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EDITED BY

Ibon Galparsoro,
Technological Center Expert in Marine
and Food Innovation (AZTI), Spain

REVIEWED BY

Jean-Sebastien Lauzon-Guay,
Acadian Seaplants, Canada

*CORRESPONDENCE

Ricardo A. Scrosati
✉ rscrosat@stfx.ca

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Abundance of seaweeds and invertebrates along gradients of intertidal elevation, wave exposure, and ice scour in Nova Scotia (Canada) in 2005

Ricardo A. Scrosati*

Department of Biology, St. Francis Xavier University, Antigonish, NS, Canada

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Alga, intertidal, invertebrate, sea ice, seaweed, wave action

Introduction

The ongoing climatic and oceanographic changes are altering historical patterns of species abundance and community structure across the globe (Pinsky et al., 2020; Wiens and Zelinka, 2024; Yin and Rudolf, 2024; Dudgeon and Strayer, 2025; Wolfe et al., 2025). To understand these ecological trends, a necessary condition is the reliable detection of change itself. To this end, the availability of baseline data is critical, as the repeated monitoring comparing past and new datasets reveals which components are changing and which ones are not (Raimondi et al., 2019; Estes and Vermeij, 2022; Meunier et al., 2024; Sato et al., 2025). Although many scientific journals now require research articles to include the underlying data, that was not the case in the past, which rendered many field datasets that remained privately stored unavailable for future comparisons. The rise of data papers in recent years provides an opportunity to make past datasets publicly available for future evaluations.

This Data Report provides an unpublished dataset describing the abundance of seaweeds and invertebrates in rocky intertidal habitats from Nova Scotia (Canada) measured in 2005. Rocky intertidal habitats are those occurring between the highest and lowest tide marks on marine rocky shores. At local scales, rocky intertidal communities are structured directly or indirectly by two major sources of variation. One is the vertical gradient of elevation. Because of tide dynamics, the duration of aerial exposure during low tides increases with elevation, determining a vertical gradient of increasing abiotic stress from low to high elevations, where extremes in temperature and desiccation are common at low tide (Raffaelli and Hawkins, 1999; Menge and Branch, 2001). The other major source of variation is wave exposure, as the hydrodynamic forces affecting organism performance strengthen greatly from sheltered to exposed habitats (Denny and Wethey, 2001). Elevation and wave exposure may also affect rates of food and propagule supply for intertidal organisms (McQuaid and Lindsay, 2007; Blanchette et al., 2008; Shanks, 2009; Lathlean et al., 2013). In rocky intertidal habitats that experience winter freezing, ice scour is another

source of biological variation by affecting the survival of organisms, ice scour also intensifying from sheltered to exposed habitats (Scrosati and Heaven, 2006).

The attached dataset describes the abundance of seaweeds and invertebrates along full gradients of intertidal elevation, wave exposure, and ice scour on two contrasting shores in Nova Scotia: the Gulf of St. Lawrence coast (which freezes completely in winter) and the open Atlantic coast (where coastal waters do not experience any extensive winter freezing). Recent observations on the Gulf of St. Lawrence coast (Scrosati and Ellrich, 2024) and on the open Atlantic coast (Scrosati et al., 2025) of Nova Scotia indicate that intertidal species distribution and abundance are changing with the changing conditions. Therefore, the attached dataset for 2005 should be relevant as a baseline against which to assess ecological change in this part of the world decades into the future.

Methods used to collect the data

Intertidal species abundance was measured at Sea Spray Shore (45° 46' 22–23" N, 62° 8' 39–41" W; hereafter SS), on the Gulf of St. Lawrence coast, and at Tor Bay Provincial Park (45° 10' 57–58" N, 61° 21' 17–22" W; hereafter TB), on the open Atlantic coast (Figure 1). These coasts belong to the NW Atlantic cold-temperate biogeographic region (Mathieson et al., 1991; Spalding et al., 2007). Values of air and seawater temperature and seawater salinity for these coasts are provided elsewhere (Scrosati and Heaven, 2007; Scrosati et al., 2020). Species abundance was measured on intertidal substrates consisting of stable bedrock (volcanic rock at SS and metamorphose sedimentary rock at TB) excluding tide pools.

To evaluate changes in species abundance with elevation, data were collected at the high, middle, and low intertidal zones. In intertidal habitats, areas experiencing a given emersion time

increase in elevation with wave action because wave splash reaches any single elevation for longer periods than what the sea level would do through tides alone (Gilman et al., 2006). Therefore, to compare species assemblages experiencing similar emersion times among the selected wave exposure levels (see below), the intertidal range was determined for each wave exposure level as the vertical distance between chart datum (0 m in elevation, or lowest normal tide in Canada) and the highest elevation exhibiting sessile perennial organisms (the barnacle *Semibalanus balanoides*), as this upper boundary is largely determined by wave splash. Only barnacles occurring on stable bedrock outside of crevices and tide pools were considered for that purpose. The measured intertidal range for each wave exposure level was then divided in three parts to delimit the high, middle, and low intertidal zones for sampling purposes. Thus defined, the upper intertidal boundary relative to chart datum was 1.66 m (wave-sheltered) and 1.70 m (wave-exposed) at SS and 1.56 m (wave-sheltered), 1.99 m (intermediate exposure) and 2.16 m (wave-exposed) at TB (wave action is normally stronger on the open Atlantic coast than on the Gulf of St. Lawrence coast). To ensure the accuracy of these determinations, these elevations were measured on days with calm seas and involved the use of a stadia rod, a sighting scope, and tide height data. The boundaries between the high, middle, and low intertidal zones were permanently marked with small mounds of marine epoxy (A-788 Splash Zone Compound, Z-Spar, Los Angeles, USA) affixed to the rocky substrate following the coastline.

Wave exposure levels were determined through observations of breaking wave heights made during 2004 and 2005. Because waves are often smaller on the southern Gulf of St. Lawrence coast than on the open Atlantic coast of Nova Scotia, two exposure levels were selected for SS (sheltered and exposed) and three for TB (sheltered, intermediate, and exposed). Sheltered intertidal areas either faced land or were fully protected by rocky formations that blocked incoming swell, exposed areas faced open waters directly without any obstructions, and areas of intermediate exposure were only

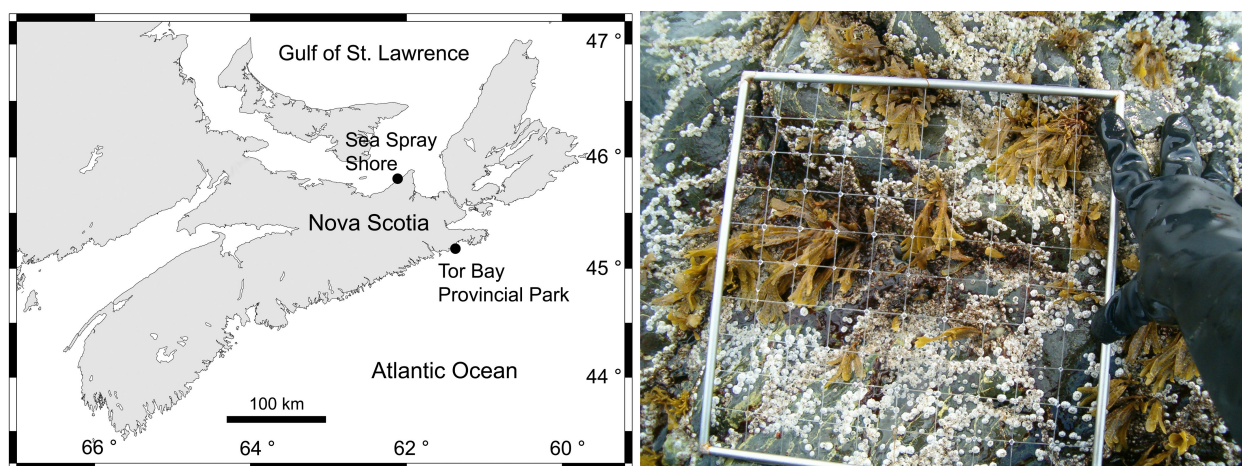


FIGURE 1
(Left panel) Map indicating the studied coastal locations in Nova Scotia, Canada. (Right panel) Photograph showing the sampling device, a square frame measuring 25 cm x 25 cm.

partially protected by rocky formations. Measures of maximum water velocity taken in the surveyed habitats in the summer and fall of 2005 using dynamometers (Bell and Denny, 1994) supported the selection of these exposure levels, as maximum water velocity averaged 3.4 m/s in sheltered areas and 5.2 m/s in exposed areas at SS and averaged 4.3 m/s in sheltered areas, 6.5 m/s in areas under intermediate exposure, and 7.5 m/s in exposed areas at TB (Scrosati and Heaven, 2007).

Sea ice develops extensively on the Gulf of St. Lawrence coast every winter (Saucier et al., 2003). When ice fragments scour intertidal substrates because of tides, wind, or waves, a great deal of biological disturbance may result. Measurement of the damage (angle of deformation) caused by sea ice to metallic cages affixed to the rocky substrate at SS indicated that ice scour is strong (mean angle of deformation of 90°) on wave-exposed areas and relatively mild (mean angle of 47°) on wave-sheltered areas (Scrosati and Heaven, 2006). Therefore, the two levels used for wave exposure at SS also represented differences in winter ice scour intensity (see also Figure 2).

The data on species abundance were collected between 8 July and 21 August 2005, when species richness is typically highest on these coasts. The abundance of all seaweeds and invertebrates was measured at low tide for each combination of elevation and exposure (six such combinations for SS and nine for TB; see above). For each combination of elevation and exposure, the abundance of each identified taxon was quantified as percent cover in 20 quadrats (25 cm x 25 cm) that were placed at random on the substrate. Nearby quadrats were never contiguous. Overall, we surveyed tens of meters of shoreline (see the latitude-longitude ranges referred to above). Percent cover was chosen as the abundance metric because alternative measures (e.g., density of individuals) cannot always be determined reliably for clonal sessile organisms (Scrosati, 2005) or (e.g., biomass) would have implied destructive sampling, which was avoided in order to retain these areas amenable for long-term monitoring. Additionally, measuring the abundance of all taxa using a single metric was deemed important to analyze overall species diversity and composition (Scrosati and Heaven, 2007; Heaven and Scrosati, 2008) without applying data transformations that would have distorted the dataset. The sampling device was a metallic frame divided in 100 squares using monofilament line (Figure 1). The percent cover of each encountered taxon was measured as the number of square subdivisions in a quadrat that were covered 50% or more by that taxon. If a given taxon was present in a quadrat but covered less than 1% of it, the percent cover of that taxon in that quadrat was recorded as 0.5%. The encountered taxa were identified using field guides (Gibson, 2003; Martínez, 2003) and taxonomic keys (Pollock, 1998; Sears, 1998; Villalard-Bohnsack, 2003). Organisms were mostly identified at the species level, but a few were identified at higher taxonomic levels (genus or higher) due to morphological unclarity, as is often the case in non-destructive surveys that identify all producers and consumers in intertidal communities (Broitman et al., 2001; Boaventura et al., 2002; Kimbro and Grosholz, 2006; Russell et al., 2006). Due to the similar

appearance observed within the taxa identified above the species level, these taxa likely included only one or a few species. For example, the genus *Mytilus* (blue mussels) includes two cryptic species in this region (*M. edulis* and *M. trossulus*) and genetic studies (necessary to tell those species apart) showed that their relative abundance varies with wave exposure (Tam and Scrosati, 2014). Epiphytic brown algae included *Elachista fucicola* and/or *Pylaiella littoralis* (Longtin et al., 2009). The so-called green algal crust likely represented thalli of the crustose red alga *Hildenbrandia rubra* that had lost their red pigments due to abiotic stress. The status of the species and genus names listed in the attached dataset were verified in February 2026 using the World Register of Marine Species (WoRMS, 2026). Photographs of the surveyed habitats are provided in Figure 2.

Relevance of this dataset for the future

The attached dataset was used already to evaluate the effects of elevation, wave exposure, and ice scour on intertidal species abundance (Scrosati and Heaven, 2008) and community composition (Heaven and Scrosati, 2008) on these Atlantic Canadian shores. More broadly, other uses have included tests of an environmental stress model of community organization, focusing on overall species diversity (Scrosati and Heaven, 2007) and the diversity of functional groups (Scrosati et al., 2011). Given the age of this dataset and the ongoing climatic and oceanographic changes that are affecting species abundance across the world, these data could further be valuable as a reference on which to evaluate future biological changes on these coasts. For example, on the Gulf of St. Lawrence, the extent of winter sea ice is decreasing (Galbraith et al., 2024) and seawater temperature is increasing (Scrosati and Ellrich, 2024). On the open Atlantic coast of Nova Scotia, fragments of sea ice drifting from northern latitudes at the end of the winter are becoming rare (Scrosati et al., 2025) and unusually severe cold snaps can occur in winter linked to the Arctic amplification (Cameron and Scrosati, 2023). These environmental changes are already being paralleled by alterations in the abundance and distribution of intertidal species on both coasts (Cameron and Scrosati, 2023; Scrosati and Ellrich, 2024; Scrosati et al., 2025), so more changes are likely to happen in the upcoming decades. Changes in the abundance of foundation species such as canopy-forming seaweeds and mussels may, in turn, help predict potential changes in the abundance of the myriad species that those organisms host in their dense stands (Watt and Scrosati, 2013; Arribas et al., 2014; Cameron et al., 2024). The recent literature offers excellent examples of the importance of baseline data to reliably identify species abundance changes (Sagarin et al., 1999; Wethey and Woodin, 2008; Weslawski et al., 2010; Menge et al., 2022; Monteiro et al., 2022; Navarrete et al., 2022; Storch et al., 2022) and even to forecast future changes under projected conditions (Wilson et al., 2019). These contributions therefore

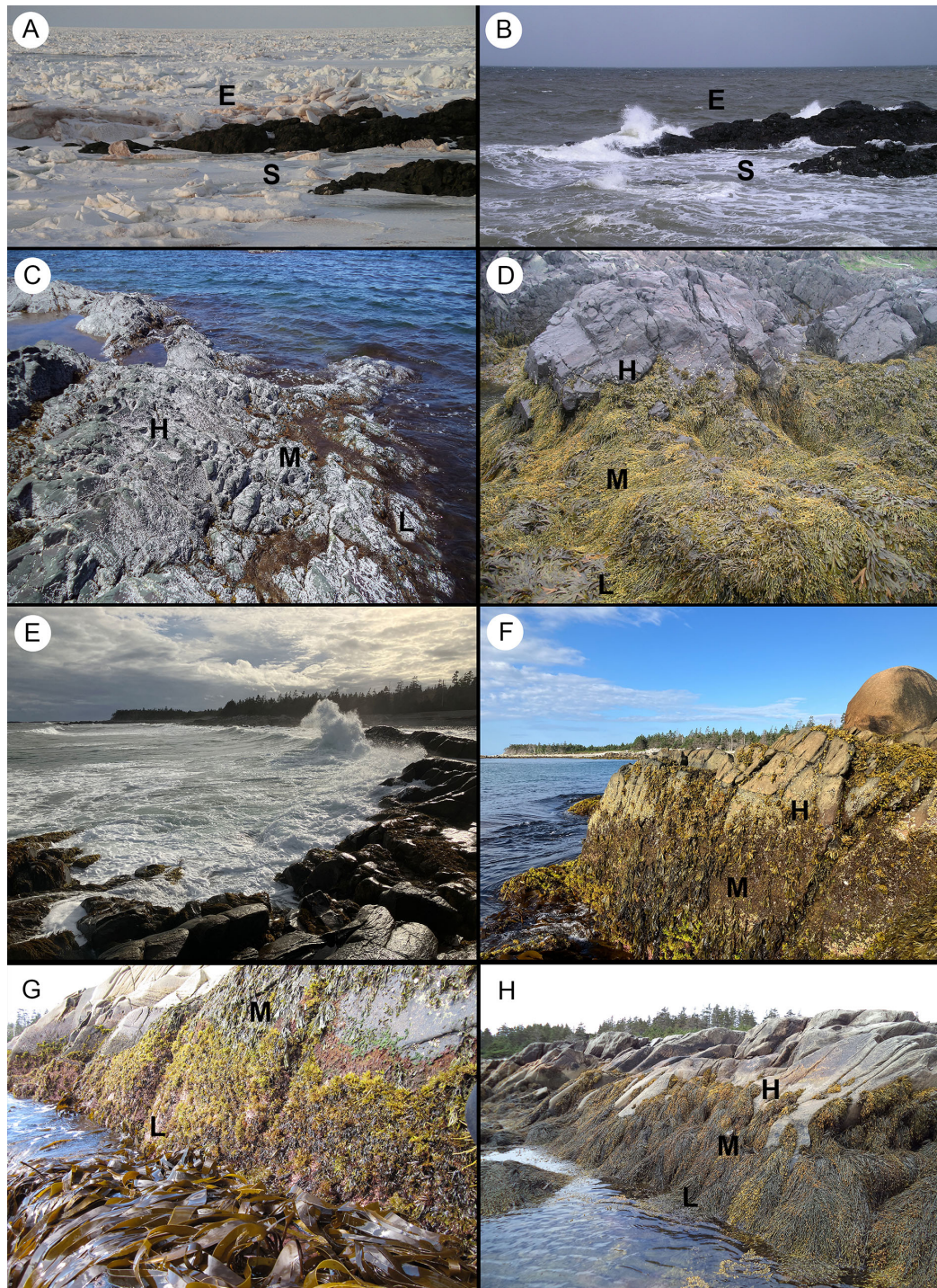


FIGURE 2

(A) View of the Gulf of St. Lawrence coast of Nova Scotia near Sea Spray Shore covered by sea ice in winter (6 March 2005), showing exposed habitats (E) facing open waters and experiencing intense ice scour and sheltered habitats (S) facing land and experiencing relatively mild ice scour. (B) View of the same sites on the Gulf of St. Lawrence coast after the winter sea ice has melted (31 March 2007), showing exposed habitats (E) facing open waters and experiencing intense wave action and sheltered habitats (S) facing land and experiencing little wave action. (C) View at low tide of the high (H), middle (M), and low (L) intertidal zones of a wave-exposed area at Sea Spray Shore (2 July 2020) showing an abundance of mostly barnacle recruits (recruited after the ice season) at all elevations and seasonal algae at the lower half of the shore. (D) View at low tide of the high (H), middle (M), and low (L) intertidal zones of a wave-sheltered area at Sea Spray Shore (10 June 2009) showing an abundance of fucoid algae (*Ascophyllum nodosum* and *Fucus* spp.). (E) View of a wave-exposed area on the open Atlantic coast of Nova Scotia at Tor Bay Provincial Park (21 September 2024). (F) View at low tide of the high (H) and middle (M) intertidal zones of a wave-exposed area at Tor Bay Provincial Park (27 July 2024) showing barnacles and algae at the high zone and a higher algal cover (including *Fucus*) at the middle zone. (G) View at low tide of the middle (M) and low (L) intertidal zones of a wave-exposed area at Tor Bay Provincial Park (26 September 2011) showing *Fucus* at the middle zone and *Chondrus crispus* above kelp at the low zone. (H) View at low tide of the high (H), middle (M), and low (L) intertidal zones of a wave-sheltered area at Tor Bay Provincial Park (3 July 2020) showing an abundance of fucoid algae (*Ascophyllum nodosum* and *Fucus* spp.). All photographs were taken by the author.

predict that this Data Report could be very valuable in this regard for this part of the world.

Data availability statement

The full dataset on intertidal species abundance is freely available from the Figshare online repository: <https://doi.org/10.6084/m9.figshare.31362763>.

Author contributions

RS: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing.

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