**Supplementary Material**

Table S1. Summary of peer-reviewed papers (in reverse chronological order) that have evaluated the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) reports and/or the efficacy of Canada’s Species At Risk Act (SARA) at protecting at-risk marine fishes, including the taxonomic groups assessed, number of species assessed, the species’ SARA status, the purpose of the study, the part of the SARA process reviewed, data reviewed, and main findings of the study.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Taxa | No. species assessed | SARA Status | Purpose | Which part of the SARA process? | Data Reviewed | Main Findings | Ref.  |
| All | 369 | COSEWIC Assessed (more than once) | Assess the effectiveness of biodiversity conservation in Canada through SARA | SARA Listing | COSEWIC Assessments; Listing Decisions; Finalized Recovery Strategies | -5.4% of at-risk species improved to ‘not-at-risk’ (five were from increased sampling effort)-47% of Special Concern species declined into a higher risk category-56 out of 221 species had critical habitat fully identified | 1 |
| Marine Fishes, FW Fishes | 54 | Listed vs. Not-Listed | Determine if there are economic thresholds that prevent SARA listing | SARA Listing  | Listing Decisions; Reasons for listing/not-listing | -No marine fish with an estimated cost of protection greater than zero was listed on SARA -Rationale used in listing decisions was inconsistent between marine and freshwater fishes | 2 |
| All  | 146 | Listed | Assess major threats to listed species and if the SARA recovery process is working | Final Recovery Strategies | COSEWIC Assessments; Finalized Recovery Strategies | -Ambition of recovery goals was not linked to particular threats-Species threatened with biological resource use were less likely to be listed under SARA and/or to have a finalized recovery strategy | 3 |
| All | 164 | Listed  | Assess management of species at risk in Canada by looking at the lead agency responsible for recovery strategies | Final Recovery Strategies | Finalized Recovery Strategies | -Only 17% of strategies created by DFO included critical habitat-50% increase in recovery strategies that identified critical habitat after court judgments | 4 |
| All | 668 | COSEWIC Assessed | Compare ESA and SARA in protecting species at risk | SARA Deadlines | COSEWIC Assessments; SARA Process Deadlines | -SARA’s strength is all status evaluations are conducted by COSEWIC-ESA’s strengths are more stringent deadlines and listing decisions cannot consider socioeconomic factors. | 5 |
| All | 518 | Listed | Audit to determine if departments have followed their deadlines for creating SARA measures for listed species | Final Recovery Strategies; Final Action Plans; Final Management Plans | Final Recovery Strategies; Final Action Plans; Final Management Plans | -84% of recovery strategies were overdue by more than three years -43% of these recovery strategies did not include critical habitat-There are 97 required action plans, yet only 7 have been created | 6 |
| Marine Fishes | 3 | Listed | Uses the case study of listed wolfish species on SARA to describe protection and challenges for marine fishes under SARA | SARA Listing  | Listing Decisions; Semi-structured Interviews of Key Informants and Harvesters | -Limited evidence that listing wolfish has increased harvester stewardship and engagement in their conservation-Suggest SARA needs a delisting strategy, specifically delisting requirements and deadlines. | 7 |
| Marine Fishes | 61 | COSEWIC Assessed | Describe how COSEWIC assesses the extinction risk of marine fishes | COSEWIC Assessments; SARA Listing  | COSEWIC Assessments; Listing Decisions; Marine Fishes Case Studies | -Marine fishes are showing severe declines but few have been listed on SARA Schedule 1-Case studies of marine fishes show some with strong conservation measures and others with limited measures | 8 |
| All | 176 | Listed | Evaluate SARA, outline its strengths/weaknesses and provide suggestions for improvement | SARA Listing; Final Recovery Strategies; Final Action Plans | COSEWIC Assessments; Listing Decisions; Finalized Recovery Strategies; Finalized Action Plans | -SARA needs delineation between science and policy-176 species were listed in 2003 but only one of these species has a recovery strategy | 9 |
| All | 339 | COSEWIC Assessed At-Risk | Link threats of at-risk species to industries | COSEWIC Assessments | COSEWIC Assessments; IUCN unified threats classification system | -Biological resource use was the highest threat to Canadian at-risk species-Threats from fishing were difficult to mitigate but species threatened by fishing had a high probability of recovering  | 10 |
| All | 577 | COSEWIC Assessed | Update summaries on Canadian species at risk and provide spatial and temporal analyses on COSEWIC assessed fishes | COSEWIC Assessments; SARA Listing | COSEWIC Assessments; Listing Decisions | -Proportion of FW fishes on SARA is slightly lower than other taxa.-SARA has not listed an Endangered or Threatened marine fish since its proclamation in 2003 | 11 |
| All | 202 | Listed vs. Not-Listed | Expand on Mooers et al. (2007), to describe SARA’s listing process  | SARA Listing  | Listing Decisions; Reasons for listing/not-listing | -Species were less likely to be listed if harvested or commercial fishing was listed as a threat, had DFO as their responsible authority, were found in northern Canada or if found almost entirely within Canada | 12 |
| All  | 186 | Listed vs. Not-listed | Determine if there are taxonomic or geographic biases in SARA listings | SARA Listing  | Listing Decisions | -Biases against listing marine fishes, marine mammals and species in northern Canada | 13  |
| Marine Fishes | NA | Listed | Examine SARA and how it worked for the first two years, focusing on marine fishes | SARA Listing; SARA Measures | General SARA Process | -Describes uncertainties in SARA implementation for marine fishes-Provides suggestions for SARA reform by increasing marine protected areas and improving the *Fisheries Act* | 14 |

1 Favaro et al. 2014; 2 Schultz et al. 2013; 3 McCune et al. 2013; 4 Taylor and Pinkus 2013; 5 Waples et al. 2013; 6 Office of the Auditor General Canada 2013; 7 Dawe and Neis 2012; 8 Powles 2011; 9 Mooers et al. 2010; 10 Prugh et al. 2010; 11 Hutchings and Festa-Bianchet 2009; 12 Findlay et al. 2009; 13 Mooers et al. 2007; 14 Vanderzwaag and Hutchings 2005

Table S2. Comparison of the COSEWIC status, SARA status, range, reason for COSEWIC designation, threats, habitat, and management for: (A) five rockfish species (seven when the species are split into populations), (B) three wolffish species, *Anarhichas spp.,* and cusk, *Brosme brosme*.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| A) | **Rougheye Rockfish Type I & Type II, *Sebastes sp. type I & type II*** | **Longspine Thornyhead*, Sebastolobus altivelis*** | **Yelloweye Rockfish Pacific Outside & Inside Waters, *Sebastes ruberrimus*** | **Bocaccio,*****Sebastes paucispinis*** | **Canary Rockfish,** ***Sebastes pinniger*** |
| COSEWIC Status | Special Concern | Special Concern | Special Concern | Endangered | Threatened |
| SARA Listing | Listed | Listed | Listed | Not Listed | Not Listed |
| Canadian Range | Pacific Ocean: BC continental shelf/slope between 170 and 650 m | Pacific Ocean | Pacific Ocean: from Alaska border to Washington State | BC Marine Waters | Coastal waters of BC |
| Reason for COSEWIC Designation | Large and long-lived, abundance is uncertain, suggestions of mortality, susceptible to population collapse, difficult to identify the two cryptic species | Slow-growing, estimated decline in CPUE over 50% in past 8 years, cause of decline is fishing, no management strategy, potential rescue from US populations  | Late maturity and long-lived making it susceptible to human-induced mortality, no detected significant declines | Severe declines and low spawning abundance due to low recruitment and high fishing  | Large, late maturity, long lifespan, long generation, slow recovery after a population decline, two surveys show declines, uncertainty in abundance trends, fishing is the most likely cause of decline, |
| Threats | Fishing mortality on long-lived species, lack of knowledge because it is recently discovered, difficult to identify the two cryptic species | Overfishing in low productivity environments, ~49 million fish removed from 1996-2004 | Fishing, recreational catches are not well monitored | Commercial harvest, recreational harvest, bycatch in fisheries | management is not supported by a risk analysis |
| Habitat | Soft bottoms, boulders, slopes greater than 20 degrees, 170-650m in depth, avoids flat bottoms? | Not much data, prefers soft sand or mud bottoms, deep-water, low productivity environments with high pressure and reduced oxygen concentrations | 19-251 m depth, hard, complex substrates, vertical relief (broken rock, rock reefs, ridges, overhangs, crevices, caves, cobble/boulder fields) | Can be semi-pelagic, variety of bottom types at 60-240 m | Rocky bottom in 70-270m on the continental shelf |
| Management (Average % of FA policy included in IFMPs) | 75.00% | 75.00% | 77.5% | 87.50% | 75.00% |
| Reference | COSEWIC 2007*a* | COSEWIC 2007*b* | COSEWIC 2008 | COSEWIC 2013 | COSEWIC 2007*c* |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| B) | **Cusk,** ***Brosme brosme*** | **Northern Wolffish, *Anarhichas denticulatus*** | **Atlantic Wolffish,** ***Anarhichas lupus*** | **Spotted Wolffish,*****Anarhichas minor*** |
| COSEWIC Status | Endangered | Threatened | Special Concern | Threatened |
| SARA Listing | Not Listed | Listed | Listed | Listed |
| Canadian Range | Atlantic Ocean including the Scotian Shelf, Gulf of Maine and the northwest Atlantic Ocean  | Eastern and Western Arctic Ocean, Atlantic Ocean including the Gulf of Maine, Scotian Shelf, Grand Banks, Gulf of St. Lawrence, Northeastern Newfoundland and Labrador Sea | Eastern Arctic Ocean, Atlantic Ocean including the Bay of Fundy, Scotian Shelf, Grand Banks off Newfoundland, Gulf of St. Lawrence, northeastern Newfoundland and Labrador Sea | Eastern Arctic Ocean, Atlantic Ocean including the Scotian Shelf, Grand Banks, Gulf of St. Lawrence, northeastern Newfoundland and the Labrador Sea |
| Reason for COSEWIC Designation | Large, slow-growing species, declining since 1970, ~85% decline in the total number of mature individuals over 3 generations, strong evidence its area of occupancy has declined, average fish size has declined, so far management has not stopped the decline | Large declines in abundance and range size during 1980’s, small increases since 2002 that correspond with recovery measures (mandatory live release), recovery could be limited by bycatch in fisheries, at low levels compared to 1970’s | Large declines in abundance and area of occupancy during the 1980’s-mid 1990’s, increasing in abundance and area of occupancy since probably due to reduced commercial fisheries where it’s caught as bycatch, species is at low abundance compared to early 1980’s, still declining in abundance on Scotian Shelf and Southern Gulf of St. Lawrence | Large declines in abundance and area of occupancy during the 1970’s-mid 1990’s, some increases since probably due to reduced bottom fisheries that catch this species as bycatch and they now have a mandatory release protocol, abundance is low compared to historical levels |
| Threats | Overfishing as bycatch to Cod, Haddock, Pollock, Halibut and Lobster Fisheries | Bycatch in commercial fisheries, climate change (particularly water temperature) | Commercial fisheries (mainly bycatch), environmental fluctuations, climate change | Bycatch in commercial fisheries, climate factors |
| Habitat | Hard, rough, rocky substrates, not often on smooth sand, common at temperatures from 0°-14°C, not usually found near shore or at depths <20-30m, occurs between 150-450m depth, but has been found at 1185 m | Adults are found on the bottom and in the water column usually at depths of 500-1000m, caught on all bottom types but most common on sand in the spring and shell hash in the fall, commonly found at 2°-5°C | Typically on the continental shelf on rocky or sandy bottoms, temperature range -1.5°C to 13°C | Not well known, usually found on the bottom as a juvenile and adults at 200-750 m on the continental shelf or in deep trenches |
| Management (Average % of FA policy included in IFMPs) | 52.5% | 54.17% | 54.17% | 54.17% |
| Reference | COSEWIC 2012*d* | COSEWIC 2012*a* | COSEWIC 2012*b* | COSEWIC 2012*c* |

Table S3. MSC certified fisheries in Canada, their interactions with species assessed by COSEWIC as being at-risk, and those at-risk species that are recognized as ETP species by the MSC.

|  |  |  |
| --- | --- | --- |
| **MSC Certified Fishery** | **Interactions with at-risk species (COSEWIC)** | **Recognized as ETP species (SARA listed)** |
| Atlantic halibut (*Hippoglossus hippoglossus*) | Cusk (*Brosme brosme*) Atlantic cod (*Gadus morhua*), American plaice (*Hippoglossoides platessoides*), redfish (*Sebastes fasciatus*), thorny skate (*Amblyraja radiate*), spiny dogfish (*Squalus acanthias*), porbeagle shark (*Lamna nasus*) | Spotted, Northern and Atlantic wolffish (*Anarhichas minor, denticulatus, lupus*) |
| Northern/striped shrimp (*Pandalus borealis/Pandalus montagui*) | Cusk, Atlantic cod, American plaice, redfish, spiny dogfish | Spotted and Northern wolffish |
| Scotia haddock (*Melanogrammus aeglefinus*) | Cusk, Atlantic cod, white hake (*Urophycis tenuis*), spiny dogfish, porbeagle shark  | Spotted, Northern and Atlantic wolffish  |
| Arctic surf clam (*Mactromeris polynyma*) | American plaice  | None listed in assessment report |
| Eastern offshore scallop (*Placopecten magellanicus*) | Cusk, Atlantic cod, American plaice, thorny skate, winter skate (*Leucoraja ocellata*), spiny dogfish  | Spotted and Northern wolffish |
| Eastern offshore lobster (*Homarus americanus*) | Cusk, Atlantic cod, white hake, redfish, spiny dogfish | None listed in assessment report |
| Full Bay scallop (*Placopecten magellanicus*) | Cusk, thorny skate, winter skate, American plaice  | Atlantic wolffish |
| Gulf of St. Lawrence snow crab (*Chionoecetes opilio*) | None cited in assessment report | Spotted and Atlantic wolffish  |
| Isle de Madeleine lobster (*Homarus americanus*) | None listed in assessment report | Northern and Atlantic wolffish  |
| NFLD and Labrador snow crab (*Chionoecetes opilio*) | Atlantic cod, American plaice  | Spotted and Northern wolffish |
| Northwest Atlantic swordfish (*Xiphias gladius*) | Porbeagle shark, blue shark *(Prionace glauca*), bluefin tuna (*Thunnus thynnus*), shortfin mako (*Isurus oxyrinchus*) | White shark (*Carcharodon carcharias*) |
| Grand Bank yellowtail flounder (*Limanda ferruginea*) | Atlantic cod, American plaice, redfish, porbeagle shark, blue shark | Spotted, Northern and Atlantic wolffish  |
| Scotian shelf snow crab (*Chionoecetes opilio*) | Atlantic cod, American plaice, redfish, thorny skate | Spotted and Northern wolffish |
| Scotian shelf shrimp (*Pandalus borealis*) | American plaice, redfish, thorny skate | Spotted and Northern wolffish |
| Pacific chum salmon (*Oncorhynchus*) | Coho, sockeye, chinook salmon (*Oncorhynchus kisutch, nerka,* *tshawytscha)*  | None listed in assessment report |
| Pacific pink salmon (*Oncorhynchus gorbuscha*) | Coho, sockeye, chinook salmon | None listed in assessment report |
| Pacific sockeye salmon (*Oncorhynchus nerka*) | Sockeye salmon | White sturgeon (*Acipenser transmontanus*) |
| Pacific halibut (*Hippoglossus stenolepis*) | Basking shark (*Cetorhinus maximus*) rockfish species (*Sebastes spp*.), Boccaccio (*Sebastes paucispinis)*, chinook salmon, longspine thornyhead (*Sebastolobus altivelis*) | None listed in assessment report |
| Pacific albacore tuna (*Thunnus alalung*a) | Blue shark | None listed in assessment report |
| Pacific hake mid-water trawl (*Merluccius productus*) | Rockfish species, Boccaccio, chinook salmon  | Sturgeon species (*Acipenseridae*) |
|  | **Total: 18** | **Total: 5** |

Supplementary References

COSEWIC. 2007a. COSEWIC assessment and status report on the rougheye rockfish *Sebastes sp. type I* and *Sebastes sp. type II* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. viii + 36. [online] Available from <http://www.sararegistry.gc.ca/virtual_sara/files/cosewic/sr_sebastes_sp_e.pdf> [accessed 20 October 2014].

COSEWIC. 2007b. COSEWIC assessment and status report on the longspine thornyhead *Sebastolobus altivelis* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. vi + 27. [online] Available from <http://publications.gc.ca/collections/collection_2007/ec/CW69-14-527-2007E.pdf> [accessed 20 October 2014].

COSEWIC. 2007c. COSEWIC assessment and status report on the Canary Rockfish *Sebastes pinniger* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. vi + 71. [online] Available from <https://www.registrelep-sararegistry.gc.ca/default.asp?lang=En&n=2364E762-1> [accessed 20 October 2014].

COSEWIC. 2008. COSEWIC assessment and status report on the Yelloweye Rockfish *Sebastes ruberrimus*, Pacific Ocean inside waters population and Pacific outside waters population, in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. vii + 75. [online] Available from <http://www.sararegistry.gc.ca/virtual_sara/files/cosewic/sr_yelloweye_rockfish_0809_e.pdf> [accessed 20 October 2014].

COSEWIC. 2012a. COSEWIC assessment and status report on the Spotted Wolffish *Anarhichas minor* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. x + 44. [online] Available from http://www.registrelep-sararegistry.gc.ca/virtual\_sara/files/cosewic/sr\_loupe\_tachete\_spotted\_wolffish\_1113\_e.pdf [accessed 20 October 2014].

COSEWIC. 2012b. COSEWIC assessment and status report on the Atlantic Wolffish *Anarhichas lupus* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. ix + 56. [online] Available from http://publications.gc.ca/collections/collection\_2013/ec/CW69-14-262-2013-eng.pdf [accessed 20 October 2014].

COSEWIC. 2012c. COSEWIC assessment and status report on the Northern Wolffish *Anarhichas denticulatus* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. x + 41. [online] Available from http://publications.gc.ca/collections/collection\_2013/ec/CW69-14-241-2013-eng.pdf [accessed 20 October 2014].

COSEWIC. 2012d. COSEWIC assessment and status report on the cusk *Brosme brosme* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. x + 85. [online] Available at: <http://publications.gc.ca/collections/collection_2013/ec/CW69-14-332-2013-eng.pdf> [accessed 20 October 2014].

COSEWIC. 2013. COSEWIC assessment and status report on the Bocaccio *Sebastes paucispinis* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. xi + 49. [online] Available from <http://www.sararegistry.gc.ca/virtual_sara/files/cosewic/sr_Bocaccio_2013_e.pdf> [accessed 20 October 2014].

Dawe, J.L., and Neis, B. 2012. Species at risk in Canada: Lessons learned from the listing of three species of wolfish. Marine Policy **36**: 401-413.

Favaro, B., Claar, D.C., Fox, C.H., Freshwater, C., Holden, J.J., Roberts, A., and UVic Research Derby. 2014. Trends in extinction risk for imperiled species in Canada. PLOS One 9(11): e113118. doi:10.1371/journal.pone.0113118.

Findlay, C.S., Elgie, S., Giles, B., and Burr, L. 2009. Species listing under Canada’s Species at Risk Act. Conservation Biology **23**(6): 1609-1617.

Hutchings, J.A., and Festa-Bianchet, M. 2009. Canadian species at risk (2006-2008), with particular emphasis on fishes. Environmental Reviews **17**: 53-65.

McCune, J.L., Harrower, W.L., Avery-Gomm, S., Brogan, J.M., Csergo, Davidson, L.N.K., Garani, A., Halpin, L.R., Lipsen, L.P.J., Lee, C., Nelson, J.C., Prugh, L.R., Stinson, C.M., Whitney, C.K., and Whitton, J. 2013. Threats to Canadian species at risk: an analysis of finalized recovery strategies. Biological Conservation **166**: 254-265.

Mooers, A.O., Prugh, L.R., Festa-Bianchet, M., and Hutchings, J.A. 2007. Biases in Legal Listing under Canadian Endangered Species Legislation. Conservation Biology **21**(3): 572-575.

Mooers, A.O., Doak, D.F., Findlay, C.S., Green, D.M., Grouios, C., Manne, L.L., Rashvand, A., Rudd, M.A., and Whitton, J. 2010. Science, Policy, and Species at Risk in Canada. BioScience **60**(10): 843-849.

Office of the Auditor General of Canada. 2013. 2013 Fall Report of the Commission of the Environment and Sustainable Development Chapter 6- Recovery Planning for Species at Risk. [online] Available from <http://www.oag-bvg.gc.ca/internet/English/parl_cesd_201311_e_38658.html> [accessed 20 October 2014].

Powles, H. 2011. Assessing Risk of Extinction of Marine Fishes in Canada – The COSEWIC Experience. Fisheries **36**(5): 231-246.

Prugh, L.R., Sinclair, A.R.E., Hodges, K.E., Jacon, A.L., and Wilcove, D.S. 2010. Reducing threats to species: threat reversibility and links to industry. Conservation Letters **3**: 267-276.

Schultz, J.A., Darling, E.S., and Côté, I.M. 2013. What is an endangered species worth? Threshold costs for protecting imperiled fishes in Canada. Marine Policy **42**: 125-132.

Taylor, E.B., and Pinkus, S. 2013. The effects of lead agency, nongovernmental organizations, and recovery team membership on the identification of critical habitat for species at risk: insights from the Canadian experience. Environmental Reviews **21**(2): 93-102.

Vanderzwaag, D.L., and Hutchings, J.A. 2005. Canada’s Marine Species at Risk: Science and Law at the helm, but a Sea of Uncertainties. Ocean Development & International Law **36**(3): 219-259.

Waples, R.S., Nammack, M., Cochrane, J.F., and Hutchings, J.A. 2013. A Tale of Two Acts: Endangered Species Listing Practices in Canada and the United States. Bioscience**63**(9): 723-734.