Availalibility of Primary Data on Marine Invasive Alien Species for Robust Species Distribution Modelling: A Global Assessment of What’s Known and Next Steps in Developing the Biodiversity Data Commons

Preliminary Results

A technical report will be available by early 2012.

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Cumulative and synergistic effects of myriad human-induced stressors, of which one of the most widespread is the spread of invasive alien species, are causing extinctions and altered marine biodiversity, including reduced species diversity, reduced abundance, changes in distribution (latitudinal and depth), altered age and sex structures, altered temporal and spatial spawning patterns, reduced viability of offspring, reduced genetic diversity, and altered evolutionary characteristics of populations. The small proportion of these introduced species that are invasive disrupt ecosystems in various manners, threatening biodiversity, food security, human health, trade, transport and economic development. Ecological impacts of marine IAS include: major shifts in community composition, reduced species richness, declines in abundance and local extirpations of native species, niche contraction of native species, reduced genetic diversity within native species, reduced ecosystem functioning and reduced habitat structure. Biodiversity informatics can support reliable monitoring and forecasts of the spread of invasive species. We assess the suitability of available primary data via the Ocean Biogeographic Information System and Global Biodiversity Information Facility portals for robust modeling of past, current and projected future distributions of marine invasive alien species. The marine invasive alien species included in the “100 of the World’s Worst Invasive Alien Species” were employed as case studies. Criteria to assess suitability of available data resources were: (i) Sample size of primary species-level occurrence records with coordinates and date; (ii) time series length; (iii) temporal (decadal and seasonal) distribution of data; and (iv) spatial distribution (latitudinal and depth) across species’ known native and introduced range.

For the 12 marine invasive alien species included in this analysis, sample sizes ranged from 0 – 28,330, with a mean of 2,711 (± 2,339 SD of the mean). There was uneven distribution of data records by season, and only two of the 12 species had > 30 records for all four seasons. Time series lengths ranged from 0 – 178 years, with a mean of 79 years (± 18 years SD of the mean). The 12 species had an average of 1.75 10-year periods where > 30 records fell within a 10-year period. Four of the 12 species had ≥ 2 10-year periods with > 30 records. The 12 species had > 30 data records for an average of 13% (± 3.4% SD of the mean, range 0 – 33.3%) of their known areas of distribution. Of the total 32,534 point occurrence records for the 12 species, 1.4% contained information on the observed depth of the organisms. Results highlight several challenges for species’ distribution modeling employing primary species-level point occurrence...
data published to the OBIS and GBIF portals. Data quality issues, including taxonomic, spatial and temporal gaps, and lack of capture of information on resolution, and time and depth of observed organisms, which apply across species groups, are central obstacles. For example, data quality on alien species requires sufficient sample sizes and time series lengths to distinguish between pioneer individuals of a nonnative species and those that successfully established a reproducing population in a non-indigenous area. Augmented data publication to fill identified gaps, and modified metadata standards to capture fundamental information on resolution, time of observation, and three-dimensional position, are needed. Mechanistic models might be the optimal choice for estimating species’ distributions, as they account for both habitat changes and population dynamics.

Results suggest that available biodiversity data resources provide sufficient information for robust modeling to estimate past temporal and spatial patterns in the latitudinal distribution and spread of several prioritized marine IAS, and to project future distributions across portions of the species’ known native and introduced ranges. Filling the identified gaps in taxonomic, spatial and temporal coverage, and capturing information on resolution, will contribute to the continued growth in relevance of the OBIS and GBIF portals for the continued development of the global biodiversity information commons to support large spatial- and temporal-scale studies to contribute to understanding the change and loss in global marine biodiversity.

Introduced, alien species are organisms outside of their natural geographic range, transported accidentally or deliberately by people so as to relax or eliminate natural barriers to the dispersal of and expansion of species’ distributions, such as temperature and land masses, altering natural patterns of biogeography. Alien species are invasive when they are able to establish a reproducing population in a non-indigenous area, expand in abundance and area, and become dominant or damaging in the new area. On the order of thousands of species have been distributed outside of their indigenous range, and a small fraction of these, but growing number, are invasive. Some nonnative species may be able to become invasive in degraded environments. The small proportion of these introduced species that are invasive disrupt ecosystems in various manners, threatening biodiversity, food security, human health, trade, transport and economic development. The cost of damage caused by invasive alien species is estimated as US$ 1.4 trillion per annum – close to 5% of GDP. Economic costs of damage and control is estimated at USD 1.4 trillion per year globally, and exceeds USD 120 billion annually in the U.S.A. alone. Ecological impacts of marine invasive alien species include: major shifts in community composition, reduced species richness, declines in abundance and local extirpations of native species, niche contraction of native species, reduced genetic diversity within native species, reduced ecosystem functioning and reduced habitat structure. Ecological impacts of marine invasive alien species include: major shifts in community composition, reduced species richness, declines in abundance and local extirpations of native species, niche contraction of native species, reduced genetic diversity within native species, reduced ecosystem functioning and reduced habitat structure.

The complex, synergistic effects of multiple drivers of change and loss in marine biodiversity, including overexploitation, habitat degradation, pollution, climate change and the spread of marine invasives, result in invasive aliens becoming dominant and declines in genetic to ecosystem diversity. The wide spread of alien species that thrive in disturbed, human-altered ecosystems in combination with commensurate extinctions of native species, leads to taxonomic homogenization, where at regional and global scales, ecosystems are becoming increasingly similar in terms of their gene pools (genetic homogenization), species compositions (taxonomic homogenization), and ecosystem functioning (functional homogenization), collectively referred to as biotic homogenization, as generalists come to predominate in place of
specialist niche species and unique communities are replaced by those comprised of more cosmopolitan species. The ecological impacts of marine invasive alien species are poorly understood due to a general paucity of understanding of altered distributions of nonnative marine species, the single factor effects of alien species introductions, and the interrelationships between native and alien species, and possible positive (mutualistic and commensalistic) interactions between multiple introduced species.

Species introductions have increased exponentially in number and geographical extent in recent years due to increased global trade and travel. For example, an estimated 7,000 species are transported via ballast water released from marine vessels. Other vector categories include: (i) Hull fouling on marine ships; (ii) Deliberate release, such as for cultivation and stocking; (iii) Accidental release of ornamental species used in the aquarium trade; (iv) Accidental escapement of species (target, parasites and pathogens) used in aquaculture and ranching industries; and (v) Accidental escapement related to research. Changes in species’ distributions in response to climate change is yet another cause of species introductions. The spread of genetically modified organisms, such as through the escapement of fish from aquaculture facilities, and pollen from genetically modified plants fertilizing wild cousins, is another mechanism for species introductions.