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Monograph

Surprising episodic recruitment and growth of Antarctic sponges: Implications for ecological resilience

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ABSTRACT

Sponges are the most conspicuous component of the Antarctic benthic ecosystem, a system under stress both from climate change and fishing activities. Observations over four decades are compiled and reveal extremely episodic sponge recruitment and growth. Recruitment occurred under different oceanographic conditions on both sides of McMurdo Sound. Most of the sponges appear to have recruited in the late 1990s–2000. Observations from 2000 to 2010 follow thirty years of relative stasis with very little sponge recruitment or growth followed by a general pattern of recruitment by some forty species of sponges. That there was almost no recruitment observed on natural substrata emphasizes the contrast between potential and realized recruitment. This unique data set was derived from a region noted for physical stasis, but the episodic ecological phenomena highlight the importance of rare events. Against a background of intermittent food resources and the low metabolic costs of stasis, understanding the causes of irregular larval supply, dispersal processes, recruitment success and survivorship becomes critical to predicting ecosystem dynamics and resilience in response to increasing environmental change. Our time-series emphasizes that long-term data collection is essential for meaningful forecasts about environmental change in the unique benthic ecosystems of the Antarctic shelf.

1. Introduction

All ecosystems are impacted by human activity, including climate change. To understand the consequences of environmental change one needs to understand the mechanisms underlying the ecological resilience to both natural and anthropogenic disturbances. This understanding allows predictive capacities on ecosystem response to perturbations. Resilience is supported by resistance to the disturbance, and rate of succession leading to recovery from the perturbations. The successional capacity of populations and communities to respond and recover from change is related to the time-scales of recruitment, dispersal and growth.

Here we consider long-term data on the benthic ecosystem of McMurdo Sound, Antarctic. The Antarctic benthos are often considered stable due to the apparent persistence of communities over multiple years in the presence of a relatively constant oceanographic environment. Nevertheless, long-term observations have revealed profound changes in benthic community structure associated with episodic recruitment (Dayton, 1989; Dayton et al., 2013). This paper addresses the recruitment component of resilience with long-term observations of recruitment and growth of some 40 sponge species on artificial, experimental structures located in very different environmental settings on each side of McMurdo Sound, as well as the results of a settlement experiment on natural substrata. The paper extends long-term ecological observations of habitat-forming foundation species to over 40 years. This unique data set, interpreted with extensive natural history information, provides a novel perspective on the recruitment and growth of sponges and other selected invertebrates of McMurdo Sound, Antarctica.

Polar climate change is associated with the break-up of ice shelves, and increased scour from the resulting icebergs, as well as changes in sedimentation and productivity associated with changes in sea ice cover. Oceanographically isolated for approximately 35 M years, Antarctic shelf benthos evolved in the veritable absence of shell-crushing predators (e.g. crabs, rays) and under extremely stenothermic conditions (Gili et al., 2006), and is now responding to rapid changes in ice cover (Turner et al., 2014; Gutt et al., 2015a). As oceanographic barriers become leaky with climate change, species invasions from the north or

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simple expansion of ranges represent another episodic event with broad-scale consequences (Aronson et al., 2015). There are also impacts of various fisheries, especially long-line fishing gear being lost and dragged over the bottom, flattening and dislocating invertebrates and depleting ecologically important fish.

Antarctic benthic communities are reasonably well described (Gutt, 2007), and there is a preliminary understanding of disturbances in Antarctic benthic communities (Thrush et al., 2006). However, there has been little opportunity to study successional patterns following disturbance to the seafloor in the Antarctic because we lack the temporal baseline critical to understanding successional changes. The studies that have been conducted track individual disturbance events and include recruitment in iceberg scours (Arntz et al., 1994; Gutt, 2001; Gutt and Piepenburg, 2003), observations of successional patterns after a large section of the Larsen Ice Shelf broke up (Gutt et al., 2011, 2013; Fillinger et al., 2013), the recession of the glacier in Potter's Cove (Torre et al., 2012; Sahade et al., 2015) and increased ice scour (Barnes et al., 2014). These extremely valuable studies address single events but provide limited insight into the consequences of longer time scale variation in dispersal, recruitment, growth, and survivorship in the Antarctic benthos. The long-term observations of foundation sponge species presented here allow interpretation of variability and succession in the relatively stable environment of McMurdo Sound, Antarctica.

1.1. Background

1.1.1. General background

McMurdo Sound (Fig. 1) is characterized by strong East-West and North-South gradients reflecting the sources and advection of primary production (Dayton and Oliver, 1977; Barry, 1988; Thrush et al., 2006). The east sound is characterized by southerly currents that bring phytoplankton from a large and productive polyna north of Ross Island (Barry et al., 2003). In contrast, the mainland or west side of McMurdo Sound is characterized by slow, northerly currents sourced beneath the Ross Ice Shelf that bathe the Explorers Cove regions of New Harbour (Fig. 1) with very poor planktonic food resources (Barry, 1988; Barry and Dayton, 1988). Thrush et al. (2006) offers a comprehensive review of patterns in productivity and disturbance. The natural sea bottom varies greatly on either side of McMurdo Sound (Fig. 1). Most of the Ross Island substrata are volcanic gravels with occasional lava extrusions forming rocky ridges. In contrast, the southwest side of the sound from Explorers Cove in New Harbour to the south is sand with gravel along the shore (Dayton and Oliver, 1977).

The benthic community of the eastern side of McMurdo Sound has a long history of ecological research starting with collections from the historic age of Scott and Shackleton to the IGY (International Geophysical Year 1957–58) era of the late 1950s and early 1960s (Dearborn, 1965; Bullivant and Dearborn, 1967). Biota of the southern Hut Point

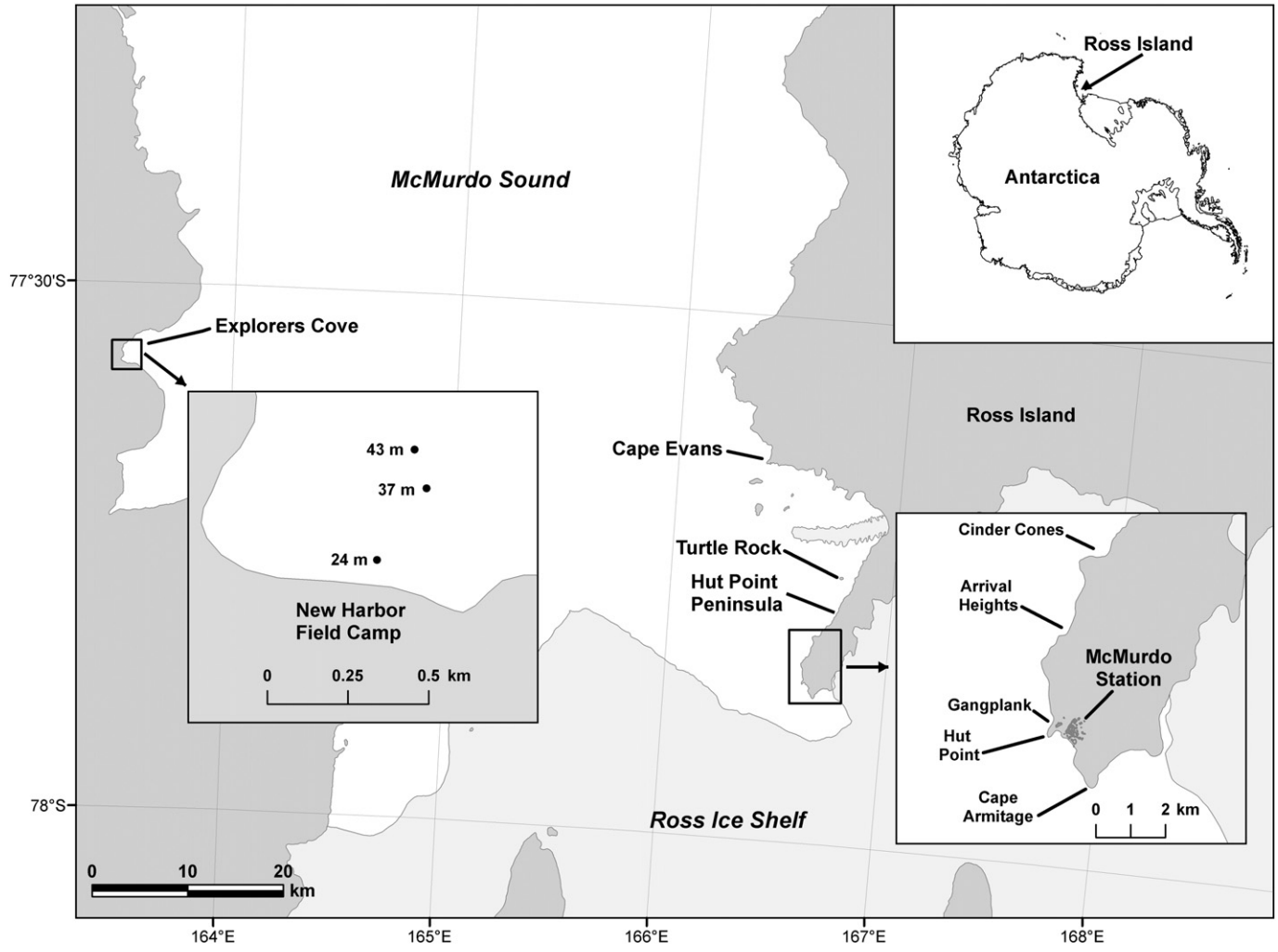

Fig. 1. Map of southern McMurdo Sound.