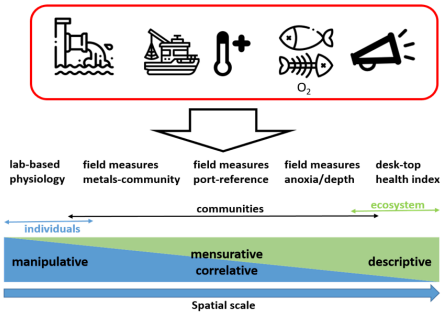
CANADIAN HEALTHY OCEANS NETWORK

Canada's Ocean Inhabitants and Ecosystems Confront Multiple Stressors

SEC 01

WHY THIS SCIENCE BRIEF?

Global changes increase the urgency of evaluating the effects of multiple stressors on organisms to ecosystems.



The global ocean is increasingly facing multiple stressors. CHONe researchers studied a variety of stressors in Canadian waters, including metals, eutrophication (nutrients), global change (temperature), and noise, and devised methods to characterize and report on multiple stressors at local and regional spatial scales on both the Atlantic and Pacific coasts. While perhaps most visible at local, coastal scales (e.g. sewage outfalls and ports), multiple stressors also act at larger scales and in off-shore waters, such as bottom trawling effects on seafloor environments and shipping-related noise impacts on marine mammals. Ocean managers require better methods to define and evaluate these stressors and how they interact to impact the many organisms that live in, rely on, and contribute to the health and productivity of marine ecosystems that provide numerous benefits to Canadians.

SEC 02

OUR RECOMMENDATIONS

These recommendations emerge from the collective work across CHONe:

- Identify the appropriate spatial and temporal scales to address the conservation question/issue of interest (e.g. target species, community, habitat or ecosystems).
- Utilize integrative ecosystem health indicators at scales appropriate to the scales of impact.
- Create a virtual government/academic Centre of Expertise to oversee/coordinate research on effects and interactions of multiple stressors on different levels of biological complexity.
- Develop a mechanism to automatically update multi-stressor data in a collaborative platform in near-real-time.

SEC 03

THE CHALLENGE, NEED, AND OPPORTUNITY

Challenge - A question of scale: Canadian marine waters include 17% of the world's coastal zones, an environment which humans both impact and rely heavily on for their wellbeing. In addition to the challenge of considering this vast area, the lack of available spatial and time-series data on stressors creates an additional hurdle. Although considerable relevant information exists in various formats, well-informed decisions require further and readily accessible information as well as a better understanding of how stressors interact. Sustainable management of ocean use requires a holistic approach that makes full use of this data.

Need - A question of coordination: A virtual government/academic Centre of Expertise on multiple stressors will foster interactions between researchers with diverse and relevant expertise to work with policy-makers to identify and address the most pressing sustainability issues. Such collaborations will ensure innovative research to deliver benefits based on examining complex issues from multiple angles to meet science and policy needs.

Opportunity - A question of forward-thinking: The creation of future scenarios of the influence of multiple stressors based on projected global change represents one of the foremost research opportunities. Scenarios could be implemented within a spatially referenced platform accessible to managers, scientists, and the general public.

SEC 04

OUR APPROACH

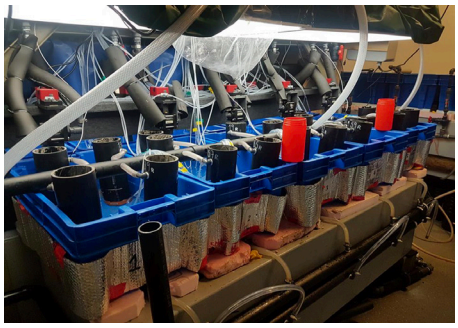
The increasing diversity of anthropogenic stressors in marine habitats have multiple impacts on individual organisms, communities, biodiversity, and ecosystem functions. Methods to assess cumulative effects include experimental manipulations, comparative studies, and descriptive and modelling approaches. Interactions among stressors may be complex and must be carefully considered to develop health indicators and guide management actions.

CHONe researchers worked to: (1) investigate the isolated and combined effects of ocean stressors on responses measured at multiple levels of biological complexity; (2) evaluate ecosystem health indicators to detect the influence of multiple stressors; (3) detect tipping points ("points of no return") for faunal communities that reflect the impact of environmental and anthropogenic stressors, and; (4) evaluate cumulative effects on species and food webs by quantitatively predicting the relative magnitude of both direct and indirect effects of stressors in the Gulf of St. Lawrence. Answering these questions can provide specific guidance for management and conservation. We describe examples of CHONe key research outcomes and outputs to illustrate the importance and utility of considering relationships among stressors for the development of management tools.

SEC 05

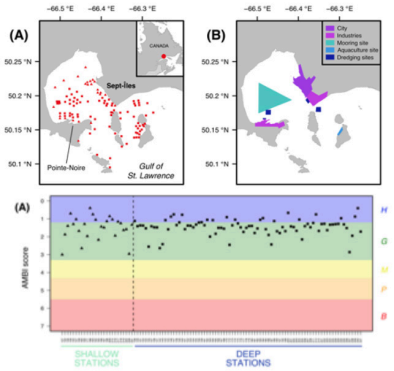
CHONe EXAMPLES

Lab-based experiments: CHONe's study on the effect of multiple stressors at multiple levels of biological complexity (bivalve mortality, growth, shell formation, energy content, and microphytobenthos biomass) showed interacting effects of one and three months exposure to a warming ocean (+ 6 °C), salinity variation (freshwater pulses or presses), and nutrient enrichment (natural or enriched levels). Salinity variation and nutrient enrichment, individually and combined, caused strong impacts on shell formation and energy content in mussel and clam tissues. In contrast, warming had no effect. Our work highlights the prevalence of antagonistic interactions, the importance of examining the effects of single and multiple stressors through time, and the need to consider multiple responses to understand the complexity of stressor interactions.



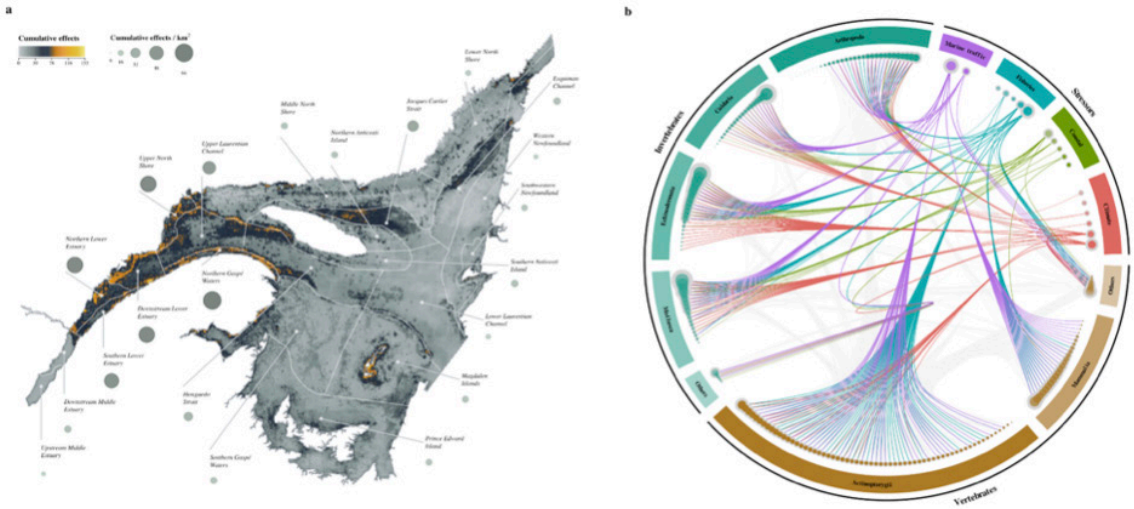
SEC 06

CHONe EXAMPLES



Comparative field measurements: CHONe researchers detected an overall "good status" for the marine ecosystem at Sept-Îles (Québec), a major industrial harbour area in the Gulf of St. Lawrence. Sixteen benthic community-focused environmental indicators indicated unstressed benthic communities with relatively high diversity and many species known to be sensitive to perturbation. This study provides valuable information for local-scale assessments, allowing scientists and stakeholders to understand better how human activities may influence coastal ecosystems. (Figure adapted from Dreujou et al. 2021).

Descriptive "desk-top" stressor quantification: A CHONe study on the cumulative effects of global change and human activities on Gulf of St. Lawrence species developed a novel approach that explicitly considers indirect effects that propagate through the underlying web of interactions to structure marine communities. This approach exposed complex properties arising from species interactions, highlighting cumulative effects on species that conventional approaches would otherwise overlook. Fishes and marine mammals, including fisheries and species at risk, are particularly prone to indirect effects. Our analysis offers the first ecosystem-based approach relevant to the management of exploited and endangered species to evaluate the less obvious yet significant trophically-mediated effects arising from species interactions in a multiple stressors framework.



With the goal of informing the MPA planning process on the Northern Shelf Bioregion in British Columbia, CHONe researchers developed a method for incorporating connectivity achieved through the movement of adult stages of marine species in locations with limited data availability. The area was selected to capitalize on ongoing MPA network planning jointly by the Government of Canada, Province Government of British Columbia, and 16 First Nations. Using habitat data, researchers identified hotspots of connectivity and, based on these hotspots: (1) inferred moderate connectivity among existing MPAs, and (2) identified other important sites for maintaining connectivity that should be proposed as additional MPAs within the network. Using future ocean conditions for 2065-2078, we predicted a decrease in the connectedness of existing MPAs for adult stages of commercially important Dungeness crab and shortspine thornyhead.

SEC 07

CONCLUSION

We identified, quantified, mapped, and evaluated the footprint and impacts of multiple stressors in Canada's oceans in order to cultivate a more panoptic management strategy for Canada's valued ocean environments. In keeping with the UN Decade Implementation Plan, CHONe research focused on better elucidating and understanding multi-stressor/multi-user environments and their effect on marine ecosystems and their resources, including under climate change scenarios. Expanding this work to consider other areas in Canada's Oceans and further stressors will help identify efficient and systematic solutions to maintain Healthy and Resilient Oceans

SEC 08

ANTICIPATED BENEFITS

Establishing a Centre of Expertise on multiple stressors supports a clean, healthy, productive, sustainable and predicted ocean. These outcomes benefit Canadians and support United Nations Sustainable Development Goals 14 and the United Nations Decade of Ocean Science. The likelihood of successful outcomes, however, significantly increases only by engaging coastal communities, Indigenous groups, industry, and other ocean stakeholders, including the governments that represent them..

SEC 09

GET IN TOUCH

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