiliae</i> ON
Northern madtom	<i>Noturus stigmosus</i> ON
Lake Utopia rainbow smelt	<i>Osmerus mordax</i> NB
Coho salmon	<i>Oncorhynchus kisutch</i> BC
Sockeye salmon	<i>O. nerka</i> BC
Chinook salmon	<i>O. tshawytscha</i> BC
Westslope cutthroat trout	<i>O. clarkii lewisii</i> BC, AB
Atlantic salmon	<i>Salmo salar</i> QC, NB, PE, NS, NL
Aurora trout	<i>Salvelinus fontinalis timagamiensis</i> ON
Spring cisco	<i>Coregonus</i> sp. QC
Squanga whitefish	<i>Coregonus</i> sp. YK
Shortnose cisco	<i>C. reighardi</i> ON
Shortjaw cisco	<i>C. zenithicus</i> NT, AB, SK, MB, ON

Table 3 (concluded).

Species		Locations
Bering cisco	<i>C. laurettae</i>	YK
Grass pickerel	<i>Esox americanus vermiculatus</i>	ON, QC
Banded killifish	<i>Fundulus diaphanus</i>	MB, ON, QC, NL
Blackstripe topminnow	<i>F. notatus</i>	ON
Stickleback	<i>Gasterosteus</i> sp.	BC
Rocky Mountain sculpin	<i>Cottus</i> sp.	AB
Cultus pygmy sculpin	<i>Cottus</i> sp.	BC
Shorthead sculpin	<i>C. confusus</i>	BC
Columbia sculpin	<i>C. hubbsi</i>	BC
Deepwater sculpin	<i>Myoxocephalus thompsonii</i>	NT, AB, SK, ON, QC
Eastern sand darter	<i>Ammocrypta pellucida</i>	ON, QC
Channel darter	<i>Percina copelandi</i>	ON, QC
Warmouth	<i>Lepomis gulosus</i>	ON
Striped bass	<i>Morone saxatilis</i>	QC, NB, PE, NS
Marine fishes		
White shark	<i>Carcharodon carcharias</i>	PAC, ATL
Porbeagle	<i>Lamna nasus</i>	ATL
Shortfin mako	<i>Isurus oxyrinchus</i>	ATL
Basking shark	<i>Cetorhinus maximus</i>	PAC, ATL
Blue shark	<i>Prionace glauca</i>	PAC, ATL
Tope	<i>Galeorhinus galeus</i>	PAC
Bluntnose sixgill shark	<i>Hexanchus griseus</i>	PAC
Winter skate	<i>Leucoraja ocellata</i>	ATL
Atlantic cod	<i>Gadus morhua</i>	ATL, ARC
Cusk	<i>Brosme brosme</i>	ATL
Roundnose grenadier	<i>Coryphaenoides rupestris</i>	ATL, ARC
Roughhead grenadier	<i>Macrourus berglax</i>	ATL
Rougeye rockfish	<i>Sebastes</i> sp.	PAC
Yelloweye rockfish	<i>S. ruberrimus</i>	PAC
Bocaccio	<i>S. paucispinis</i>	PAC
Canary rockfish	<i>S. pinniger</i>	PAC
Longspine thornyhead	<i>Sebastolobus altivelis</i>	PAC
Atlantic wolffish	<i>Anarhichas lupus</i>	ATL
Northern wolffish	<i>A. denticulatus</i>	ATL
Spotted wolffish	<i>A. minor</i>	ATL

in the above-mentioned categories) (Tables 2, 3). Among the 36 endangered and extirpated wildlife species, fishes are the dominant taxonomic group (25%). Of the 112 fishes in these 5 categories, most (76%) are freshwater or diadromous (i.e., species that move regularly between fresh and salt water), probably because of the shorter history of marine fish status assessments (see below).

The first fishes assessed by COSEWIC, at its April 1980 assessment meeting, were freshwater and diadromous species: shortnose sturgeon, speckled dace, blueback herring, *Alosa aestivalis*, and the giant stickleback, *Gasterosteus* sp., that inhabit two lakes on Haida Gwaii. With the exception of herring (not at risk), all species were assessed as rare (now special concern).

During the first decade of fish assessments, the species considered were concentrated in southwestern Ontario (Fig. 2a). The distribution expanded during the first 20 years of assessments to include more of southern British Columbia and southern Quebec, with the density of species at risk most noticeably increasing in southern Ontario, Quebec, and Manitoba (Fig. 2b). Collating all assessments from April 1980 through November 2008, the distribution of fishes at

risk has increased across the country with the highest concentrations in southern British Columbia, southern Manitoba, southwestern Ontario, and southeastern Quebec (Fig. 2c). Of the 20 marine fishes assessed to be at risk (Table 3), 8 are found only in the Atlantic, 7 only in the Pacific, 3 species inhabit both oceans, and 2 Atlantic species also inhabit eastern waters of the Arctic Ocean.

Temporally, the numbers of freshwater and diadromous fishes assessed as being endangered, threatened, and special concern in Canada has increased in an approximately linear fashion since 1980 (Fig. 3). During the first 20 years, most of the assessments were in the special concern category. However, since the late 1990s, most species were assessed as endangered. As of December 2008, 76 wildlife species of freshwater and diadromous fishes had been assessed as being at risk in Canada. Of Canada's estimated 205 freshwater and diadromous biological fish species (Nicholas Mandrak, Department of Fisheries and Oceans, Burlington, ON; personal communication), 57 (28%) have been assessed as being at risk throughout all or parts of their range. An additional 6 have been assessed as extinct, 31 as not at risk, and 15 as data deficient.

Fig. 2. Distribution of freshwater and diadromous fishes assessed by COSEWIC as being at risk in Canada. (a) All species assessed from 1980 through 1989. (b) All species assessed from 1980 through 1999. (c) All species assessed from 1980 through 2008.

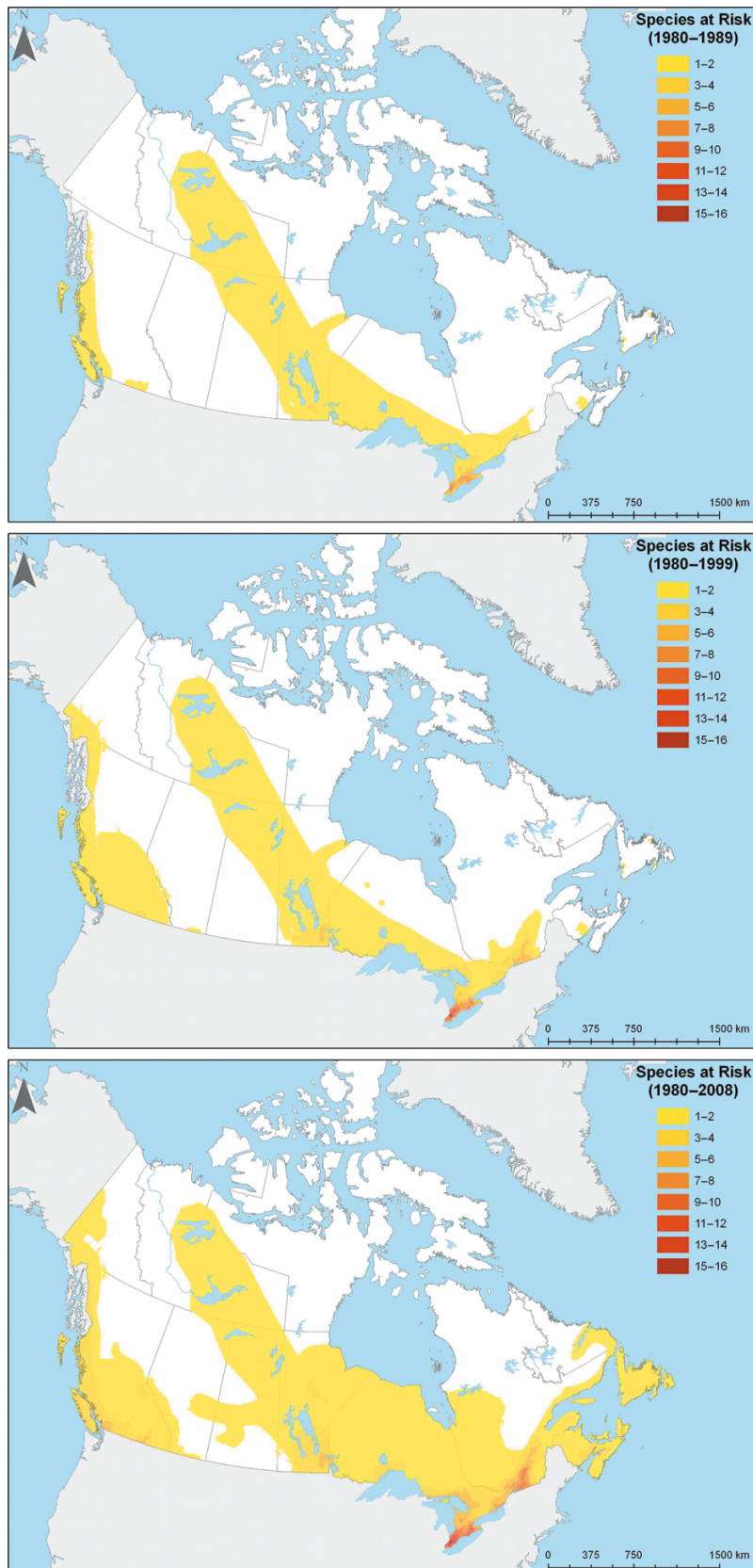
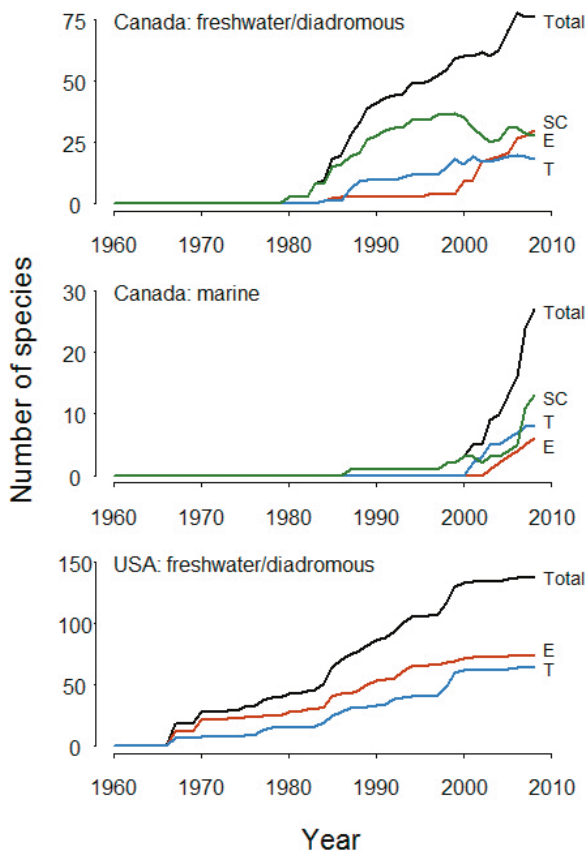


Fig. 3. Temporal trends in the assessment of freshwater, diadromous, and marine fishes at risk in Canada, and of freshwater and diadromous fishes listed as endangered or threatened in the United States. Abbreviations: E, endangered (red lines); T, threatened (blue lines); SC, special concern (green lines).



Since the initial assessment of a marine fish in 1987, the number assessed as being at risk has increased steadily, notably since the late 1990s (Fig. 3). The first marine fish wildlife species to be assessed as endangered was the Newfoundland and Labrador population of Atlantic cod (because of an estimated 97% reduction in abundance since the early 1960s) in 2003. Since then, endangered marine fishes have included porbeagle, *Lamna nasus*, basking shark (Pacific), white shark (Atlantic), *Carcharodon carcharias*, winter skate (Southern Gulf of St. Lawrence), *Leucoraja ocellata*, and roundnose grenadier. Of Canada's estimated 834–950 biological species of marine fish (Coad 1995; Reist 1997), 20 (2.1%–2.4%) have been assessed as being at risk.

Since the proclamation of SARA and the beginning of the post-assessment consultation process in 2003, fishes have represented the taxonomic group least likely to be included on Canada's legal list of species at risk (Mooers et al. 2007). Although the incidence of national legal listing among freshwater fishes (82%) is comparable to (albeit lower than) that of most other taxa, the Canadian government has yet to list any of the endangered or threatened marine fishes assessed as being at risk since the passage of SARA (the first special concern marine fishes, for which SARA requires management plans, were listed in January 2009; Canada 2009).

The primary reason for not listing threatened and endangered marine fishes would appear to be based on the perception that the short-term socioeconomic costs to business, industry, and consumers of listing exceed the longer-term socioeconomic benefits of listing (Mooers et al. 2007). The latter include non-extractive and non-use economic benefits associated with species conservation (Canada 2009). These benefits have yet to be quantitatively incorporated in the cost-benefit analyses associated with the listing of fishes at risk, ostensibly because of limited data (but see Rudd 2009), despite a Government of Canada directive which requires that government departments and agencies “assess regulatory and non-regulatory options to *maximize net benefits to society as a whole*” [*italics added*] when they perform cost-benefit analyses in support of regulatory decisions, such as those associated with the listing of species under SARA (Canada 2007).

For many species, the extended-consultation process, coupled with the referral of species back to COSEWIC for further consideration, has led to unduly lengthy delays in listing decisions. For example, as of March 2009, the federal government had yet to make a listing decision on three species assessed by COSEWIC more than 5 years ago: bocaccio, *Sebastes paucispinis* (threatened: 2002), cusk, *Brosme brosme* (threatened: 2003), and the Arctic population of Atlantic cod (special concern: 2003). This situation reveals an unexpected and unfortunate weakness of SARA: the ability of the federal government to postpone almost indefinitely listing decisions.

Assessment and legal listing of fishes in the United States

To place the assessments of Canadian fishes in some perspective, a comparison with those undertaken in the land mass with which it is contiguous seems appropriate. One caveat to this comparison is that while Canadian data for all assessed species (including those deemed data deficient or not at risk) are readily available, in the US data are available only for those species that have been listed under the ESA as endangered and threatened. To our knowledge, there is no publicly available list of species recommended for listing by US government agencies (who are responsible for undertaking the assessments) that were subsequently not accepted by the US Federal Government.

The first fishes listed in the US were assessed under the auspices of the Endangered Species Preservation Act (1966), the immediate predecessor of the ESA (1973). In 1967, the US Fish and Wildlife Service reported that 29% of the native endangered or threatened vertebrates were fishes (www.fws.gov; accessed 2 January 2009). In 1996, for vertebrates only, the US approved criteria for assessing populations or groups of populations, termed distinct population segments (DPSs, or evolutionarily significant units for Pacific salmon), below the biological species level (USFWS 1996). Within the Canadian context, a DPS is functionally equivalent to a wildlife species (or DU) (Hutchings and Festa-Bianchet 2009). As of January 2009, of the 374 vertebrates listed as endangered and threatened in the US (including DPSs), 37% were fishes (http://ecos.fws.gov/tess_public/TESSBoxscore; accessed 6 January 2009).

Among the approximately 205 biological species of freshwater and diadromous fishes in Canada (Nicholas Mandrak,

Department of Fisheries and Oceans, Burlington, ON; personal communication), 33 (16%) have been assessed as endangered or threatened throughout all, or parts, of their Canadian range. This level of assessed risk of extinction is similar to that in the US where, of approximately 965 biological species of freshwater and diadromous fishes (www.fishbase.org), 118 (12%) have been listed as endangered or threatened under the ESA. By contrast, only 1 of the approximately 2150 (www.fishbase.org) marine fishes in the US has been listed as endangered or threatened under the ESA. In Canada, of 13 biological species of marine fishes assessed as endangered or threatened, none has been legally listed, as noted above. The governments of both countries appear extremely reluctant to apply national endangered species legislation to enable the recovery of marine fishes at heightened risk of extinction.

Temporally, the number of listed fishes in the US increased steadily to the year 2000 at a rate of approximately 4 species or DPSs per annum (Fig. 3). Since 2000, however, the number of listed fishes has changed little, with the rate of listing having declined by more than one order of magnitude.

Concluding remarks

The primary objectives of the present study were twofold. The first was to provide a review of species status assessments undertaken by COSEWIC from 2006 to 2008. In so doing, we fill a temporal gap in the treatments of COSEWIC's assessments since the committee's inception and provide a contemporary perspective on the latest data concerning species at risk in Canada. The primary threats facing the nearly 600 Canadian wildlife species at risk include anthropogenic-induced mortality (e.g., over-exploitation), habitat alteration and destruction, invasive species, and climate change (Venter et al. 2006). Our second objective was to focus on temporal, spatial, and taxonomic variation in the assessments of the most numerous imperilled group of vertebrates in Canada. Although the number of fishes assessed as being at risk increases annually, the addition of fishes to the SARA legal list is slower than that for any other component of Canada's fauna and flora (Mooers et al. 2007).

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