Patterns and drivers of benthic macroinvertebrate assemblages in the kelp forests of southern Patagonia

Alan M. Friedlander, Enric Ballesteros, Jennifer E. Caselle, Mathias Hüne, Alyssa M. Adler, Enric Sala

Pristine Seas, National Geographic Society, Washington, DC, United States of America | Hawaiʻi Institute of Marine Biology, University of Hawaiʻi, Kāneʻohe, Hawaiʻi, United States of America | Centre d'Estudis Avançats de Blanes-CSIC, Blanes, Girona, Spain | Marine Science Institute, University of California Santa Barbara, Santa Barbara, California, United States of America | Centro de Investigación para la Conservación de los Ecosistemas Australes (ICEA), Punta Arenas, Chile | Division of Marine Science and Conservation, Nicholas School of the Environment, Duke University, Beaufort, North Carolina, United States of America

Introduction

- Southern Patagonia kelp forests are among the least impacted ecosystems on Earth with high habitat heterogeneity
- Giant kelp Macrocystis pyrifera and Lessonia spp. structure ecological communities across a high gradient of coastal diversity
- Study objectives were to assess spatial patterns, determine environmental drivers, and provide a baseline for future changes

Material and Methods

- Surveys conducted at 120 quantitative transects (25 x 2 m) across five regions in Chile and Argentina during 2017 to 2020
- Scuba divers estimated abundance of non-cryptic invertebrates ≥1 cm and counted stipes of Macrocystis and Lessonia
- Environmental variables including depth, salinity, temperature, and wave exposure were recorded at each sampling site

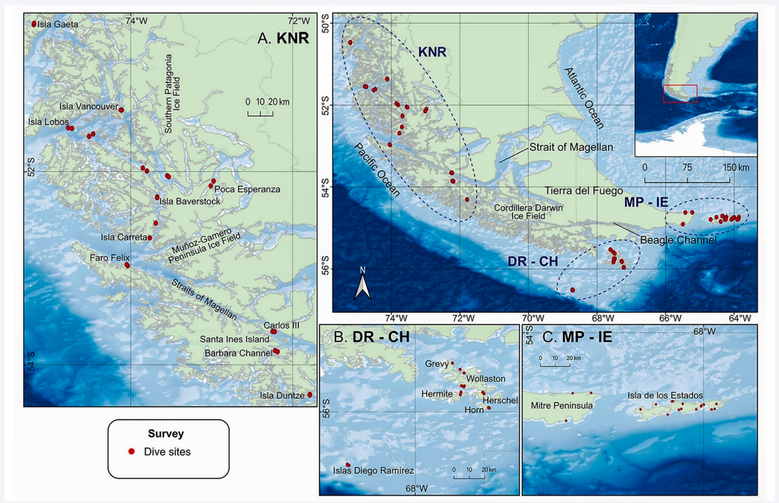


Fig 1. Sampling stations in southern Patagonia. A. KNR = Kawésqar National Reserve, B. DR = Diego Ramírez and CH = Cape Horn Archipelago, C. MP = Mitre Peninsula and IE = Isla de los Estados.

Metric	-LogLikelihood	χ^2	p		
Temp. (°C)	97.04	194.08	<0.001		
Salinity (ppt)	79.12	158.25	<0.001		
Depth (m)	68.44	136.88	<0.001		
Lessonia	36.96	73.91	<0.001		
Macrocystis	15.98	31.96	<0.001		
Metric	CH	DR	IE	KNR	MP
Temp. (°C)	9.5 (0.6)	9.5 (0.6)	8.0 (0.5)	10.5 (1.2)	8.8 (1.1)
Contrasts	C	C	B	A	C
Salinity (ppt)	32.9 (0.1)	33.5 (0.1)	32.8 (0.3)	26.2 (4.1)	33.2 (0.5)
Contrasts	AB	A	A	B	A
Depth (m)	12.8 (1.9)	13.5 (1.2)	12.9 (2.9)	7.5 (2.1)	10.4 (5.9)
Contrasts	AB	A	AB	C	B
Lessonia	1.2 (1.5)	3.5 (1.7)	1.4 (1.4)	0.3 (0.4)	0.3 (0.4)
Contrasts	B	A	B	C	C
Macrocystis	4.2 (2.9)	6.4 (2.7)	6.5 (2.9)	3.7 (2.0)	7.1 (2.4)
Contrasts	B	A	A	B	A

Table 1. Abiotic and biotic comparisons among regions in southern Patagonia. Values among regions are means and one standard deviation.

Invertebrate Assemblages

- Observed 185 unique taxa from 10 phyla, with Mollusca (n = 43) and Echinodermata (n = 33) being the most taxa-rich
- The barnacle Balanus laevis was the most dominant species, accounting for 15.2% of total abundance
- Taxa richness per transect was highest at Isla de los Estados and lowest at the remote Diego Ramírez archipelago

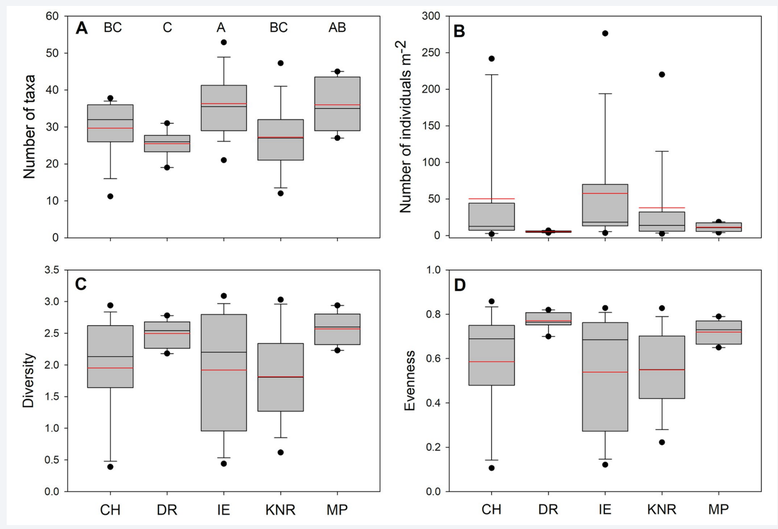


Fig 3. Comparisons of kelp forest community metrics among regions. A. Taxa richness, B. Numerical abundance (Num. individuals m^{-2}), C. Shannon-Wiener Diversity, D. Pielou's Evenness.

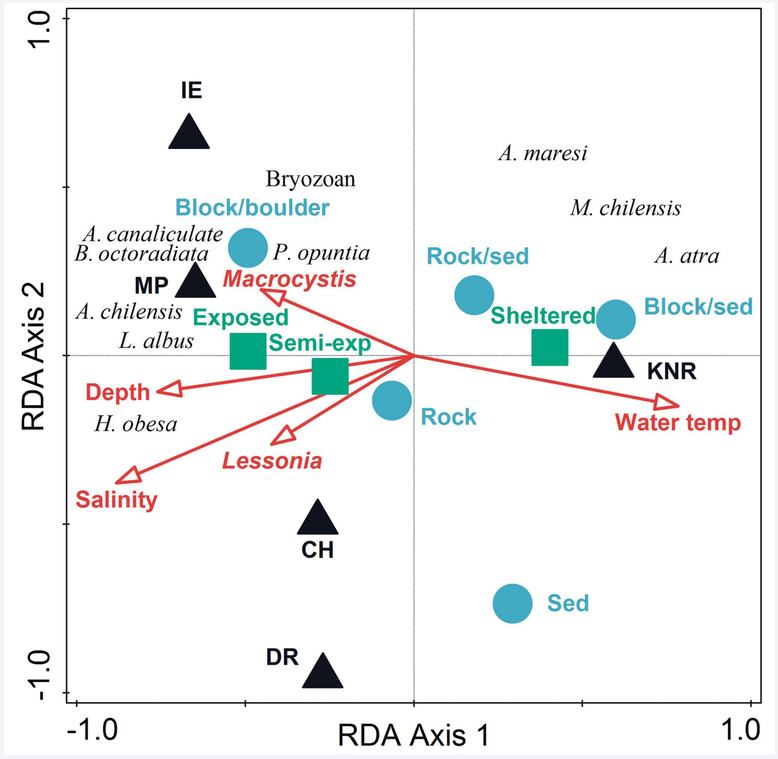


Fig 5. Triplot of results of redundancy analysis on benthic taxa abundance by region with biotic and abiotic variables (depth, salinity, temperature, habitat type, densities of Macrocystis and Lessonia kelp).

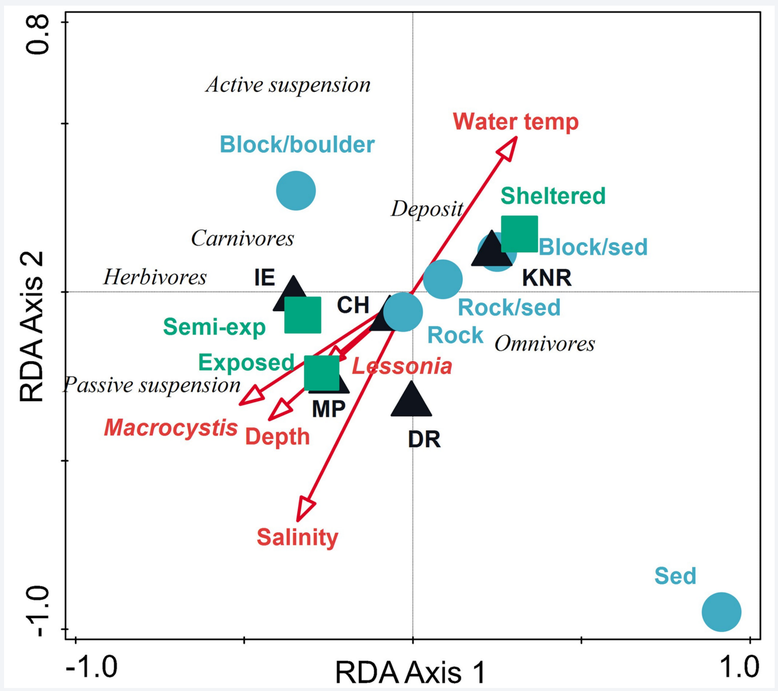


Fig 6. Triplot of results of redundancy analysis on benthic feeding guild abundance by region with biotic and abiotic variables (wave exposure, depth, salinity, temperature, densities of Macrocystis and Lessonia kelp).

Regional Characteristics

- Temperature was significantly higher and salinity significantly lower in Kawésqar National Reserve compared to other regions
- Lessonia spp. densities were significantly higher at Diego Ramírez (3.5 ± 1.7) than all other regions ($p < 0.001$)
- Macrocystis densities were highest at Isla de los Estados (6.5 ± 2.9) and Mitre Peninsula (7.1 ± 2.4)

Drivers of Community Structure

- Salinity contributed 29.8% to the explained fitted variation in taxa abundance, followed by Isla de los Estados region at 13.5%
- Kawésqar National Reserve was distinct with a greater abundance of deposit feeders, likely driven by low salinity and high turbidity
- Sheltered wave exposure sites explained 8.6% of total variation in functional feeding guild structure

Key finding
The trophic structure of the macroinvertebrate assemblages was explained mostly by wave exposure (28% of the variation), followed by salinity (12%) and the Kawésqar National Reserve region (11%).

References
[1] Clapperton CM, Sugden DE, Kaufman DS, McCulloch RD. The last glaciation in central Magellan Strait, southernmost Chile. Quaternary Research. 1995; 44: 133–148.
[2] Miloslavich P, Klein E, Díaz JM, Hernández CE, Bigatti G, Campos L, et al. Marine biodiversity in the Atlantic and Pacific coasts of South America: knowledge and gaps. PLoS ONE. 2011; 6.
[3] Dayton PK. The structure and regulation of some South American kelp communities. Ecological Monographs. 1985; 55: 447–468.
[4] Friedlander AM, Ballesteros E, Bell TW, Caselle JE, Campagna C, Goodell W, et al. Kelp forests at the end of the earth: 45 years later. PLoS ONE. 2020; 15: e0229259.
[5] Graham MH, Vasquez JA, Buschmann AH. Global ecology of the giant kelp Macrocystis: from ecotypes to ecosystems. Oceanography and Marine Biology. 2007; 45: 39–88.

Contact: alan.friedlander@hawaii.edu · DOI: 10.1371/journal.pone.0279200