Appendix 1. Survey questionnaire

Evaluating the integration of cumulative effects and multiple stressors in the management of Canada's marine conservation areas

First, you will be asked some basic information about where you work, the type of conservation area you currently work with and your level of experience working with marine conservation areas.

1) Which federal department do you work for?
    - Fisheries and Oceans Canada
    - Environment and Climate Change Canada
    - Parks Canada

2) What type of conservation area do you currently manage and/or work with?
    - National Marine Conservation Area
    - Marine Protected Area
    - National Wildlife Area
    - Migratory Bird Sanctuary
    - Other effective area-based conservation measures (please describe)
    - Other (please explain)

3) How long have you been involved in decisions affecting the design, implementation or management of marine conservation areas?
    - Less than 1 year
    - 1 to 5 years
    - 5 to 10 years
    - More than 10 years

4) In terms of your departmental hierarchy, please indicate which of the following best matches your position?
    - Junior level biologist (or scientist)
    - Senior level biologist (or scientist)
    - Junior level manager
    - Senior level manager
    - Junior level policy advisor
    - Senior level policy advisor
    - Other (please explain)

5) In which of Canada's three oceans is the conservation area(s) that you manage and/or work with? (select all that apply)
    - Pacific Ocean
    - Arctic Ocean
    - Atlantic Ocean
    - Other (please explain)

Next, you will be asked some questions about how you consider cumulative effects and/or multiple stressors in your work as well as how you define the scope of your assessments. For the rest of this survey, "stressor" is akin to "driver" and is defined as "any natural or anthropogenic pressure that causes a quantifiable change, whether positive or negative, in biological or socio-economic response". "Cumulative effects" are akin to "cumulative impacts" and are defined as "combined or accumulated quantifiable changes in biological or socio-economic response from one or more stressor(s)".

6) Do you take into account or assess **cumulative effects** in your decision-making related to conservation areas,

including their identification, implementation and management?
    - Yes
    - No (please explain)

7) Do you take into account or assess **multiple stressors** in your decision-making related to conservation areas, including their identification, implementation and management?
    - Yes
    - No (please explain)

8) At what **spatial scale(s)** do you consider cumulative effects in your decision-making related to conservation areas, including their identification, implementation and management? (select all that apply)
    - Spatial scale of the conservation area
    - Spatial scale of the anticipated effects of stressors
    - Spatial distribution of important species or habitats (e.g. Valued Ecological Components, threatened or endangered species, key species, foundation habitats)
    - Spatial distribution of marine resource use and activities (e.g. Fishing areas, marine transportation corridors, tourism and recreation)
    - Watershed
    - Bioregion or Ecozone (i.e. geographical units with characteristic flora, fauna, and ecosystems)
    - Planning region
    - Legal Precedence
    - None of the above
    - Other (please explain)

9) At what temporal **scale(s)** do you consider cumulative effects in your decision-making related to conservation areas, including their identification, implementation and management? (select all that apply)
    - Past activities and effects
    - Present activities and effects
    - Future activities and effects (up to 1 year)
    - Future activities and effects (1-5 years)
    - Future activities and effects (more than 5 years)
    - Past baseline conditions
    - Present baseline conditions
    - None of the above
    - Other (please explain)

10) What Acts, Regulations, Policies and/or Standards of practice require you to consider **cumulative ecological effects** in your decision-making related to conservation areas, including their identification, implementation and management? (please describe)

11) What Acts, Regulations, Policies and/or Standards of practice require you to consider **socio-economic effects** in your decision-making related to conservation areas, including their identification, implementation and management? (please describe)

The next set of questions will ask you about the indicators, activities, and stressors as well as the tools and the type of information you include in your assessments and decision-making related to the identification, implementation and management of marine conservation areas.

12) Which **human activities** do you consider when assessing cumulative effects in your decision-making related to conservation areas, including their

identification, implementation and management? (select all that apply)

- Fish Harvesting
- Aquaculture
- Waste discharges or marine spills
- Recreation
- Tourism
- Marine transportation
- Coastal development
- Mining (e.g. deep-sea mining)
- Offshore oil and gas development
- Agriculture (e.g. land-based nutrient pollution)
- None of the above
- Other (please explain)

13) Which **ecological** stressors do you consider when assessing cumulative effects in your decision-making related to conservation areas, including their identification, implementation and management? (select all that apply)
    - Changes in climate conditions (e.g. temperature, precipitation, acidification, UV radiation)
    - Changes in sediment inputs
    - Changes in nutrient inputs
    - Physical disturbance
    - Disease
    - Introduction of pollutants
    - Introduction of non-indigenous species
    - Anthropogenic litter/debris
    - Anthropogenic Noise
    - Light
    - None of the above
    - Other (please explain)

14) What are three key ecological indicators that you use when assessing cumulative effects in your decision-making related to conservation areas, including their identification, implementation and management. (Please describe)

15) Please indicate any **social** indicators (e.g. cultural use, human health & community well-being) you consider when assessing cumulative effects in your decision-making related to conservation areas, including their identification, implementation and management. (select all that apply)
    - Quality of human health (e.g. stress levels)
    - Access to community services (e.g. education)
    - Community welfare (e.g. standard of living)
    - Population composition (e.g. demographics)
    - Local marine resource use patterns (e.g. fishing areas, marine transportation corridors, tourism and recreation)
    - Local values and beliefs regarding marine resources
    - Other (please explain)

16) Please indicate any **economic** indicators (e.g. employment & economic value of industries) you consider when assessing cumulative effects in your decision-making related to conservation areas, including their identification, implementation and management. (select all that apply)
    - Economic value of fisheries in the area
    - Economic value other industries in the area (e.g. tourism)
    - Nature of employment in the area (e.g. fish harvester versus tour boat operator)
    - Employment / Unemployment rates
    - Household income levels

- Community infrastructure and business
- Possible displacement issues (i.e. availability of alternative income or livelihood sources)
- None of the above
- Other (please explain)

17) How important are **ecological** indicators (e.g. spawning stock biomass, fishery recruitment, species diversity) when assessing cumulative effects in your decision-making related to conservation areas, including their identification, implementation and management?
    - Very important
    - Somewhat important
    - Somewhat unimportant
    - Not important

18) How important are **social** indicators (e.g., community well-being, cultural use) when assessing cumulative effects in your decision-making related to conservation areas, including their identification, implementation and management?
    - Very important
    - Somewhat important
    - Somewhat unimportant
    - Not important

19) How important are **economic** indicators (e.g. employment) when assessing cumulative effects in your decision-making related to conservation areas, including their identification, implementation and management?
    - Very important
    - Somewhat important
    - Somewhat unimportant
    - Not important

20) Do you consider the potential *negative* cumulative **ecological** effects (e.g. decreases in fish populations outside of the conservation area) of a conservation area in your decision-making related to conservation areas, including their identification, implementation and management?
    - Yes
    - No (please explain)

21) Do you consider the potential *positive* **socio-economic** cumulative effects (e.g. improved quality of human health or increased value of industries in the area) of a conservation area on human communities in your decision-making related to conservation areas, including their identification, implementation and management?
    - Yes
    - No (please explain)

22) Do you consider the potential *negative* **socio-economic** cumulative effects (e.g. loss of employment or loss of cultural/traditional use of the area) of a conservation area on human communities in your decision-making related to conservation areas, including their identification, implementation and management?
    - Yes
    - No (please explain)

23) What sources of **ecological** information do you use to assess cumulative effects in your decision-making related to conservation areas, including their identification, implementation and management? (select all that apply)
    - Published peer-reviewed meta-analyses or literature reviews
    - Other published peer-reviewed papers
    - Published books
    - Unpublished papers or reports
    - Spatial data

- Monitoring data
- Traditional management practices
- Other environmental managers / practitioners
- Personal Experience
- Expert opinion
- Traditional ecological knowledge
- Citizen science
- None of the above
- Other information (please describe)

24) Referring to the previous question, are these information sources specific to the ecosystem or conservation area that you manage and/or work with?
    - All or mostly from your ecosystem or conservation area
    - About evenly mixed
    - All or mostly from other ecosystems or conservation areas

25) What sources of **socio-economic** information do you use when assessing cumulative effects in your decision-making related to conservation areas, including their identification, implementation and management? (select all that apply)
    - Published peer-reviewed social science literature
    - Published books
    - Unpublished papers or reports
    - Economic information (e.g., employment data)
    - Demographic information
    - Cultural information
    - Traditional management practices
    - Other managers or practitioners
    - Personal experience
    - Expert opinion
    - Traditional knowledge
    - Local or community knowledge (e.g., local fishermen)
    - None of the above
    - Other (please explain)

26) Referring to the previous question, are these information sources specific to the ecosystem or conservation area that you manage and/or work with?
    - All or mostly from your ecosystem or conservation area
    - About evenly mixed
    - All or mostly from other ecosystems or conservation areas

27) What barriers, if any, exist that may limit or prevent you from incorporating **ecological** information in your decision-making related to conservation areas, including their identification, implementation and management? (select all that apply)
    - Quality of data
    - Quantity of data
    - Availability of data
    - Relevance of data to your work
    - No barriers exist
    - None of the above
    - Other (please explain)

28) What barriers, if any, exist that may limit or prevent you from incorporating **socio-economic** information in your decision-making related to conservation areas, including their identification, implementation and management? (select all that apply)
    - Quality of data
    - Quantity of data
    - Availability of data
    - Relevance of data to your work
    - No barriers exist
    - None of the above

- Other (please explain)

29) For this question, a framework is defined as "a description of steps and components necessary to achieve desired goals". Do you use any specific frameworks when assessing cumulative effects in your decision-making related to conservation areas, including their identification, implementation and management?
    - Yes (please name or specify)
    - No

30) Which tools do you use when assessing cumulative effects in your decision-making related to conservation areas, including their identification, implementation and management? (select all that apply)
    - Mapping
    - Experiments
    - Single-species models
    - Multi-species models
    - Ecosystem models (e.g. Atlantis, EcoSim)
    - Risk assessment models
    - Qualitative models (e.g. loop analysis, fuzzy logic, cognitive maps, signed digraphs)
    - Driver-Pressure-State-Impact-Response (DPSIR) models or variants (e.g. DAPSI(W)R(M))
    - Pathways of Effects models
    - Decision support tools (e.g. InVEST, MarineMap, Marxan)
    - Agency-specific tools (please specify)
    - None of the above
    - Other (please specify)

The next set of questions will ask you about how you consider and incorporate stressor interactions, stressor-effect relationships, and tipping points in your assessments and decision-making related to the identification, implementation and management of marine conservation areas.

31) Which stressor interaction types do you consider in your in decision-making related to the identification, implementation and management of marine conservation areas? (select all that apply)
    - Additive (i.e. cumulative effect = sum of individual stressor effects)
    - Antagonistic (i.e. cumulative effect < sum of individual stressor effects)
    - Synergistic (i.e. cumulative effect > sum of individual stressor effects)
    - None
    - Other (please describe)

32) How do you incorporate interactions among multiple stressors into your decision-making related to the identification, implementation and management of marine conservation areas? (select all that apply)
    - Quantitatively (e.g. using numeric estimates of interaction strength)
    - Qualitatively (e.g. categorizing an interaction as synergistic, additive, or antagonistic without estimates of interaction strengths)
    - Do not incorporate (please explain)
    - Other (please describe)

33) Regardless of implementation, how important do you think it is to consider different potential stressor interaction types in your decision-making related to the identification, implementation and

management of marine conservation areas?

- Very important
- Somewhat important
- Somewhat unimportant
- Not important

34) Which types of stressor-effect relationships (e.g. the relationship between temperature and species mortality) do you consider in your decision-making related to the identification, implementation and management of marine conservation areas? (select all that apply)
    - Categorical (i.e. a change in stressor magnitude causes a positive or negative change in effect)
    - Linear (i.e. a change in stressor magnitude causes a linear change in effect)
    - Smooth nonlinear (i.e. a change in stressor causes a continuous nonlinear change in effect)
    - Discontinuous nonlinear, or hysteresis (i.e. a change in stressor magnitude causes a discontinuous change in effect that is hard to reverse)
    - None
    - Other (please describe)

35) Regardless of implementation, how important do you think it is to consider *nonlinear* stressor-effect relationships in your decision-making related to the identification, implementation and management of marine conservation areas?
    - Very important
    - Somewhat important
    - Somewhat unimportant
    - Not important

36) We define a tipping point as a drastic change in the ecosystem that are hard to reverse. Do you consider potential ecosystem tipping points in your decision-making related to the identification, implementation and management of marine conservation areas?
    - Yes (please describe)
    - No

37) If yes, do you consider how *multiple* stressors may affect the existence of tipping points in your decision-making related to the identification, implementation and management of marine conservation areas?
    - Yes (please describe)
    - No

38) Regardless of implementation, how important do you think it is to consider potential ecosystem tipping points or thresholds in your decision-making related to conservation areas, including their identification, implementation and management?
    - Very important
    - Somewhat important
    - Somewhat unimportant
    - Not important

This question will ask you about adaptive management.

39) Do you incorporate any of the following elements of adaptive management in your decision-making related to conservation areas, including their identification, implementation and management? (select all that apply)
    - Defining the problem:
        - Clearly stating management goals and objectives

    - Regarding management actions as experimental treatments that will increase knowledge of the system being managed
    - Exploring alternative management actions
    - Developing conceptual models that predict the results of management actions
    - Explicitly stating assumptions
    - Involving stakeholders and scientists when defining the management problem
- Designing management plans:
    - Involving stakeholders and scientists when designing management plans
    - Peer-reviewing designs of management plans
- Monitoring:
    - Monitoring or assessing baseline conditions
    - Monitoring the implementation and effectiveness of management actions
- Evaluating results and adjusting actions:
    - Comparing monitoring results against goals and objectives
    - Comparing monitoring results against model predictions
    - Monitoring the impacts of management actions
    - Comparing results against model predictions
    - Documenting improved knowledge from management action impacts
    - Adjusting hypotheses, conceptual models, and management actions with improved knowledge from previous management actions
- Other (please describe)

40) Finally, is there anything else you would like to tell us about how you assess cumulative effects and/or multiple stressors in your decision-making related to conservation areas, including their identification, implementation and management? (please explain)