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## **Appendix S1. Descriptions of regional biological datasets**

This supplementary information provides details of the broad-scale biological datasets collated and analysed separately for each region, including site-by-species abundance data from seabed trawl, benthic sled and/or grab/core surveys, from three regional-scale marine ecosystems. The biological datasets were collated for the continental shelf of the Great Barrier Reef (S1-1), the Gulf of Maine area (S1-2), and the deep Gulf of Mexico (S1-3). These datasets were sourced from research and governmental databases; some were from historical periods (1950's – 1960's, and 1980s) as well as recent time periods (1990's – 2000's).

### *S1-1. Great Barrier Reef (GBR)*

The ~200K km<sup>2</sup> GBR study area, comprising the continental shelf (< ~100 m) in the region, was comprehensively surveyed (Fig. S1-1) by the Great Barrier Reef Seabed Biodiversity Project between 2003 and 2006 (Pitcher *et al.* 2007). The surveys used a representative sampling design, stratified on 29 environmental variables in proportion to their importance from analyses of pre-existing benthic data. A 1.5 m epi-benthic sled with a 25 mm stretched mesh cod-end, was deployed for 200 m at 1,189 sites during 24 hr operations on 6 voyages and sampled 4,240 taxa from >10 phyla of fishes, invertebrates and plants, providing 68,350 site-by-species records. Of these sled data, 616 taxa present at >23 sites were analysed (the same occurrence threshold as Pitcher *et al.* 2007). A ~10 m swept-width single-rigged prawn otter-trawl with stretched mesh size of 50 mm, was deployed for 1 km at 458 sites during night-time operations on 4 voyages and sampled 2,899 taxa from >7 phyla of fishes and invertebrates, providing 37,272 site-by-species records. Of these trawl data, 357 taxa present at >23 sites (same criterion as sled) were analysed as a separate set. Survey biomass data were scaled to standardised sampling effort and  $\log(x + \min(x, x > 0))$  transformed.

### *S1-2. Gulf of Maine Area (GoMA)*

The ~250K km<sup>2</sup> GoMA study area encompassed the continental shelf (< ~600 m) in the region (Fig. S1-2; Incze *et al.* 2010). Three major data sources (below) were accessed, representing the largest spatial and temporal survey coverages collected by US (Northeast Fisheries Science Center (NEFSC) of the National Marine Fisheries Service (NMFS), National Oceanographic and Atmospheric Administration (NOAA)) and Canadian (Fisheries and Oceans Canada (DFO)) federal research agencies (Greenlaw *et al.* 2010). These surveys provided 5 datasets that were analysed separately. For each, the standardized survey abundance data were transformed using  $\log(x + \min(x, x > 0))$ , and the occurrence threshold for including species in analyses was the minimum set by random forest (i.e. >5 unique values of abundance, which typically corresponded to >>5 sites).

1. The NEFSC Benthic Database comprises surveys from a variety of samplers including grabs, dredges and trawls; the data are available on the Ocean Biogeographic Information System ([www.iobis.org](http://www.iobis.org)). We selected the Theroux & Wigley (1998) benthos data for GoMA, which comprised 0.1 m<sup>2</sup> Smith-McIntyre grab samples collected during summer months (primarily July–August) from 1956 to 1965 (most between 1956 and 1961). A subset of 478 grab sites, selected to coincide with all the available environmental variables, included abundance data for 315 species, of which 53 were analysed.

2. The DFO Ecosystem Survey Database includes demersal fish and, more recently, invertebrates sampled during annual surveys on the Scotian Shelf and in the Bay of Fundy in July, and on Georges Bank in February–March (see Chadwick *et al.* 2007 for details). The surveys used randomised sampling stratified by depth, with allocation of tows proportional to variance in catch (D. Clark, unpublished). Data were exported from a dataset published on OBIS by Clark & Branton (2007), for a subset of surveys from 1996–2007 that coincided with all the environmental variables (Greenlaw *et al.* 2010). These surveys used a Western IIA trawl with a 19 mm mesh cod-end liner and swept width of about 12.5 m, towed at 3.5 knots for 30 minutes, yielding a swept-area of ~0.041 km<sup>2</sup> (Shackell & Frank 2003). The 2004 summer survey was excluded due to irregularities in rigging of the trawl (D. Clark, unpublished). The selected data included 1032 trawls and 95 species from the Scotian Shelf, of which 60 species were analysed and separately, 1299 trawls and 81 species from Georges Bank, of which 52 species were analysed.

3. The NEFSC Groundfish Trawl Survey Database for the GoMA region includes demersal fish and invertebrates sampled during annual surveys conducted in both the fall (generally in October) and spring (generally in April), using randomised sampling stratified by depth, with allocation of tows to specific sites in proportion to stratum area (Azarovitz 1981). On average, 350 sites were trawled per seasonal survey, corresponding to approximately one site every 27 km. Data were exported from a dataset available from OBIS, for a subset of surveys from 1996–2007 that coincided with the environmental data and with complete identifications of fish species and more comprehensive enumeration of invertebrates (Greenlaw *et al.* 2010). These surveys used a Yankee 36 fish trawl with a 13 mm mesh cod-end liner and swept width of about 9.5 m, towed at 3.8 knots for 30 minutes, yielding a swept area of ~0.033 km<sup>2</sup>. The selected data included 1,975 trawls and 98 species from the spring survey, of which 69 species were analysed and separately, 2,001 trawls and 146 species from the fall survey, of which 84 species were analysed.

### *S1-3. Deep Gulf of Mexico (DGoMx)*

The ~500K km<sup>2</sup> DGoMx study area comprised the continental slope and abyssal plain in the region (Fig. S1-3). Samples were taken by box core and trawl in two studies (below) supported by the Minerals Management Service (MMS), US Department of Interior: the Deep Gulf of Mexico Benthos Study (DGoMB) between 2000 and 2002 (Rowe & Kennicutt 2008; Rowe & Kennicutt 2009) and the Northern Gulf of Mexico Continental Slope Study (NGoMCS) between 1983 and 1985 (Gallaway, Martin & Howard 1988). These surveys provided 5 datasets that were analysed separately. For each, the survey abundance data were scaled to standardised sampling effort and  $\log(x + \min(x, x > 0))$  transformed and, again, the random forest minimum occurrence criterion was used.

1. During the DGoMB study, a 0.2 m<sup>2</sup> box core (Boland & Rowe 1991) was deployed at 51 sites (with 271 core replications in total). The top 15 cm of sediments were sieved through 300  $\mu$ m mesh and 980 macrofauna species were retrieved (Wei *et al.* 2010). Of these, 211 species were analysed. Harpacticoid copepods were sampled from 5 sub-cores (core area = 0.01 m<sup>2</sup>) within a box core. The top 3 cm of sediments were retained and sieved through 63  $\mu$ m mesh. A total of 43 sites (pooled from 416 sub-core replications) by 658 species were recorded (Baguley *et al.* 2006). Of these, 46 species were analysed. A 10 m swept-width semi-balloon otter trawl with 64 mm stretch mesh and 25 mm cod-end was towed at 40 sites, parallel to the isobaths at a speed of 2–4 knots. A total of 387 megafauna species (including fishes and invertebrates) were recorded (Powell *et al.* 2003). Of these, 60 species were analysed.

2. During the NGoMCS study, a standard box core (area = 0.06 m<sup>2</sup>) was used to sample benthic macrofauna. The same sampling procedure and sieve size as in the DGoMB study were

used and 1548 species were recorded in 45 sites (324 core replications in total). Of these, 205 species were analysed. A 9 m swept-width semi-balloon otter trawl with 38 mm stretch mesh and 13 mm cod end mesh was also towed at the core locations at a speed of 1–3 knots, for one hour at sites shallower than 1300 m and two or more hours at deeper sites. A total of 694 species including fishes and invertebrates were recorded in 45 sites (Pequegnat, Gallaway & Pequegnat 1990). Of these, 184 species were analysed.

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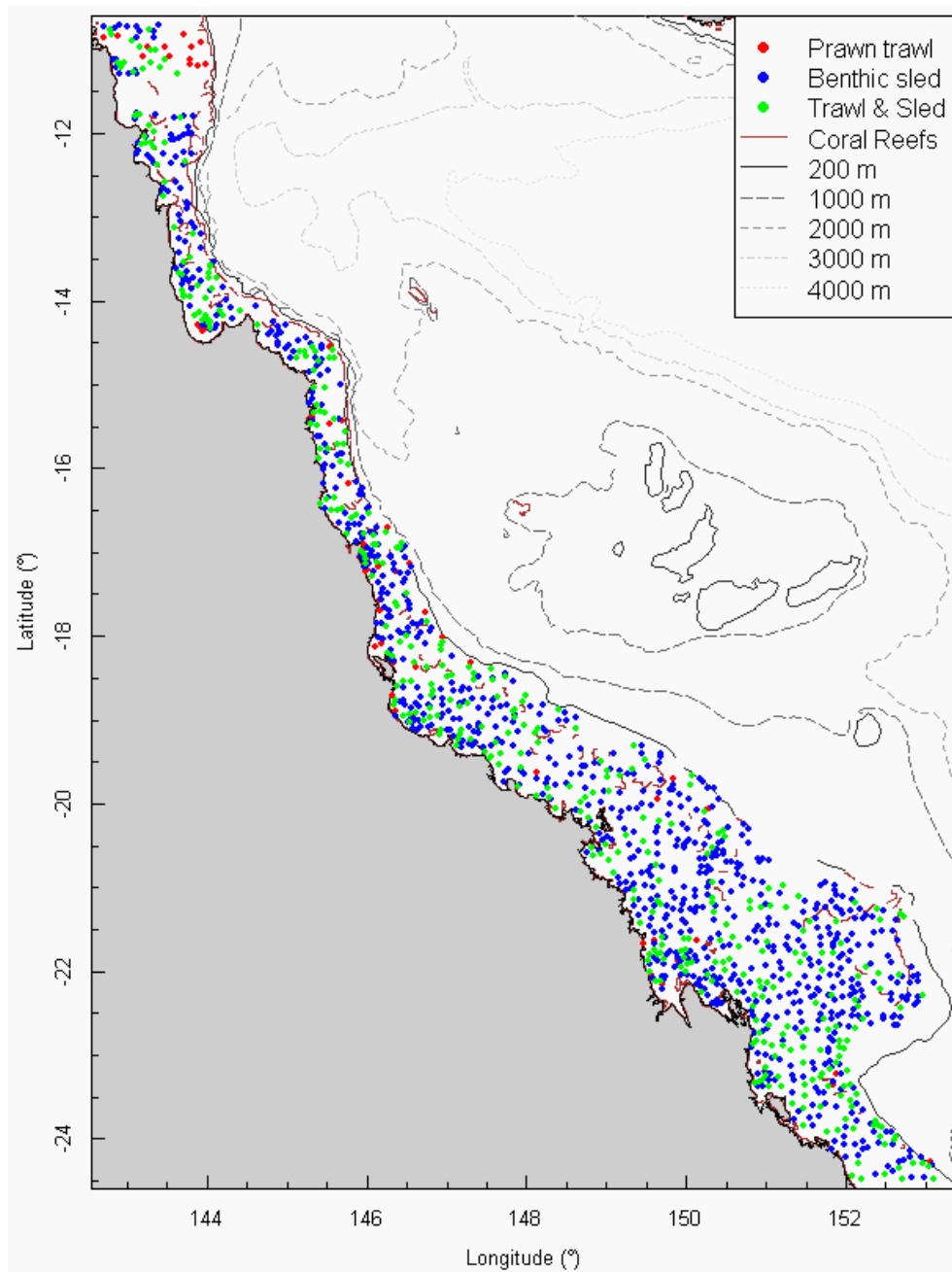


Fig. S1-1. Map of the Great Barrier Reef study area, showing sites sampled by epibenthic sled and prawn trawl, or both, between 2003 and 2006.

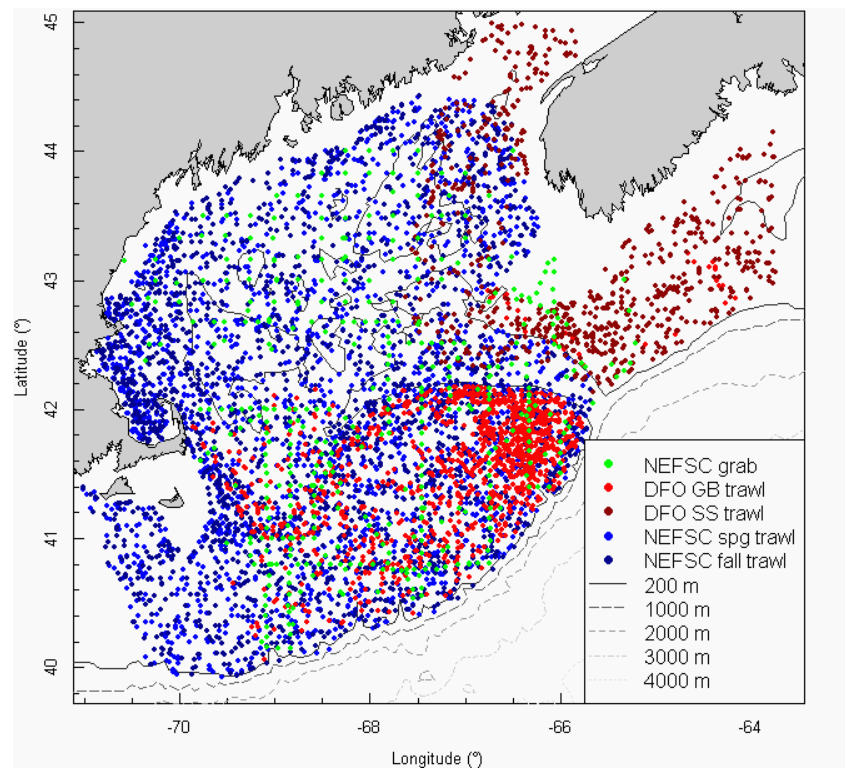


Fig. S1-2. Map of the greater Gulf of Maine study area, showing sites sampled by grab in the NEFSC Benthic Database, and by fish trawl in the DFO and NEFSC ground fish surveys.

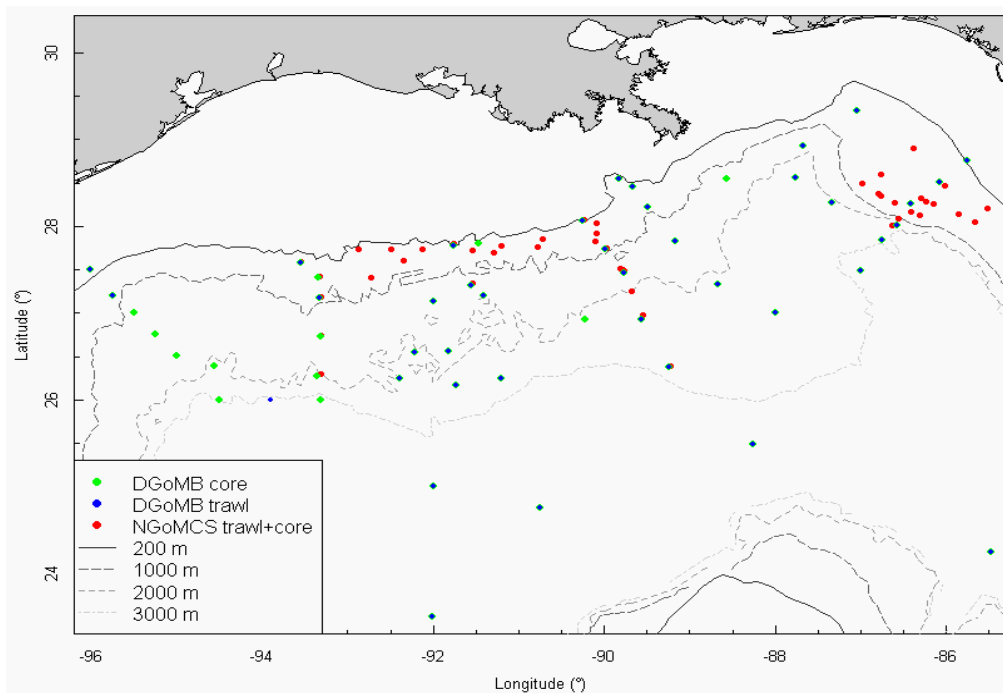


Fig. S1-3. Map of deep Gulf of Mexico benthos study area, showing box core and otter trawl sites sampled by the DGoMB Study in summers of 2000 to 2002, and by the NGoMCS Study in summers of 1983 to 1985.