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SỞ TÀI NGUYÊN VÀ MÔI TRƯỜNG THÀNH PHỐ ĐÀ NẴNG
DA NANG DEPARTMENT OF NATURAL RESOURCES AND ENVIRONMENT

Climate-smart spatial planning assessment in support of conservation and blue growth in Da Nang city's marine environment

A report from the ACCORD project

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Executive summary

This study assessed ocean climate modelling datasets to establish what sensitivities to climate change could be identified for species of commercial and conservation value in the waters of Da Nang City, Vietnam, and what actions could be taken to support their adaptation to these pressures. Commissioned via UK Research and Innovation Official Development Assistance National Capability funded project 'Addressing Challenges of Coastal Communities through Ocean Research for Developing Economies' (ACCORD), and co-developed with the Da Nang Department of Natural Resources and Environment with the support of PEMSEA, our main ambition was to highlight what spatial management activities could be undertaken in the waters off the city to support climate change adaptation in its resources. We identified substantial sensitivities of species of commercial and conservation value across the whole bay and its offshore waters to climate change under increasing global greenhouse emissions. For species that occupy the water column (as opposed to the seabed), this sensitivity appeared to be concentrated in the southern part of the bay. Importantly, fishing pressure exacerbated the pressure of climate change on pelagic target species, highlighting the challenges of delivering food security and a growing blue economy imposed by a changing climate. Additionally, lowered emissions, in line with the Paris Agreement, would deliver clear benefits to all types of species assessed, supporting a more sustainable path for the exploration of Da Nang's marine resources and it's blue economy. Recommendations are made about how the Coastal Use Zoning Plan for Da Nang City could be adapted to support climate change adaptation in these species and habitats, as well as the broader sustainability of these ecosystems.

Glossary

- Adaptation (to climate change): describes actions (management) or natural processes that promote sustainability of nature and human society, given the projected impacts of climate change.

- Climate signal: a change in environmental conditions consistent with long-term climate trends, expressing an ecosystem state that is not observed in the reference period (e.g. present decade).

- Demersal: a species that lives in association with the seabed.

- Pelagic: a species that occurs in the water column.

- Spatial meta-analysis: a specific statistical method employed here to analyse climate modeling data and to quantify the emergence of the climate signal.

1. Introduction

Due to its strategic location and a long history of shipping, trade, and warfare, Da Nang is at present the third largest city of Socialist Republic of Vietnam, and the largest in its Central Region. The city is currently experiencing accelerated economic growth, in tandem with planning and infrastructure development (Scarwell and Leducq 2021 and references therein). This growth is partly bolstered by a strong reliance on, and role in, the maritime economy of the broader region, and is supported by growing international interest and investment in regional, land- and sea-based industries (Tien and Thuy 2020, Scarwell and Leducq 2021). The 90 km stretch that composes Da Nang's shoreline is thus an area where a number of sectors of key economic importance, especially tourism, compete for space against a backdrop of growing urbanization and human footprint (Nguyen, Nguyen et al. 2020). This pressure impacts the natural environment that sustains the activities of many of these sectors, with urban waste (including plastic) an important concern impacting sensitive habitats such as coral reefs, and reducing water quality (Nguyen, Nguyen et al. 2020).

Responding to these growing pressures, the Coastal Use Zoning Plan for Da Nang City ("CUZP", People's Committee of Da Nang City 2005), was devised under the Coastal Strategy for the city, to promote integrated spatial planning of economic activities in the Da Nang coastal area. Specifically, the CUZP provides the local government with an effective mechanism to regulate and manage space sharing between different maritime sectors reliant on, and supporting, the near shore ecosystem (e.g. protection of key ecosystems, port development and shipping, tourism, fishing, urban development), as well as the means to support the implementation of the aims of the Coastal Strategy. The CUZP thus provides integrated zoning for different activities present in the region, as well as the mechanisms for the regulation of space-sharing. The plan takes into account the local environment, an environmental risk assessment, integrated data sources for the region, and the present profile of economic/maritime based activities reliant on the coastal zone at the time of its design (including water- and land-based activities and ecosystems; CUZP Fig.1, People's Committee of Da Nang City 2005).

As in other regions of the world, however, effective spatial planning and management of coastal and marine space requires climate change adaptation considerations (Frazão-Santos, Agardy et al. 2020, Queirós, Talbot et al. 2021). Indeed, failing to account for fast climate-driven changes in coastal and marine ecosystems taking place in the coming decades is unlikely to lead to effective outcomes for sustainable blue growth, leaving behind conservation targets and vulnerable communities that rely on maritime sectors (Queirós, Talbot et al. 2021).This is also true for Vietnam. Recent work has highlighted that climate change will present important challenges to Vietnam's East Sea within the next few decades (Kay, Avillanosa et al. 2021). That work, which included the coastal waters of Da Nang city, identified that warming between 1.1-2.9^{o}C, reduced salinity, and increased incidence of extreme weather by mid-century are likely, posing important threats to the sustainability of key species such as coral and associated, commercially exploited fish, all of which impact reliant blue economy sectors (Kay, Avillanosa et al. 2021 and references therein). Warming, associated with high nutrient conditions that can result from natural processes and land run-off, can also spur the incidence of harmful algal blooms, in turn affecting the resilience of tourism reliant on good water conditions, fisheries, and aquaculture to name a few sectors (Tang, Kawamura et al. 2004). All of these areas of activity are affected by the CUZP.

In the present study, we aimed to assess what challenges and opportunities climate-driven change may pose, specifically, to coastal ecosystems of interest to Da Nang city, and how these may be capitalized upon to promote adaptive routes that ensure the effective delivery of the aims of the CUZP. We built on recent climate modeling data for the marine environment and key species of interest for the region, as well as a range of other spatial datasets. Using these datasets as inputs, we then undertook a state-of-the-art marine-spatial planning specific analysis of this modelling evidence (Queirós, Talbot et al. 2021) to identify, within Da Nang Bay, sites potentially hosting climate-resilient ecosystems underpinning nature conservation and fishing activity, as well as where the greatest vulnerabilities to climate may occur. Climate change and ocean acidification, though resulting from global greenhouse emissions, do not unfold homogenously across all regions. Especially in coastal areas, hydrography and regional-based oceanographic processes can significantly alter long-term-trends (Hauri, McDonnell et al. 2021), including conditions that may lead to regular functioning of ecosystems and support local biodiversity, serving a short- and medium term climate refuges and even bright spots (Queirós, Talbot et al. 2021). The long-term sustainability of marine species and habitats, and of economic activities that exploit them, may thus require that such refuges are protected in the present time, as a time-buying strategy supporting ecosystems and the associated blue economy, until such a time when global emissions are significantly reduced (Queirós, Talbot et al. 2021).

The ambition for this study was to map potential climate resilience in the ecosystems underpinning marine conservation and fisheries in Da Nang Bay in the coming decades, and to compare this with the current distribution of activities outlined in the CUZP. In this way, we aimed to provide Da Nang city with information that may be used to develop climate-adaptive strategies for the CUZP in support of the resilience of livelihoods depending on economic activities that rely on the health of these ecosystems.

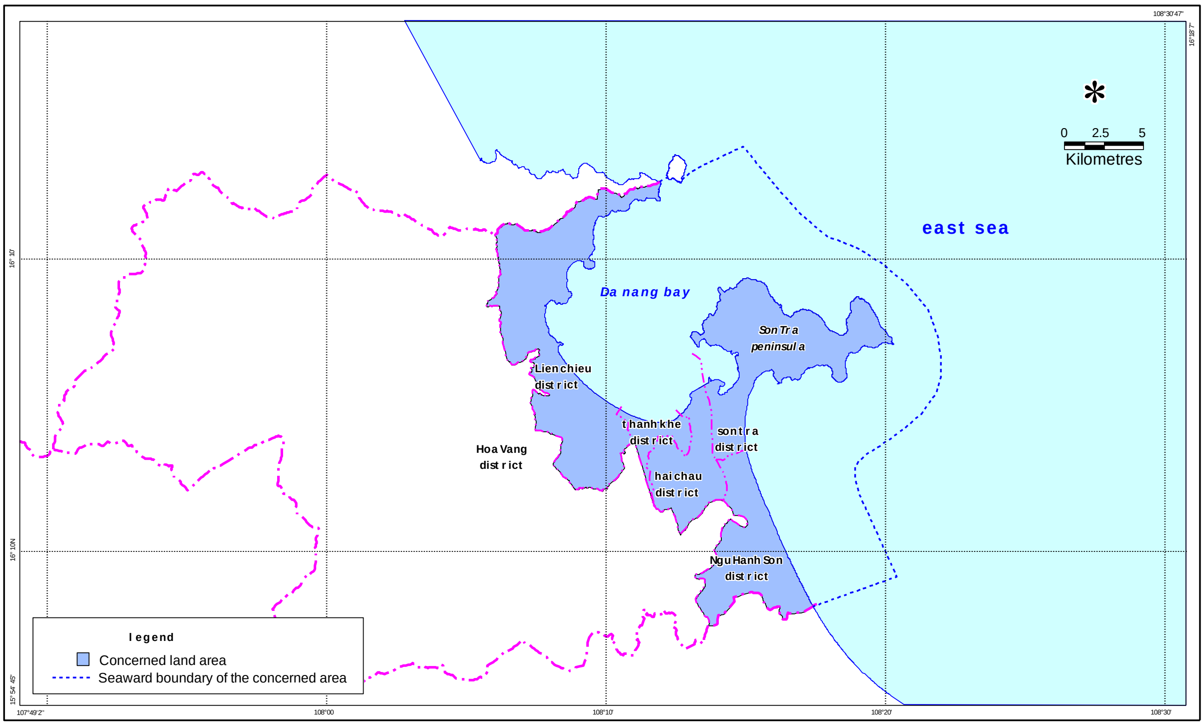

Figure 1*: The area affected by the CUZP. The area includes 5 coastal districts of Da Nang city (pink outline, over land) and the coastal fringe to 50m depth and up to 6nm from the shore (blue outline, over water). Reproduced from Coastal Use Zoning Plan for Da Nang city, 2005.*

2 Methods

Here, we build on a recent catalogue of climate modeling evidence for the marine environment in Vietnam's East Sea (Kay, Avillanosa et al. 2021) and for key species of commercial interest in the region (Sailley 2021), generated by this team for the Global Challenges Research Fund recipient UKRI project Blue Communities (blue-communities.org). We further employed state-of-the-art Marine Spatial Planning specific climate modelling analyses methods detailed in Queirós, Talbot et al. (2021), to analyse these datasets. The steps undertaken in this study, from data gathering, to modelling analyses, to output generation and interpretation, are summarized in Figure 2, for guidance.

Initial engagement with the Da Nang Department of Natural Resources and Environment ("DONRE"; Fig.2, steps 1 & 2) helped us identify key sectors as well as areas of interest within the CUZP, on which our analysis could provide information. Areas of interest included protected coral reefs around Hai Van pass and the Son Tra peninsula (Fig.1), which are also of interest to ecotourism; development of a large fishing port in the northern area of Da Nang Bay; inshore and offshore fishing activity; and the pressure of seafront urbanization and mass tourism on the coastal area. The modelling catalogue available to this study did not allow us to cover the potential effects of coastal pollution from urbanization on Da Nang's coastal ecosystem. We therefore focused this study on mapping the climate resilience of ecosystem components underpinning the conservation of (reef) habitat and the activity of fisheries.

2.1 Modelling data analyses

Modeling datasets that would enable us to quantify potential climate-driven change in ecosystem components underpinning the two key sectors of interest (conservation and fisheries) were then selected for analysis, from within the modelling catalogue available to this study, as detailed in Tables I and II (Fig. 2, step 2). We ran separate analyses for each for these sectors, as follows.

Literature review

The first step of the climate modelling data analysis method employed here (Queirós, Talbot et al. 2021) required us to *a priori* review from the literature what is the expected long-term, climate-driven trend for each of the variables modelled that we selected for analyses (Fig.2, step 3; Tables I and II). For each environmental variable in Table I, we reviewed literature to establish the expected long-term trend, specifically, based on Bindoff, Cheung et al. (2019) and Collins, Sutherland et al.(2019). Based on these references, we also reviewed literature to establish the expected long-term trends for species of interest to Vietnam fisheries listed in Table II. Based on these reviews, we expected that overall long-term trends would be negative (i.e. decreased abundance). For species dependent on seabed habitats (i.e. demersal), we based this expectation on the reliance of these species on coral and seagrass habitats, well documented as being sensitive to heat-waves (Anthony, Bay et al. 2017) and typhoons (Van Luong, Van Thao et al. 2012), and there is a high probability that all of those will affect the region without significant curbs in emissions (Bindoff, Cheung et al. 2019, Collins, Sutherland et al. 2019). Although a recent study estimated that coral may be able to adapt to warming in the Vietnam coast (Matz, Treml et al. 2020) its authors recognize that their modelling study is primarily theoretical, based on assumptions about coral adaptation and migration potential under long-term and abrupt warming, over which we have low confidence (Bindoff, Cheung et al. 2019). Our expectation, in line with consensus, was that, coral reefs are already at risks

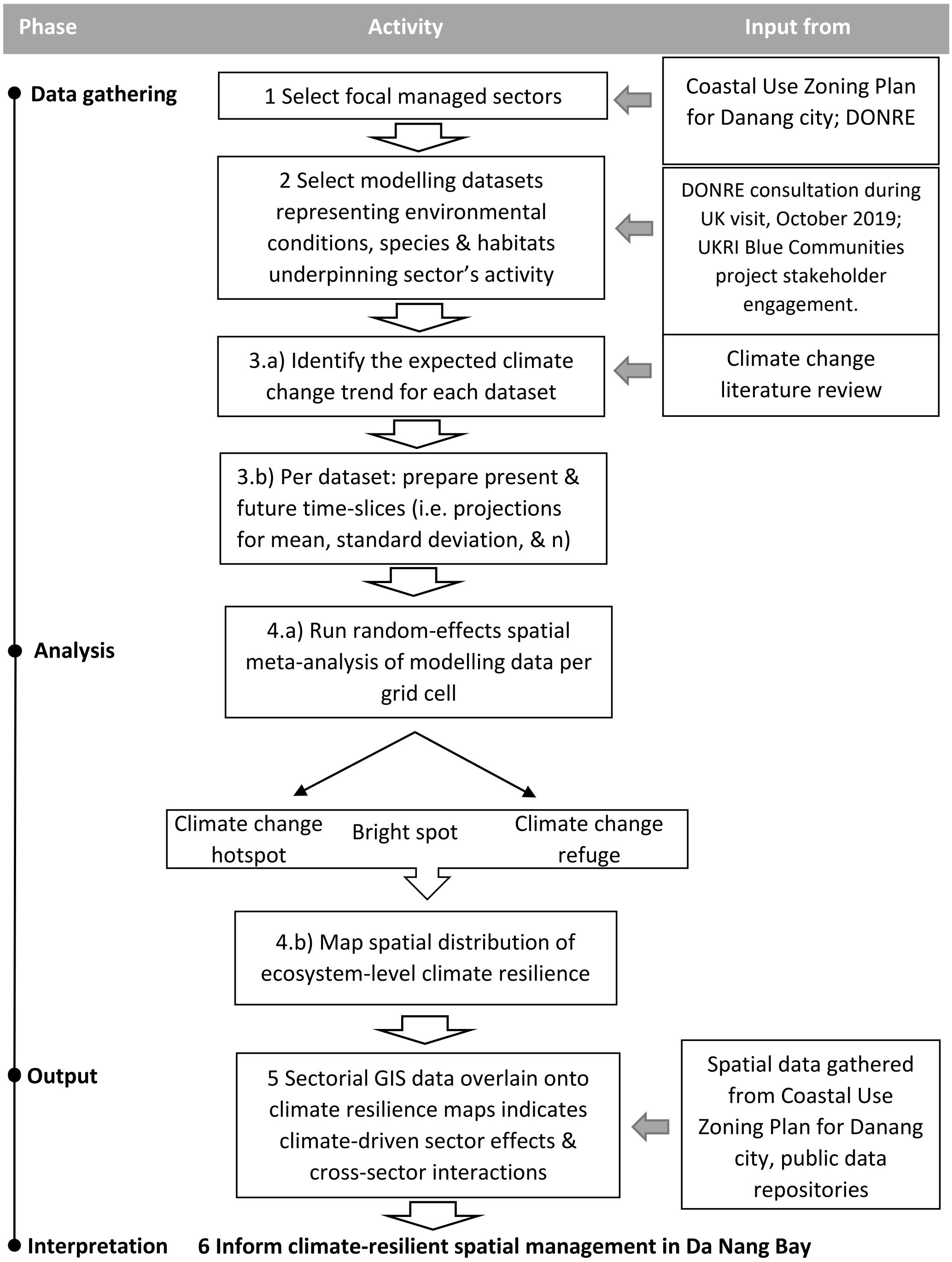

Figure 2: *Schematic representation of analysis framework employed here, modified from Queirós, Talbot et al. 2021.*

at present (Bindoff, Cheung et al. 2019), and that in addition to other pressures, heat-waves present important long-term hurdles to coral survival in the region (Collins, Sutherland et al. 2019). This threatens also species reliant on these species as habitat (i.e. demersal fished species). This potential loss of habitat for fished demersal species is therefore expected to add to other, direct effects of climate-driven environmental change on them (i.e. warming, heat-waves, deoxygenation, etc.). For species occurring in the water column (i.e. pelagic) in the coast of Vietnam, loss of those habitats will also be concerning, especially loss of breeding grounds (People's Committee of Da Nang City 2005). We further assumed that the projected decline in Net Primary Production, in addition to long-term warming, will likely lead to decreased pelagic fish abundances in the long-term (Table II), without significant curbs in CO_2

emissions (Bindoff, Cheung et al. 2019). The trends listed for each modeling dataset in Tables I and II thus reflected this assessment, expressing long-term, climate-change driven change, in the absence of significant global emissions curbs.

Calculating climate-driven effects on modelled datasets

Based on the reviewed, expected trends, our analysis method then compared, based on the present ecosystem state, with the state of that ecosystem in a period of interest in the future, modelling datasets (Tables I and II), to establish if and where any ecosystem-level climate-driven changes could be identified in our area of interest (Da Nang Bay, Fig.2 steps 4a-b). For each grid cell of the used modelling projections, each temporal comparison, sector, and emissions scenario, we constructed a random-effects meta-analysis model that tested the null hypothesis that there was no change in the ecosystem, defined by the modelling layers we included in each analysis. The meta-analysis model construction per grid cell, sector, scenario and time-frame, has two steps. First, we calculated the individual effect, estimating the degree of change in each modelling dataset included as the difference in the mean of the modelled variable between present and future, per unit of variation (i.e. the variability of the mean in the present and the future). Specifically, we calculated individual effects using the standardized mean difference estimator Hedges' g (Hedges 1982). Hedges' g is centered around 0, and we designed this analysis step (step 4.a, Fig.2) based on long-term trends reviewed (Fig.2 step 3.a). That is, for each modelling dataset considered, Hedges'g was negative if the expected long-term, climate-driven trend for each variable was observed, and positive otherwise. Maps of Hedges' g calculated in this way could then be seen to provide a visualization of the distribution of a climate change signal-to-noise ratio (Hawkins and Sutton 2012). This allowed for the comparison of the strength of the climate signal between the variables included in our analyses in the waters of Da Nang (Tables I and II). That is, a visual assessment of where each modelled variable analyzed may change the most as a result of climate change, despite their natural variability, and these figures can be found in the annex section. Second, we re-calculated the variance of the individual effects using the DerSimonian-Laird method (Borenstein, Hedges et al. 2011) to finally estimate the summary effect. The latter quantifies change at the ecosystem level (that is, when all datasets were considered toghether, perQueirós, Talbot et al. 2021). Once each meta-analysis model was constructed, our method then enabled us to identify, for the specified time-periods of interest and within each cell grid of the common model domain, whether the a climate signal emerged in the ecosystem we assessed in each analysis (as defined by the modeling layers subset included in each analysis). This information was then used to build the final output maps, per analysis (Fig.2 step 4a-b). In these, and for each grid cell, three outcomes were then possible. Each site was either: a climate change refugium (where the ecosystem underpinning each focal sector is resilient to climate change in the period of analysis); a climate change hotspot (climate-vulnerable sites, where a climate signal emerges and the ecosystem enters a new state, outside of its variability in the present time, as a result of climate change); or a bright spot (where improved habitat conditions for the species of interest to the sector analyzed may emerge, contrary to the climate trend; Figure 2, steps 4a-b). More detail about the specific statistical method employed in this analysis (i.e. spatial meta-analysis of climate modelling data), and further technical considerations and framing in the broader climate change literature, can be found in Queirós, Talbot et al. (2021).

For each analysis, climate change refugia, hotspots and bright spots were then mapped and the CUZP (Fig.3) overlain onto these maps (Fig.2, step 5). Additionally, we included in these maps the contemporary spatial distribution of warm water corals, seagrass and mangrove provided by the Global Distribution of Warm-Water Coral Reefs (UNEP-WCMC, WorldFish Centre et al. 2010), the Global Distribution of Seagrasses (UNEP-WCMC and Short FT 2020), and the World Atlas of Mangroves (Spalding, Kainuma et al. 2010) datasets. In this way, we were able to compare projected climate change effects in the ecosystems affecting conservation areas and inshore and offshore fishing areas off Da Nang city, with the current zoning plan, as well as the current distribution of vulnerable, coastal habitats of interest to economic activities in to the city (People's Committee of Da Nang City 2005).

We compared the present ecosystem state at the time of study (2011-2020) with that in the 2040-2049 and 2060-2069 in separate analyses, assessing changes in near-term and mid-term futures. All modelling analyses considered modelling projections for these ecosystems and their species (Table I and II), forced by global greenhouse gas concentration trajectories (i.e. representative concentration pathways, 'RCPs', Van Vuuren, Edmonds et al. 2011) RCP4.5 and 8.5. These two scenarios were chosen as they were seen to represent a likely range of future global greenhouse gas and aerosol concentrations, at the time of study (IPCC 2013, Hausfather and Peters 2020, Schwalm, Glendon et al. 2020). RCP4.5 assumes strong curbs in global emissions towards climate change mitigation, from 2050 onwards, while emissions continue to rise steadily throughout the 21st century under RCP8.5. Our analyses' future time-horizons then allowed us to explore near-term changes under the two emissions trajectories, which practitioners may be more interested in (i.e. the 2040s; Pınarbaşı, Galparsoro et al. 2017); as well as mid-term changes (2060s). The latter time-horizon may provide a more meaningful spread of possible futures for Da Nang Bay, as the 2060s come 10 years after emissions curbs in our lower emissions scenario considered (RCP4.5).

Because the physical-biogeochemical modeling projections we analyzed in the conservation-focused analyses have high temporal resolution (Butenschön, Clark et al. 2015, Kay, Avillanosa et al. 2021), we undertook inter-decadal analyses focused on yearly changes, as well as changes within monsoon periods, to help highlight more extreme climate change patterns which may have be smoothed out in yearly averages (Nguyen, Renwick et al. 2014). With some regional and inter-annual variability expected around the onset of the summer and winter monsoons in Vietnam (Nguyen-Le, Matsumoto et al. 2014), we have considered May to September as the south-west ("SW", also referred to as "South Asia", or "summer") monsoon period; and November to March as the north-east ("NE", also referred to as "East Asia", or "winter") monsoon (Nguyen, Renwick et al. 2014). In the fishing sector analyses, only yearly comparisons were possible across decades, as this is the temporal resolution of the model underlying the projections analyzed (Cheung, Sarmiento et al. 2013, Sailley 2021). Separate fishing sector analyses were carried out on projections simulating: a) the effects of climate change and fishing mortality such that, at each point in space and time, each species included in simultaneous runs of the Dynamic Bioclimate Envelope Model (Sailley (2021), Table II) was harvested at its Maximum Sustainable Yield ("MSY", the maximum biomass that can be taken from that species stock over one year)); or b) the effects of climate change alone (i.e. no fishing mortality, Sailley (2021)). We ran separate analyses for species that depend on the seabed (i.e. demersal), and species that occur in the water column (i.e. pelagic)

It is important to note that the domain of the biogeochemical modelling projections included here, and used to force the species distribution model employed (Table I) does not cover the very inshore waters of Da Nang (Annex plots for Table I datasets). Values for these grid cells provided in final maps are interpolated from nearby grid cells, using 8 neighbor averaging. It is also noteworthy that all modelling data analyzed derives from a single realization of an Earth System model, and different realizations can lead to variability in the climate change impacts estimated. Details can be found in Kay, Avillanosa et al. (2021).

***Table I**: Modelling datasets used in the spatial meta-analysis undertaken for marine conservation in Vietnam. All modelling projections for the analysis were produced for the GCRF Blue Communities project (Kay, Avillanosa et al. 2021)*

Output type	Modelled variable	Units	Model	Scenario	Time periods	Horizontal resolution	Expected climate trend	Reference - project
Physical/ biogeochemical	Surface dissolved oxygen	mmol m^{-3}	POLCOMS-ERSEM	RCP 4.5 RCP 8.5	2011-2020 2040-2049 2060-2069	0.1º lat x 0.1º lon	Decrease	Kay, Avillanosa et al. (2021) – Blue Communities
Physical/ biogeochemical	Bottom layer dissolved oxygen	mmol m^{-3}	POLCOMS-ERSEM	RCP 4.5 RCP 8.5	2011-2020 2040-2049 2060-2069	0.1º lat x 0.1º lon	Decrease	Kay, Avillanosa et al. (2021) – Blue Communities
Physical/ biogeochemical	Surface seawater temperature	°C	POLCOMS-ERSEM	RCP 4.5 RCP 8.5	2011-2020 2040-2049 2060-2069	0.1º lat x 0.1º lon	Increase	Kay, Avillanosa et al. (2021) – Blue Communities
Physical/ biogeochemical	Bottom layer seawater temperature	°C	POLCOMS-ERSEM	RCP 4.5 RCP 8.5	2011-2020 2040-2049 2060-2069	0.1º lat x 0.1º lon	Increase	Kay, Avillanosa et al. (2021) – Blue Communities
Physical/ biogeochemical	Mean euphotic zone total chlorophyll-a	mg m^{-2}	POLCOMS-ERSEM	RCP 4.5 RCP 8.5	2011-2020 2040-2049 2060-2069	0.1º lat x 0.1º lon	Decrease	Kay, Avillanosa et al. (2021) – Blue Communities
Physical/ biogeochemical	Net primary production	mg C m^{-2} day^{-1}	POLCOMS-ERSEM	RCP 4.5 RCP 8.5	2011-2020 2040-2049 2060-2069	0.1º lat x 0.1º lon	Decrease	Kay, Avillanosa et al. (2021) – Blue Communities
Physical/ biogeochemical	Water column sum of phytoplankton carbon	mg C m^{-2}	POLCOMS-ERSEM	RCP 4.5 RCP 8.5	2011-2020 2040-2049 2060-2069	0.1º lat x 0.1º lon	Decrease	Kay, Avillanosa et al. (2021) – Blue Communities
Physical/ biogeochemical	Water column sum of zooplankton carbon	mg C m^{-2}	POLCOMS-ERSEM	RCP 4.5 RCP 8.5	2011-2020 2040-2049 2060-2069	0.1º lat x 0.1º lon	Decrease	Kay, Avillanosa et al. (2021) – Blue Communities

Physical/ biogeochemical	Bottom non-living organic carbon	mg C m^{-3}	POLCOMS-ERSEM	RCP 4.5 RCP 8.5	2011-2020 2040-2049 2060-2069	0.1º lat x 0.1º lon	Decrease	Kay, Avillanosa et al. (2021) – Blue Communities
Physical/ biogeochemical	Surface seawater pH	scalar	POLCOMS-ERSEM	RCP 4.5 RCP 8.5	2011-2020 2040-2049 2060-2069	0.1º lat x 0.1º lon	Decrease	Kay, Avillanosa et al. (2021) – Blue Communities
Physical/ biogeochemical	Bottom layer seawater pH	scalar	POLCOMS-ERSEM	RCP 4.5 RCP 8.5	2011-2020 2040-2049 2060-2069	0.1º lat x 0.1º lon	Decrease	Kay, Avillanosa et al. (2021) – Blue Communities
Physical/ biogeochemical	Surface seawater salinity	psu	POLCOMS-ERSEM	RCP 4.5 RCP 8.5	2011-2020 2040-2049 2060-2069	0.1º lat x 0.1º lon	Decrease	Kay, Avillanosa et al. (2021) – Blue Communities

***Table II**: Modelling datasets used in the spatial meta-analysis undertaken for Vietnamese fisheries. All modelling projections for the analysis were produced for the GCRF Blue Communities project (Sailley 2021).*

Output type	Modelled species	Units	Fishery type	Model	Scenario	Time periods	Horizontal resolution	Expected climate trend	Source - project
Species distribution	*Sardinella gibbosa*	Abundance: number fish per model grid cell	Pelagic	POLCOMS-ERSEM-SS-DBEM	RCP4.5 RCP8.5	2011-2020 2040-2049 2060-2069	0.5º lat x 0.5º lon	Decrease	Sailley (2021) – Blue Communities
Species distribution	*Spratelloides gracilis*	Abundance: number fish per model grid cell	Pelagic	POLCOMS-ERSEM-SS-DBEM	RCP4.5 RCP8.5	2011-2020 2040-2049 2060-2069	0.5º lat x 0.5º lon	Decrease	Sailley (2021) - Blue Communities
Species distribution	*Rastrelliger kanagurta*	Abundance: number fish per model grid cell	Pelagic	POLCOMS-ERSEM-SS-DBEM	RCP4.5 RCP8.5	2011-2020 2040-2049 2060-2069	0.5º lat x 0.5º lon	Decrease	Sailley (2021) - Blue Communities
Species distribution	*Scomberomorus commersoni*	Abundance: number fish per model grid cell	Pelagic	POLCOMS-ERSEM-SS-DBEM	RCP4.5 RCP8.5	2011-2020 2040-2049 2060-2069	0.5º lat x 0.5º lon	Decrease	Sailley (2021) - Blue Communities
Species distribution	*Trichiurus lepturus*	Abundance: number fish per model grid cell	Pelagic	POLCOMS-ERSEM-SS-DBEM	RCP4.5 RCP8.5	2011-2020 2040-2049 2060-2069	0.5º lat x 0.5º lon	Decrease	Sailley (2021) - Blue Communities
Species distribution	*Caranx ignobilis*	Abundance: number fish per model grid cell	Pelagic	POLCOMS-ERSEM-SS-DBEM	RCP4.5 RCP8.5	2011-2020 2040-2049 2060-2069	0.5º lat x 0.5º lon	Decrease	Sailley (2021) - Blue Communities
Species distribution	*Thunnus tonggol*	Abundance: number fish per model grid cell	Pelagic	POLCOMS-ERSEM-SS-DBEM	RCP4.5 RCP8.5	2011-2020 2040-2049 2060-2069	0.5º lat x 0.5º lon	Decrease	Sailley (2021) - Blue Communities
Species distribution	*Auxis rochei*	Abundance: number fish per model grid cell	Pelagic	POLCOMS-ERSEM-SS-DBEM	RCP4.5 RCP8.5	2011-2020 2040-2049 2060-2069	0.5º lat x 0.5º lon	Decrease	Sailley (2021) - Blue Communities

Species distribution	*Rachycentron canadum*	Abundance: number fish per model grid cell	Pelagic	POLCOMS-ERSEM-SS-DBEM	RCP4.5 RCP8.5	2011-2020 2040-2049 2060-2069	0.5º lat x 0.5º lon	Decrease	Sailley (2021) - Blue Communities
Species distribution	*Anodontostoma chacunda*	Abundance: number fish per model grid cell	Pelagic	POLCOMS-ERSEM-SS-DBEM	RCP4.5 RCP8.5	2011-2020 2040-2049 2060-2069	0.5º lat x 0.5º lon	Decrease	Sailley (2021) - Blue Communities
Species distribution	*Scomberoides lysan*	Abundance: number fish per model grid cell	Pelagic	POLCOMS-ERSEM-SS-DBEM	RCP4.5 RCP8.5	2011-2020 2040-2049 2060-2069	0.5º lat x 0.5º lon	Decrease	Sailley (2021) - Blue Communities
Species distribution	*Epinephelus coioides*	Abundance: number fish per model grid cell	Demersal	POLCOMS-ERSEM-SS-DBEM	RCP4.5 RCP8.5	2011-2020 2040-2049 2060-2069	0.5º lat x 0.5º lon	Decrease	Sailley (2021) - Blue Communities
Species distribution	*Lethrinus microdon*	Abundance: number fish per model grid cell	Demersal	POLCOMS-ERSEM-SS-DBEM	RCP4.5 RCP8.5	2011-2020 2040-2049 2060-2069	0.5º lat x 0.5º lon	Decrease	Sailley (2021) - Blue Communities
Species distribution	*Lethrinus nebulosus*	Abundance: number fish per model grid cell	Demersal	POLCOMS-ERSEM-SS-DBEM	RCP4.5 RCP8.5	2011-2020 2040-2049 2060-2069	0.5º lat x 0.5º lon	Decrease	Sailley (2021) - Blue Communities
Species distribution	*Mulloidichthys flavolineatus*	Abundance: number fish per model grid cell	Demersal	POLCOMS-ERSEM-SS-DBEM	RCP4.5 RCP8.5	2011-2020 2040-2049 2060-2069	0.5º lat x 0.5º lon	Decrease	Sailley (2021) - Blue Communities
Species distribution	*Gerres oyena*	Abundance: number fish per model grid cell	Demersal	POLCOMS-ERSEM-SS-DBEM	RCP4.5 RCP8.5	2011-2020 2040-2049 2060-2069	0.5º lat x 0.5º lon	Decrease	Sailley (2021) - Blue Communities
Species distribution	*Lutjanus argentimaculatus*	Abundance: number fish per model grid cell	Demersal	POLCOMS-ERSEM-SS-DBEM	RCP4.5 RCP8.5	2011-2020 2040-2049 2060-2069	0.5º lat x 0.5º lon	Decrease	Sailley (2021) - Blue Communities

Species distribution	*Platycephalus indicus*	Abundance: number fish per model grid cell	Demersal	POLCOMS-ERSEM-SS-DBEM	RCP4.5 RCP8.5	2011-2020 2040-2049 2060-2069	0.5º lat x 0.5º lon	Decrease	Sailley (2021) - Blue Communities
Species distribution	*Pennahia argentata*	Abundance: number fish per model grid cell	Demersal	POLCOMS-ERSEM-SS-DBEM	RCP4.5 RCP8.5	2011-2020 2040-2049 2060-2069	0.5º lat x 0.5º lon	Decrease	Sailley (2021) - Blue Communities
Species distribution	*Saurida tumbil*	Abundance: number fish per model grid cell	Demersal	POLCOMS-ERSEM-SS-DBEM	RCP4.5 RCP8.5	2011-2020 2040-2049 2060-2069	0.5º lat x 0.5º lon	Decrease	Sailley (2021) - Blue Communities
Species distribution	*Siganus guttatus*	Abundance: number fish per model grid cell	Demersal	POLCOMS-ERSEM-SS-DBEM	RCP4.5 RCP8.5	2011-2020 2040-2049 2060-2069	0.5º lat x 0.5º lon	Decrease	Sailley (2021) - Blue Communities
Species distribution	*Acanthopagrus berda*	Abundance: number fish per model grid cell	Demersal	POLCOMS-ERSEM-SS-DBEM	RCP4.5 RCP8.5	2011-2020 2040-2049 2060-2069	0.5º lat x 0.5º lon	Decrease	Sailley (2021) - Blue Communities
Species distribution	*Acanthopagrus latus*	Abundance: number fish per model grid cell	Demersal	POLCOMS-ERSEM-SS-DBEM	RCP4.5 RCP8.5	2011-2020 2040-2049 2060-2069	0.5º lat x 0.5º lon	Decrease	Sailley (2021) - Blue Communities
Species distribution	*Lates calcarifer*	Abundance: number fish per model grid cell	Demersal	POLCOMS-ERSEM-SS-DBEM	RCP4.5 RCP8.5	2011-2020 2040-2049 2060-2069	0.5º lat x 0.5º lon	Decrease	Sailley (2021) - Blue Communities

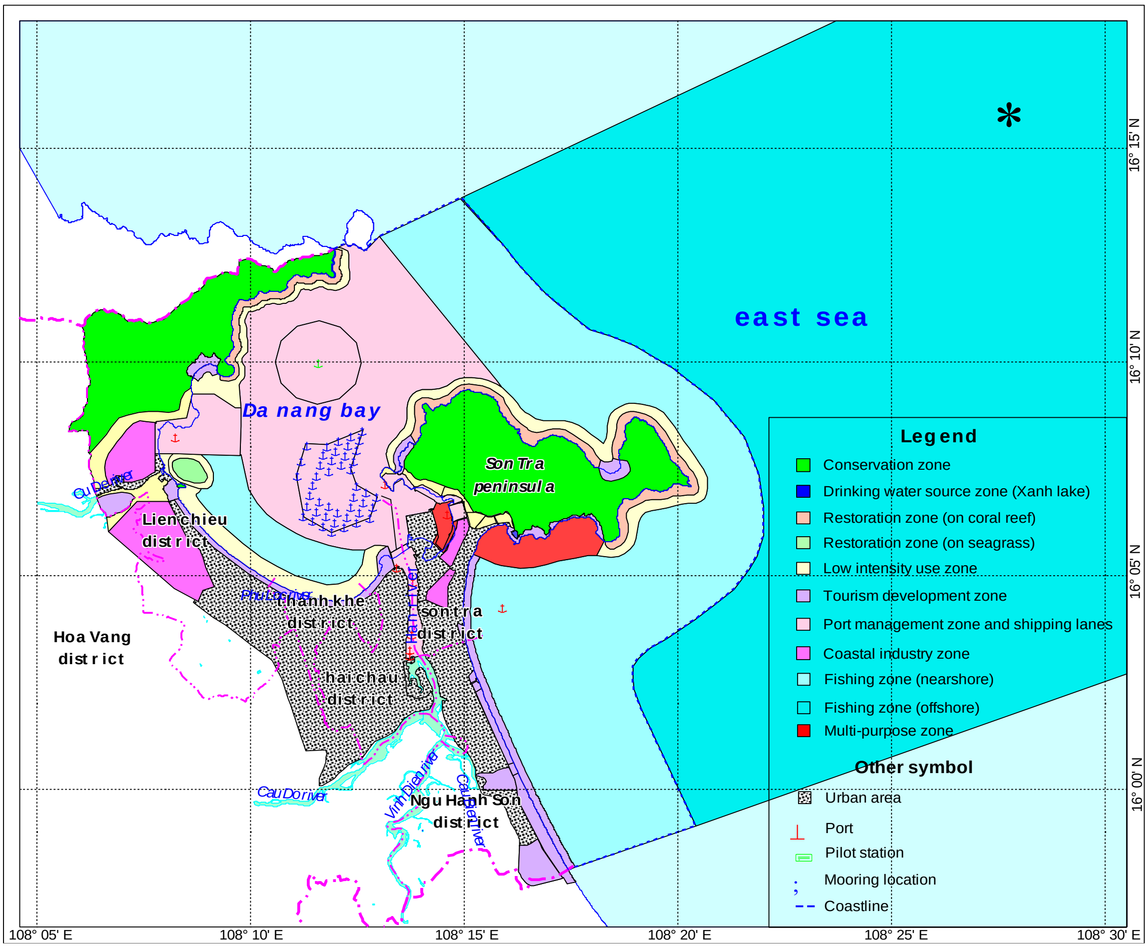

Figure 3: *Proposed zoning scheme. Reproduced from the Coastal Use Zoning Plan for Da Nang city, 2005.*

3. Results

3.1 Conservation analysis

The results of our modelling analysis for the conservation sector are given in figures 4 and 5, comparing the present with the 2040s (Fig.4) and the 2060s (Fig.5). There are distinctively different patterns of response of Da Nang's ecosystems to climate change between scenarios, highlighting the importance of the realized global emissions trajectory for the region, in the near future. Specifically, when yearly conditions were contrasted to the present decade, climate resilience was observed across the region under the lower emissions scenario we analyzed (RCP4.5) whilst the reverse was true under the higher emissions scenario (RCP8.5; Fig.4 and 5). Indeed, in this analysis, a climate signal (Hawkins and Sutton 2012, Queirós, Talbot et al. 2021) emerged across the whole region under RCP8.5 in both future decades considered, with climate change hotspots (black dots over green) marked across Da Nang's coastal waters in the bottom left hand side panels, in Fig.4 and Fig.5. Conversely, under RCP4.5 (the scenario when global emissions start decreasing sharply within the 2050s) the whole region remained as a climate refuge in the two future decades we considered, indicating a system that is within the range of the variability we observe at present (top left panel, Fig. 4 and 5). This was especially true in the 2060s (cf. the 2040s) when improved habitat conditions (i.e. a bright spot) was actually estimated north of the Son Tra Peninsula, just beyond the 6nm contour (top left panel, Fig. 5). The within monsoon period analyses identified that, overall, environmental conditions we considered within the waters covered by the CUZP (Table I) remain within

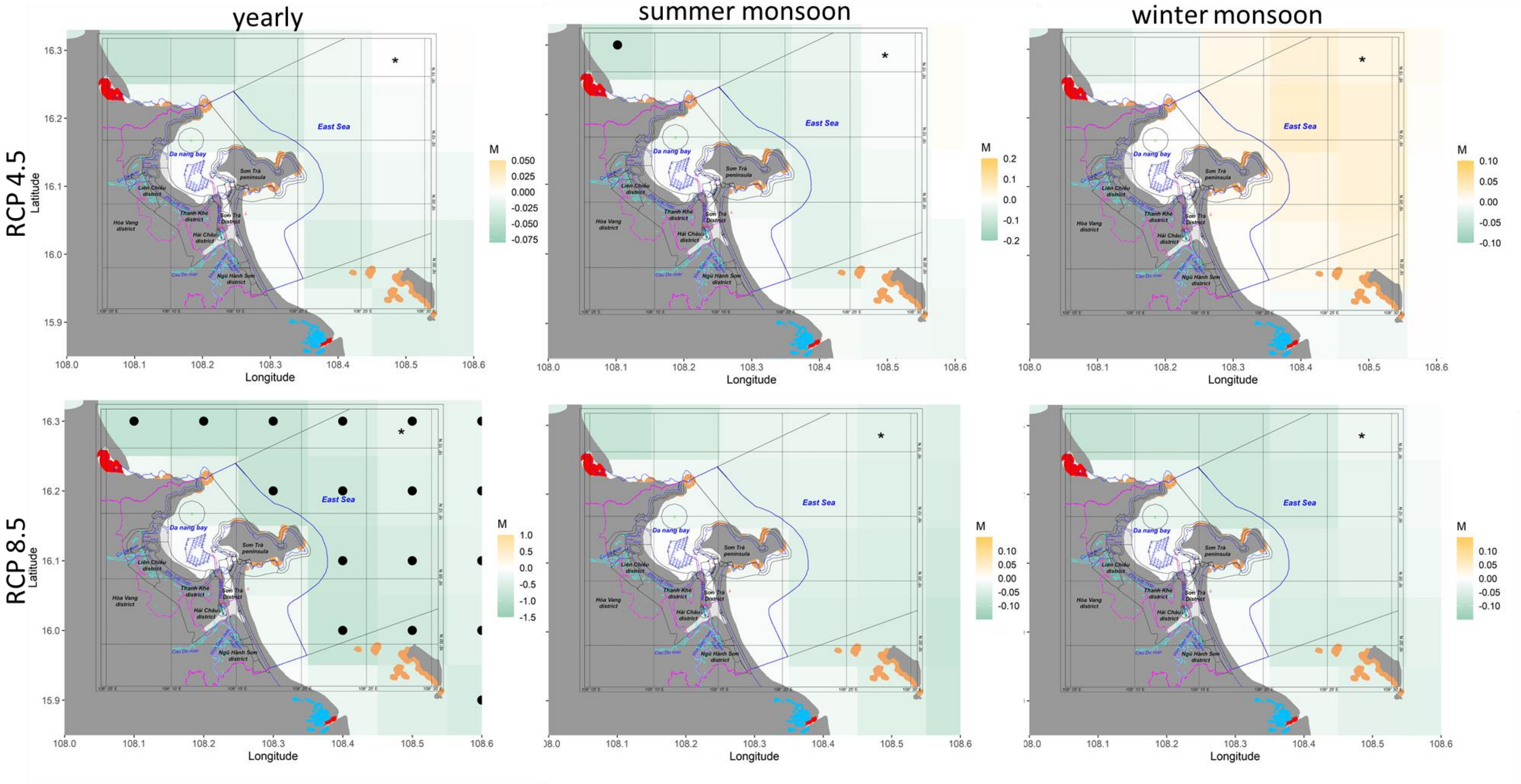

__Figure 4__: Climate modelling analysis results (i.e. spatial meta-analysis) for the conservation sector, comparing the present decade with the 2040s. The CUZP for Da Nang city is overlain (please see Fig.3). The background color ("M") indicates whether a climate trend emerges in the ecosystem underpinning these coastal habitats. Green areas indicate the emergence of a climate trend, and this is significant where black dots overlay green (i.e. climate change hotspots). Yellow is a trend contrary to climate change, specific to the period of analysis, indicating improved habitat conditions. Orange are coral habitats; red are mangroves; and blue are seagrass beds. Please see the Methods section (above) and Queirós, Talbot et al. 2021 for a detailed description of the statistical analysis framework employed.

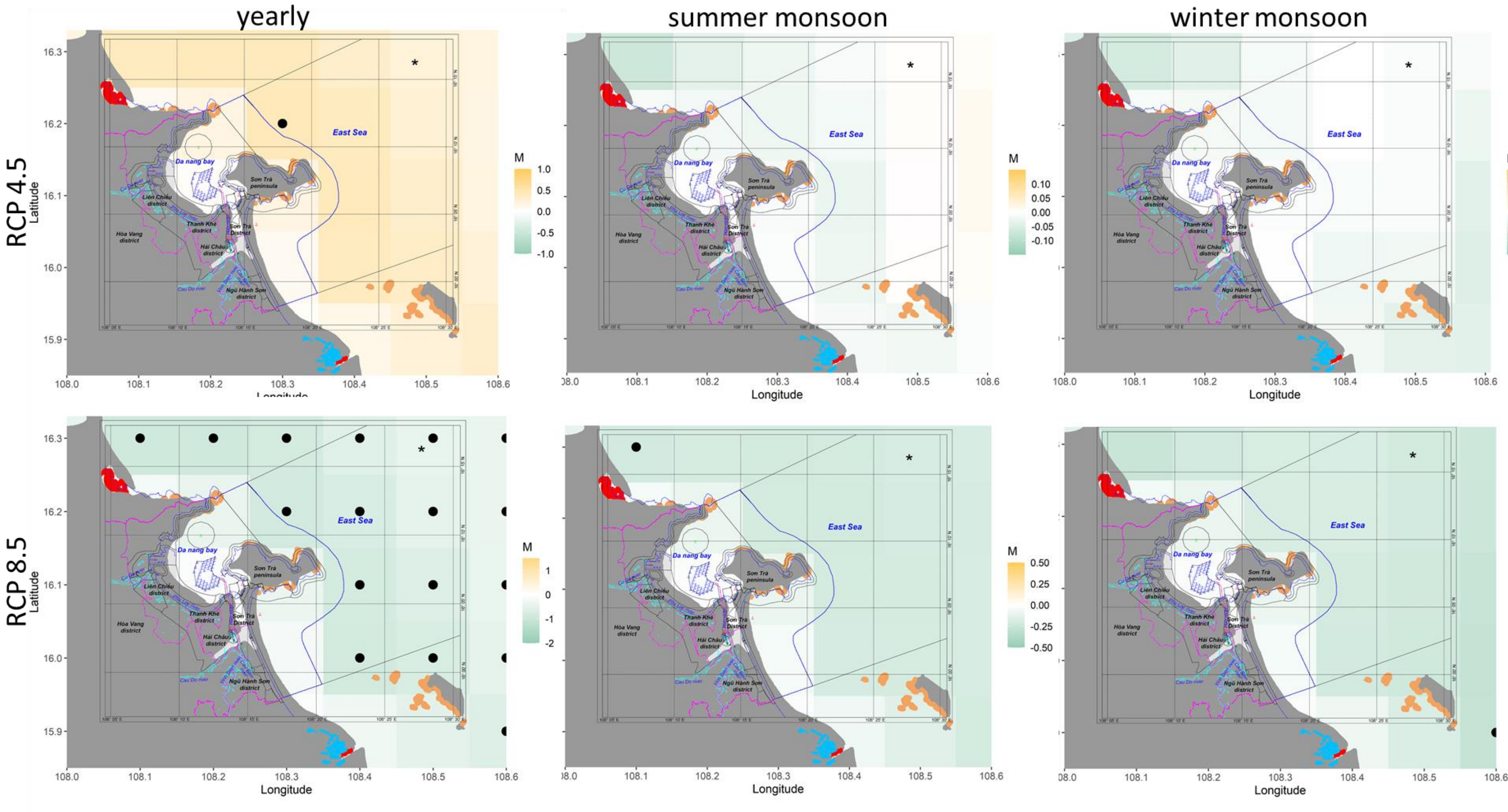

***Figure 5**: Climate modelling analysis results (i.e. spatial meta-analysis) for the conservation sector, comparing the present decade with the 2060s. The CUZP for Da Nang city is overlain (please see Fig.3). The background color ("M") indicates whether a climate trend emerges in the ecosystem underpinning these coastal habitats. Green areas indicate the emergence of a climate trend, and this is significant where black dots overlay green (i.e. climate change hotspots). Yellow is a trend contrary to climate change, specific to the period of analysis, indicating improved habitat conditions. Orange are coral habitats; red are mangroves; and blue are seagrass beds. Please see the Methods section (above) and Queirós, Talbot et al. 2021 for a detailed description of the statistical analysis framework employed.*

the range of variability we observe at present, under both emissions scenarios we considered (center and right hand side panels, top and bottom, Fig.4 and 5). It is noteworthy that we did not explicitly include heat-waves, typhoons, or storminess analyses in this study. Their potential exacerbation may, however, represent important extreme weather changes in the coming decades for the region, especially within monsoon periods (Collins, Sutherland et al. 2019).

3.2 Fishing sector analysis

Our fishing sector modelling analysis results contrasted the present decade to the 2040s (Fig.6) and the 2060s (Fig.7). Not unexpectedly, our analyses indicated that greater impacts of climate change are expected to be seen on demersal fished species of interest to the region (Table I), relative to pelagic species (left hand side panels versus right hand side panels; Fig. 6 and Fig.7). Specifically, we found climate change hotspots for fished species dependent on the seabed in all scenarios and time-frames analyzed, across the whole region affected by the CUZP (black dots over green, Fig. 6-7). In this case, the predominant driver of estimated reductions in overall fish abundances was climate change (negative M, left hand side panels, Fig.6-7), as these negative trends in demersal species abundances were exacerbated with increased emissions, being more negative under the higher emissions scenario (bottom row, left, Fig.6-7), and in the 2060s (bottom row, left, Fig.6 versus Fig.7). Notably, our analyses suggest that even the moderate changes in ocean conditions expected under the lower emissions scenario in the 2060s (relative to present time) may still lead to significant reductions in fished seabed species abundance (top row, left, Fig.7), and fishing effort seemed to have a lesser effect in face of this pressure (left hand column versus right hand side column left hand side panels, Fig.6-7).

Pelagic species exploited by fisheries in the region appeared overall more resilient to climate change, at least in the 2040s (right hand side panel, Fig.6), when overall abundances appeared to remain within the variability we see at present, though weak (if not significant) overall reductions in abundances were observed (i.e. no black dots over green). In the 2060s, however, interactions between climate change and fishing effort were estimated to be important. Under the higher emissions scenario, the abundances of pelagic species of interest to fisheries declined overall despite fishing pressure (bottom row, right, right hand side panel, Fig.7). However, under lower emissions, there were local-scaled differences in the patterns of abundance of the pelagic fish community. Under no fishing effort (top row, left, right hand side panel, Fig.7) there were marked differences in the direction of change between pelagic fish north and south of the Son Tra Peninsula, with fish in the North exhibiting significant decrease in abundance, and those south exhibiting mild increases. However, as fishing effort was introduced in simulations, the predominant trend became negative everywhere (green), with higher sensitivity in fish south of the peninsula. A closer examination of the modelling layers that were considered in these analyses (not shown) indicates that differences between simulations including fishing or no fishing effort on pelagic species, in the 2060s and under RCP4.5, reflect compensatory mechanisms between species. That is, at this lower level of climate-driven change in pelagic fish habitats (relative to RCP8.5), the individual sensitivity of different species to fishing mortality or environmental change leads to changes in community composition, as different species increase, taking up resources left over by declining, more sensitive species. However, under higher emissions, these differences are no longer relevant, and fish abundance at the community level declines (bottom row, right hand side panel, Fig. 7). Fishing sector projections for the broader region can be found in the Annex (Figs. 333 and 334). The trends in fish abundances apparent in Figs. 6 and 7 are also seen in this wider region.

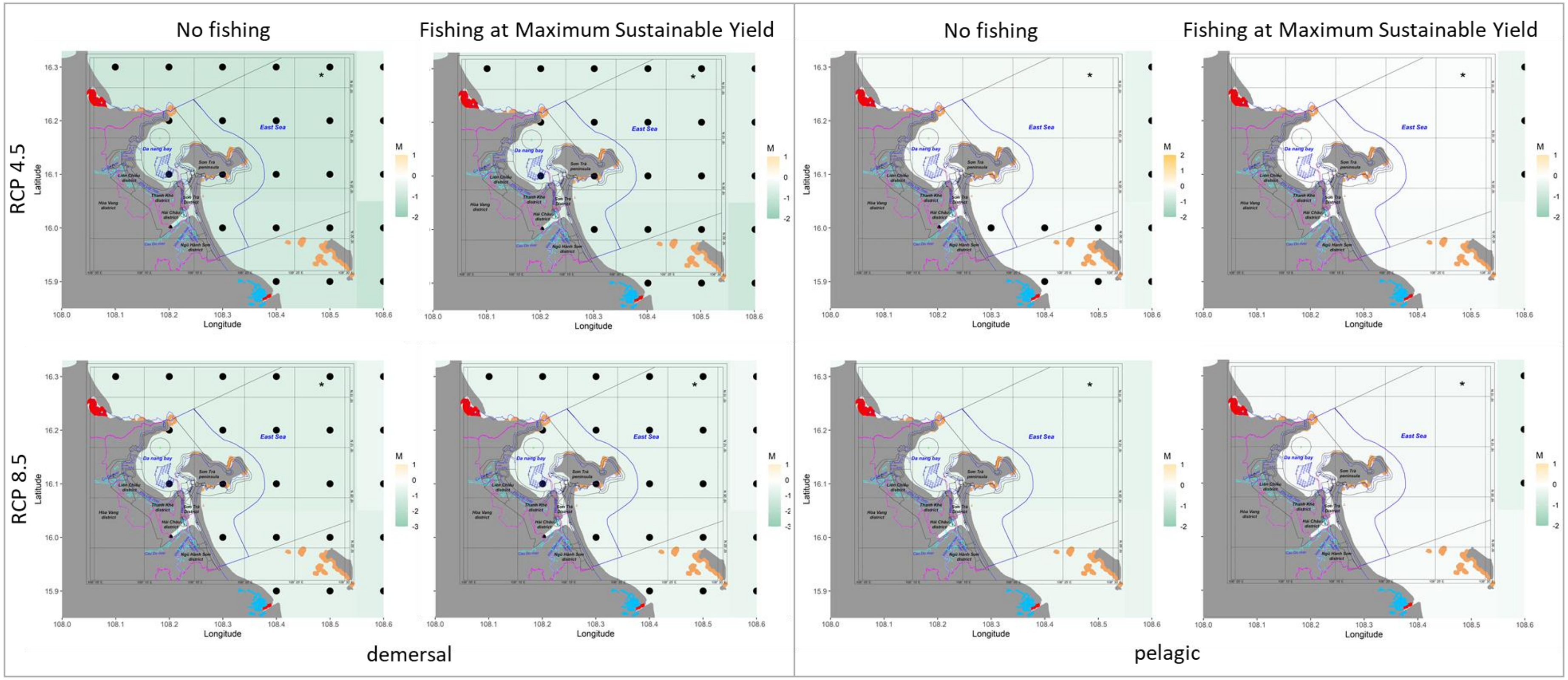

Figure 6: Climate modelling analysis results (i.e. spatial meta-analysis) for the fishing sector, comparing the present decade with the 2040s. The CUZP for Da Nang city is overlain (please see Fig.3). The background color ("M") indicates whether a climate trend emerges in the fish species community underpinning these fishing sector in the region. Green areas indicate the emergence of a climate trend, and this is significant where black dots overlay green (i.e. climate change hotspots). Yellow is a trend contrary to the long-term climate change trend, specific to the period of analysis, indicating improved habitat conditions. Orange are coral habitats; red are mangroves; and blue are seagrass beds. Please see the Methods section (above) and Queirós, Talbot et al. 2021 for a detailed description of the statistical analysis framework employed.

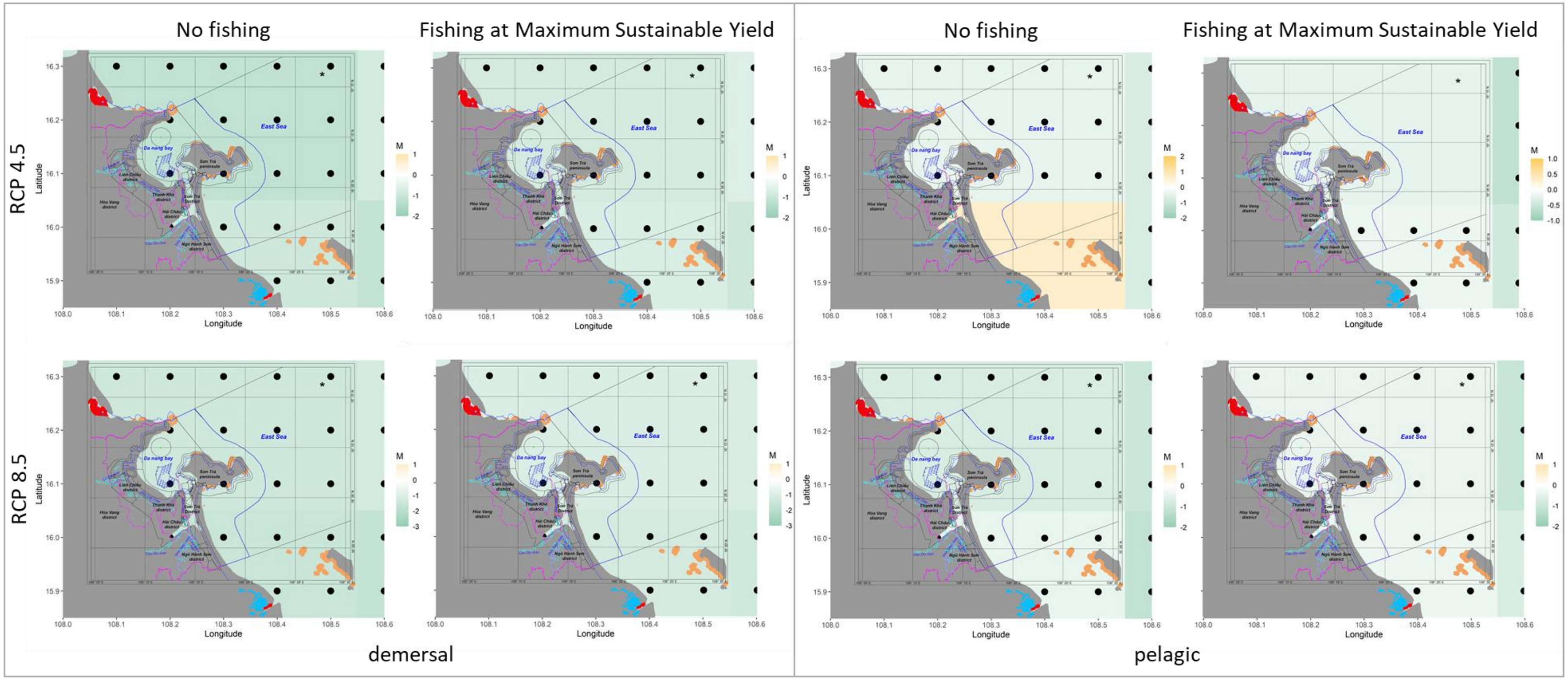

Figure 7: Climate modelling analysis results (i.e. spatial meta-analysis) for the fishing sector, comparing the present decade with the 2060s. The CUZP for Da Nang city is overlain (please see Fig.3). The background color ("M") indicates whether a climate trend emerges in the fish species community underpinning the fishing sector in the region. Green areas indicate the emergence of a climate trend, and this is significant where black dots overlay green (i.e. climate change hotspots). Yellow is a trend contrary to the long-term climate change trend, specific to the period of analysis, indicating improved habitat conditions. Orange are coral habitats; red are mangroves; and blue are seagrass beds. Please see the Methods section (above) and Queirós, Talbot et al. 2021 for a detailed description of the statistical analysis framework employed.

4 Discussion

The main finding of this report, is that reducing global emissions is a vital determinant to short- and mid-term sustainability of the coastal and marine habitats and species of interest to the economy of Da Nang city. Specifically, without strong emissions curbs, the environmental conditions needed by species of conservation and commercial interest are very likely to be strongly modified by climate related processes in the short- and mid-term, leading to ecosystem conditions that are distinct to what we see at present. We employ here two emissions trajectories (RCP4.5 and RCP8.5) representing two very different futures. Under RCP4.5, emissions continue at the present rate until the 2050s, when they decrease. Under RCP8.5, emissions double by 2050 and continue to rise until the end of the century (IPCC 2021). For Da Nang city, this may mean that by the 2040s, and under the current rate of emissions, visible changes may already be seen in key, high-valued habitats (People's Committee of Da Nang City 2005) underpinning conservation and restoration areas in the CUZP (South Hai Van, Son Tra Peninsula), such as coral and seagrass, and changes would be worse and significant under higher emissions (RCP8.5). However, by implementing the Paris Agreement, if we are able to curb emissions by the 2050s (and hopefully sooner, United Nations 2021), then habitat conditions may return to their present state by the 2060s, promoting a more sustainable future for the region. Curbing emissions beyond their current level may thus be critical to ensure the long-term sustainability of those habitats, and ecological and economic activities dependent on them, such as conservation, restoration, fishing and tourism.

Crucially, without emissions curbs that are the target of the Paris Agreement (i.e. below RCP4.5, IPCC 2021) significant reductions in the abundance of seabed fish species of relevance to the local fishing sector will likely already be seen by the 2040s, and continue into subsequent decades, even without higher emissions. These estimates should be seen as concerning for fishing concentrated both in near shore waters of Da Nang Bay, as well as waters further offshore, regulated by the fishing sector (Fig. 2-3). The assessment for pelagic species was more variable between scenarios, with communities exhibiting some degree of resilience in the short-term, under both emissions futures explored. However, in the mid-term changes would be observed. Under lower emissions (RCP4.5), the addition of even moderate fishing pressure (MSY) appeared to tip the pelagic community to significant losses in fish abundance. Some degree of variability between North and South of the Son Tra Peninsula was relevant. Our results suggest that pelagic fishing at MSY in the southern part of the Bay may become unsustainable under moderate climate change (RCP4.5) in the mid-term (2060s), whilst under higher emissions, fishing in all of the CUZP area may become unsustainable. These are bleak results for a city for which fishing activity is a key part of the local economy (People's Committee of Da Nang City 2005), especially for those in lower income brackets (Pham, Huang et al. 2014).

It is important to note that the modelling projections we analyzed here, whilst representing the state-of-the-art for the region (Kay, Avillanosa et al. 2021), did not include heat-waves, typhoons, or storminess effects. Their potential climate-driven exacerbation may, however, represent important extreme weather changes in the coming decades for the region, especially within monsoon periods (Collins, Sutherland et al. 2019). Furthermore, although corals and seagrass are the key habitats many fished species rely on in the coastal waters of Da Nang city, the impacts of climate change on coral habitats and seagrass are not quantified in the model that generated the projections for fish distributions we considered here (Sailley 2021). So it is likely that even these projection are conservative.

The CUZP as a mechanisms to support climate change adaptation

Both analyses presented here (conservation sector and fishing sector) sound an alarm about how failing to prepare for climate change may hamper the sustainability aims we design into our mechanisms to manage marine space, such as the CUZP, and the Coastal Strategy it is expected to deliver on (People's Committee of Da Nang City 2005). In Vietnam, as in other countries around the world, sustainable management of the marine economy and the species and habitats it relies on, can only come through curbing climate change (Eddy, Lam et al. 2021, Queirós, Talbot et al. 2021), and spatial planning that is adaptive to associated pressures already locked into the climate system in the near-term (Frazão-Santos, Agardy et al. 2020, IPCC 2021). This will be especially true in lower latitude regions such as Vietnam, where climate related species re-distributions will not be accompanied by new species arriving, to limit the loss of local biodiversity. Without emissions curbs, we rely heavily on a largely unproven ability of species of adapt to the speed of climate change, and the more extreme environmental patterns it is expected to bring, or to track suitable habitat where this still exists (Somero 2010).

Under these possible changes, the role of the CUZP as a mechanism to support the amelioration of other human pressures on key habitats for the city could be especially important. For instance, it has been shown that, to an extent, coral resilience to climate change can, at times, be supported by reduction of other human pressures, such as fishing and poor water quality (Carilli, Norris et al. 2009, Ellis, Jamil et al. 2019). Corals are recognized as valuable habitats in the CUZP, intrinsically and due to their role in supporting species targeted by local fisheries (People's Committee of Da Nang City 2005). If the face of potentially significant climate-driven environmental changes to the conditions that allow corals to occur in the coast of Da Nang shown here (see also Annex), the enforcement of the actions to limit human uses in the vicinity of coral conservation and restoration zones (South Hai Van and Son Tra Peninsula, Fig.8) and their buffer areas (as outlined in the CUZP, Fig.1) is an opportunity to support their ability to maintain healthy populations that may foster adaptation to climate change. It is the opportunity to give these habitats the best chance possible to withstand significant long term change, as well as to bounce back from predicted, more extreme weather patterns (Collins, Sutherland et al. 2019). It is important to note that limiting local stressors does not always lead to improved resistance of corals to climate change (because of the different sensitivities of different species to climate stressors, their sensitivity to managed pressures, and community assemblage processes, Côté and Darling 2010). Management action to this end should thus be accompanied by monitoring activities, to assess both pressure levels over time and community health. This may be seen as a necessary step with which to justify the trade-offs in the distribution of human activities that result from these actions, as balanced through the implementation of the CUZP. Similarly, the degree of human activity and growing industrialization of the Da Nang coastline and surrounding city are part of Da Nang’s character and drive its place in Vietnam’s economy (Scarwell and Leducq 2021). However, they have led to concerns being raised about the need to limit land run-off to promote the health of coastal environments (Nguyen, Nguyen et al. 2020). The ability of the CUZP to limit the impacts of often-times diffuse coastal run-off (including those of plastics) on to coastal ecosystems in Da Nang is perhaps more limited than with other human pressures that can be listed as unauthorized activities within conservation areas and buffer zones (People's Committee of Da Nang City 2005), and this affects coral health. The impacts of run-off are also more difficult to document because this requires the ability to model the physics and chemistry of coastal waters, underpinning the dispersion of run-off, among other aspects. Failing to address this potential impact on coral ecosystems in the coast of Da Nang, may thus limit the efficiency of the protected areas delineated in the CUZP, and their ability to withstand climate change. This aspect may be especially important if more stringent action toward the conservation zones were to be implemented to support the climate-resilience of these sensitive habitats, especially if restrictions were to be imposed on the activity of subsistence, indigenous fishers.

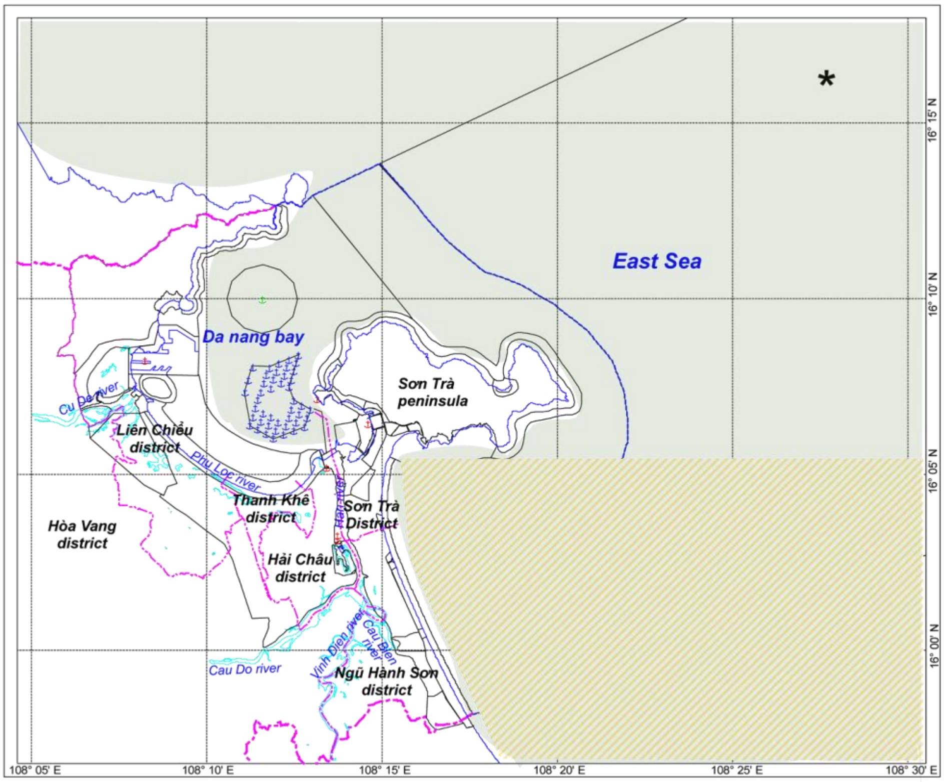

Figure 8:Suggested changes to the CZUP (Fig.3) in support of climate change adaptation. Patterned polygon (diagonal lines): reduction of human activities in this area, where possible, could bring the most benefits to Da Nang's marine ecosystem. This action could reduce human activities that may also impact ecological and economically valuable but climate sensitive coral habitats, though sensitivity was observed across the bay. Importantly, it could reduce pressure on fished pelagic species thus supporting the few species that thrive under changing climate (60s, Fig.7, 4.5 no fishing) and reducing pressure on those most sensitive to climate change (Fig.6-7, 4.5 with fishing MSY). Species such as Rastrelliger kanagurta (Indian mackerel), Trichiurus lepturus (largehead hairtail) and Rachycentron canadum (Cobia) were found to be resilient to climate change to the south of the peninsula with no fishing pressure, although R. kanagurta and R. canadum both decrease when fishing pressure is introduced. Targeted demersal fished species assessed seem particularly vulnerable to climate change across the whole bay. Reducing fishing pressure across the bay, where possible, any impacts on nursery areas, and improved water quality could contribute to their improved sustainability.

The same principles apply to seagrass habitats, also seen as valuable habitats within the CUZP, intrinsically and due to their role in supporting species targeted by local fisheries (People's Committee of Da Nang City 2005). Physical disturbance of the seabed, through the impact of fishing gear and anchors among other pressures, and land reclamation, destroy seagrass habitat (Van Luong, Van Thao et al. 2012). The CUZP determines that these and other activities should be limited within seagrass restoration areas. However, coastal water quality also affects the depth limit of seagrass, including increased turbidity, pollution and eutrophication, especially near urbanized areas (Yaakub, McKenzie et al. 2014), and lead to a contraction of seagrass habitat to shallower depths (Krause-Jensen, Carstensen et al. 2011). Furthermore, seagrass are affected by climate-driven changes in temperature, salinity and extreme weather that affects seabed stability (Van Luong, Van Thao et al. 2012). Reducing physical reclamation of seagrass habitat and disturbance of seabed habitats may, to an extent, be expected to promote resilience of seagrass to climate change, and the management of those actions can be promoted through zoning of activities as delineated in the CUZP. However, as noted for corals, monitoring and managing run-off that may lead to pollution and turbidity in the coastal zone may require additional mechanisms. Lastly, in the long-term, sea level rise will further contract both coral and seagrass habitats through changes in optical depth, which may lead to considerations about how the coastal strip adjacent to these habitats is managed to support their retreat, and thus good linkages between the CUZP and land planning in Da Nang. However, recent work suggests that Da Nang may experience relatively lower levels of sea level rise than other areas of Vietnam (Chinowsky, Schweikert et al. 2014).

Fish resilience to climate change is also expected to benefit from reduction in other pressures, managed by the CUZP (Fig.8). Whilst we considered only “sustainable” fishing effort (MSY) in our analyses (cf. no fishing), it is likely that fishing in the region is carried out at much higher levels, though we were not able to access those statistics at the time of this report. In addition to loss of key habitats and poor water quality aspects already discussed, fish species are directly affected by changes in productivity, warming, acidification, deoxygenation and circulation patterns affected by climate change, to name a few, and tropical seas are where most of these conditions will first enter a state outside of their natural variability (Bindoff, Cheung et al. 2019). Our findings are in line with recent work that projects substantial losses of fish catch potential in tropical regions, including South East Asia (Lam, Allison et al. 2020). Among other aspects, reducing fishing mortality can help support climate change adaptation in fished populations through the maintenance of a larger genetic pool, and thus of potentially larger physiological plasticity to cope with extreme weather patterns as well as potentially larger genetic diversity, which may harbor adaptation potential to climate change (Morgan, Finnøen et al. 2020). Fishing also tends to decrease maximum individual size in exploited populations, and evidence suggests that larger fish occur higher in the foodweb and vary in a more predictable manner, being thus representative of healthier and more stable populations (Queirós, Fernandes et al. 2018). Fishing, and especially when non-selective gears are used, further impacts the stability of the associated community of species, predominantly leading to habitat degradation. At the scale of the CUZP, the degree of these impacts affects the sustainability of populations exploited locally. Whilst some of these impacts affect the whole of the Da Nang coast and offshore waters, our analysis suggests that there may be different sensitivities to climate change in various locally fished species (please see Annex). Calling for reduced fisheries in areas such as Da Nang, and other areas of South East Asia, where fishers often come from the most economically vulnerable sectors of society, and where fish represents a key source of nutrition, is difficult if not impossible to argue for (Lam, Allison et al. 2020, Giron-Nava, Lam et al. 2021). And this is especially true when indigenous populations are considered, such as in Da Nang. However, the results in this report, as in other areas of the world, highlight the risks to the sustainability of this resource, and the wellbeing of dependent communities, if climate change is not considered. Our results highlight that for some fished species (i.e. seabed species), the pressure of climate change may negate any benefits from efforts to curb fishing mortality, but the model projections we analyzed (as indeed models for fish distributions in general) do not account for fish adaptation potential, and as discussed, this may be key to local subsistence. For pelagic fisheries, differences estimated in different species sensitivities (Annex) explain regional variations we estimated at the CUZP level. The information in this report thus identifies a the need for more detailed work, including necessary validation of modelling projections with local fish distribution data (largely absent). This information would help determine potential spatial management of gears within the CUZP area, beyond those already planned (People's Committee of Da Nang City 2005), and inform management strategies supporting potential climate change adaptation for these species. This could help reduce the pressure on more sensitive species for which environmental pressures may be greater, locally (Annex).

It is important to note that a key challenge of providing policy relevant climate change information is the frequent mismatch between large scale, ecosystem-based modelling tools typically employed to study climate change impacts in the ocean, and the scale covered by local policy mechanisms such as the CUZP. This challenge is explored in detail in Queirós, Talbot et al. (2021). This aspect is especially relevant for the fishing sector analysis carried out here, and caution should be employed in the future uses of the findings presented in this report.

Conclusion

Based on all the evidence analyzed, we believe that adaptation to the pressures imposed on Da Nang's marine resources by climate change will be best supported through a reduction of destructive, human activities South of the Son Tra Peninsula (Fig.8). Whilst increased emissions are likely to bring significant negative impacts on both exploited and protected species of interest across the Bay, gain may be especially important for pelagic fisheries if those efforts are concentrated on its southern waters. The CUZP and the Coastal Strategy it is expected to deliver, enshrine sustainability aims for Da Nang's coastal waters. The work carried out in its preparation (i.e. detailed identification of current habitats and zone uses) place Da Nang in an excellent starting point from which to consider climate-adaptive actions for these species, habitats, and dependent sectors of its economy. The COVID pandemic limited much of the face-to-face work that was initially envisaged to support a closer co-development of this report and its assessment. In light of these circumstances, the findings presented here are expected to serve as a useful starting point that helps identify datasets, evidence and tools available to Da Nang city to further its ambition to support the sustainability of its coastal nature, by promoting climate-smart zoning.

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Climate-smart spatial planning assessment in support of conservation and blue growth in Da Nang city's marine environment.

A report from the ACCORD project. (2022)

Ana M Queirós, Elizabeth S Talbot, Susan Kay, Sevrine Sailley, Trang Vu Hoang Le, Chin Thi Pham and Steve Widdicombe

Annex: Projected changes in fished species distributions and environmental conditions

Summary: The following maps illustrate the individual effects estimated for each fished species considered in Table II, and the biogeochemical modelling layers for environmental conditions considered in Table I, under the two emissions scenarios we considered, and comparing the present decade (2011-2020) with the 2040s and the 2060s. Please Section 2 of the main report.

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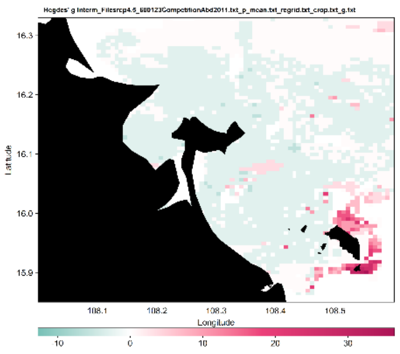

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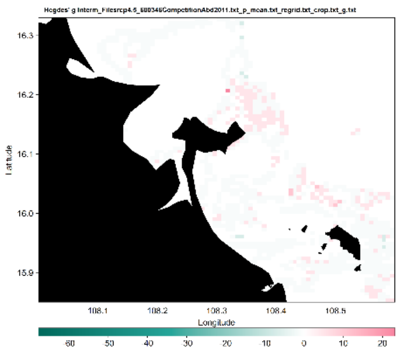

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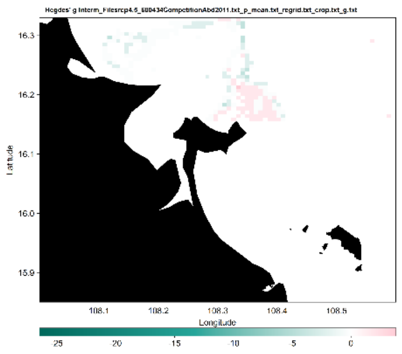

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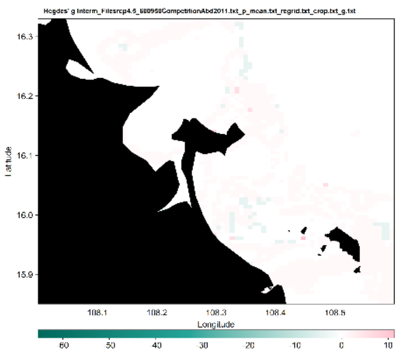

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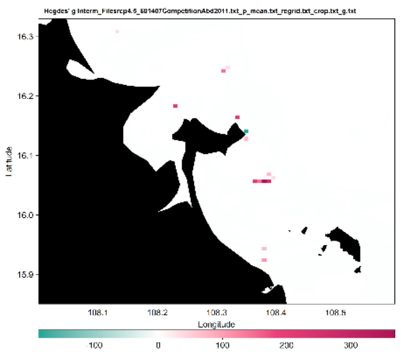

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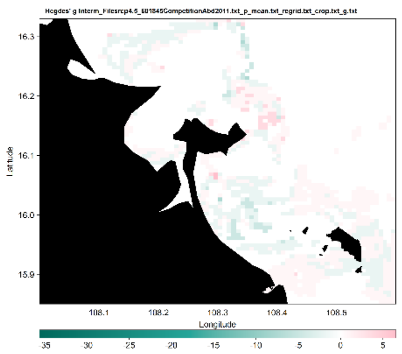

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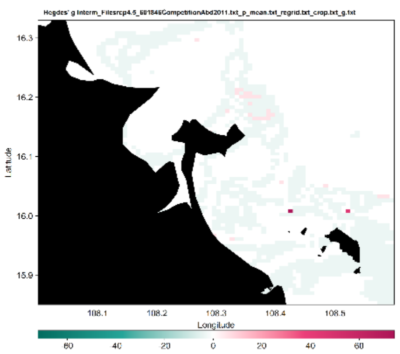

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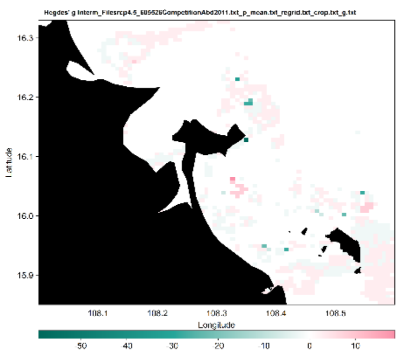

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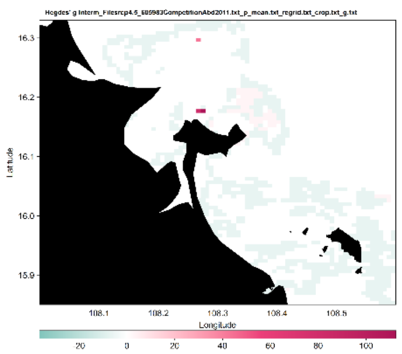

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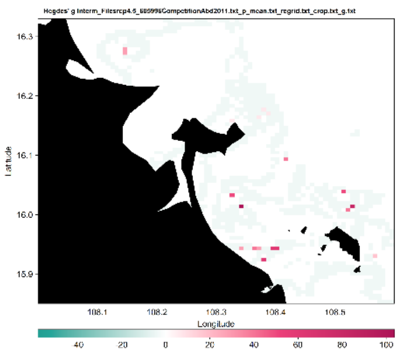

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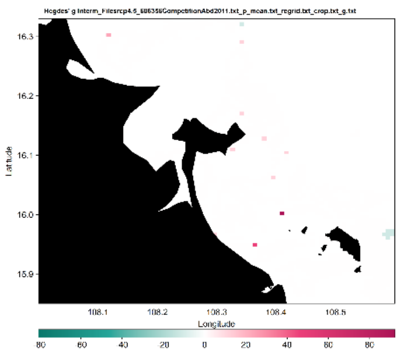

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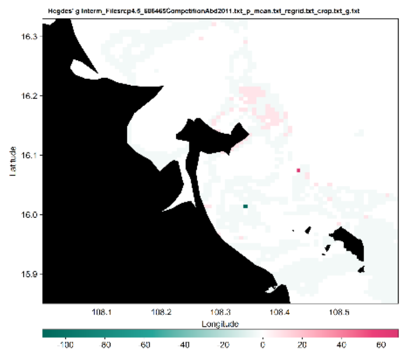

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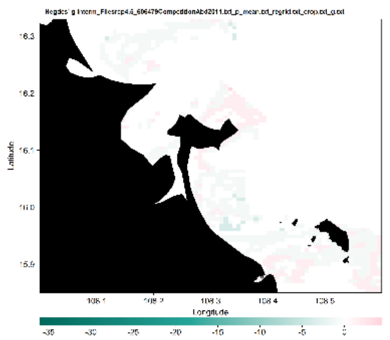

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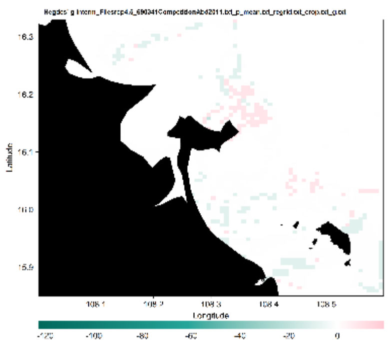

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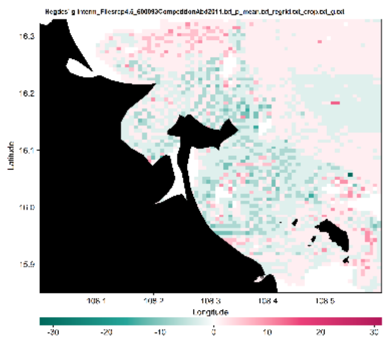

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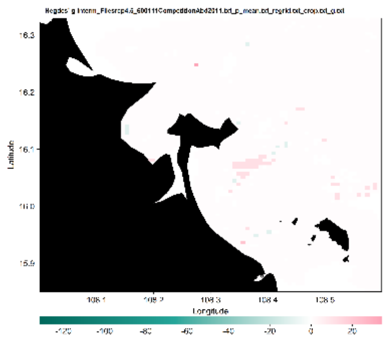

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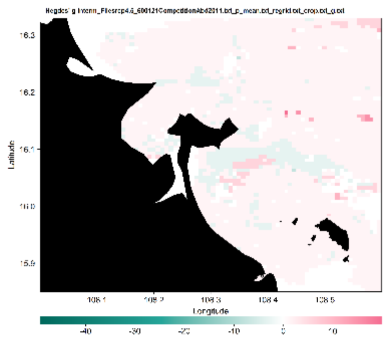

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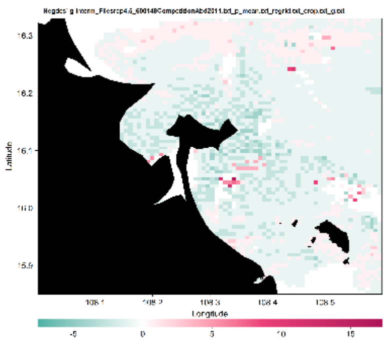

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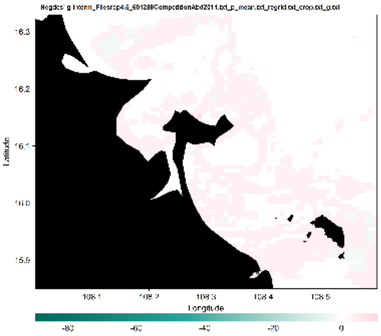

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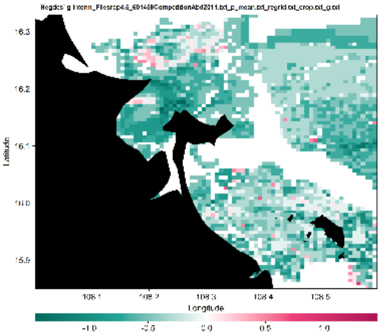

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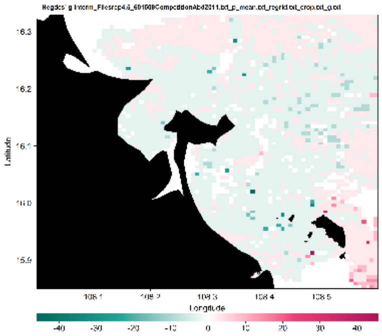

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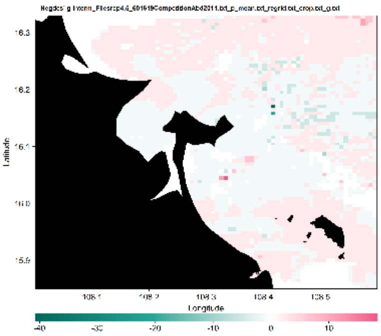

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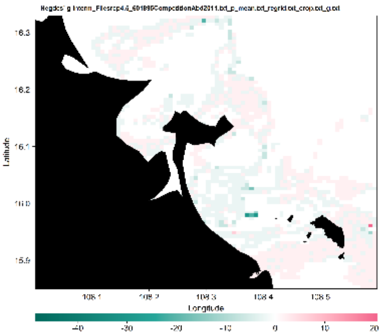

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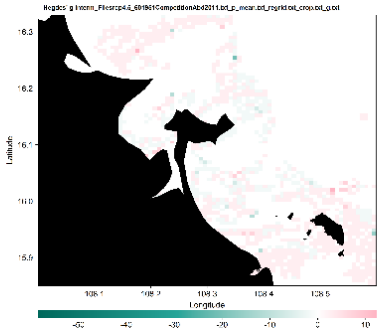

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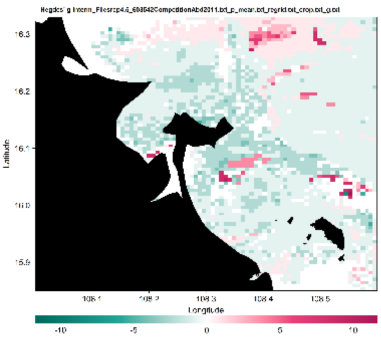

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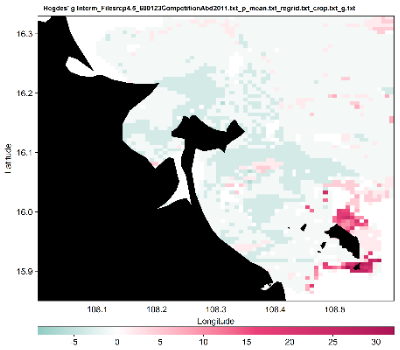

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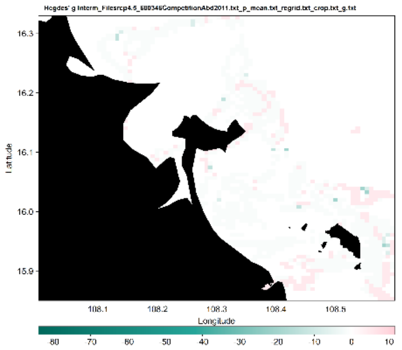

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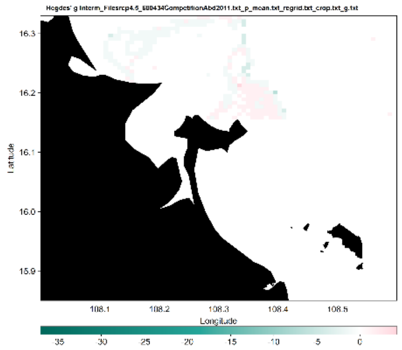

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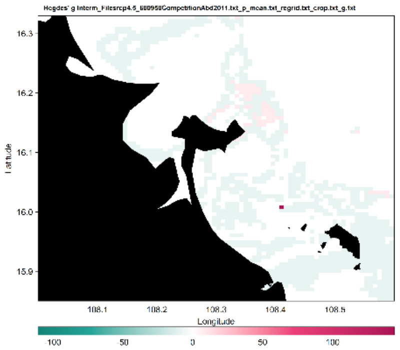

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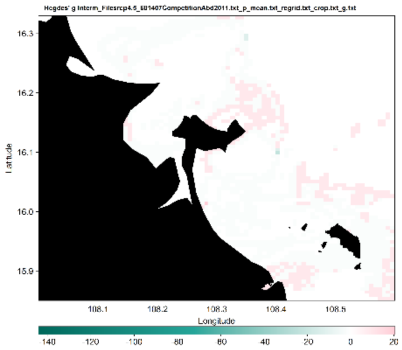

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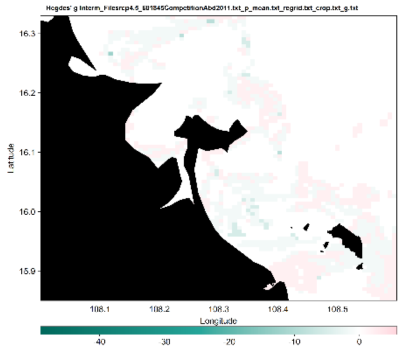

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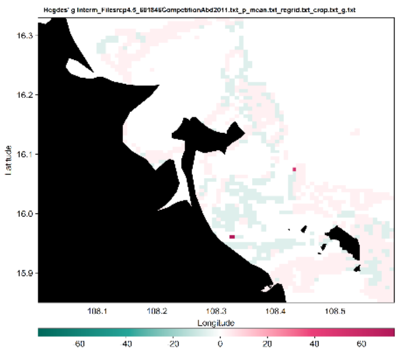

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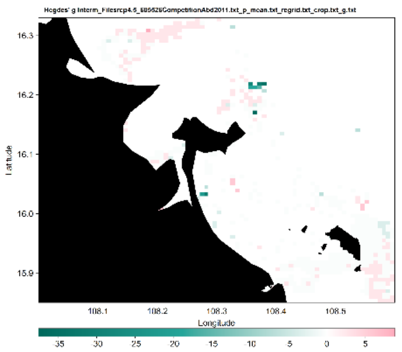

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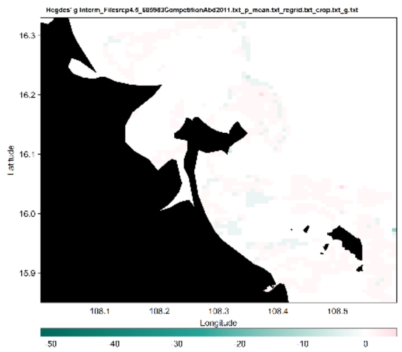

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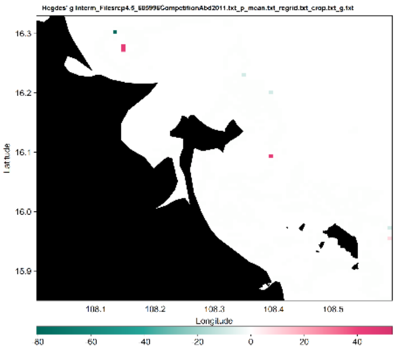

Figure 35: *Gerres oyena* Hedge's g between 2011-2020 and 2040-2049 under RCP4.5 MSY1. Green areas indicate predicted decreases in abundance, pink areas indicate predicted increases in abundance

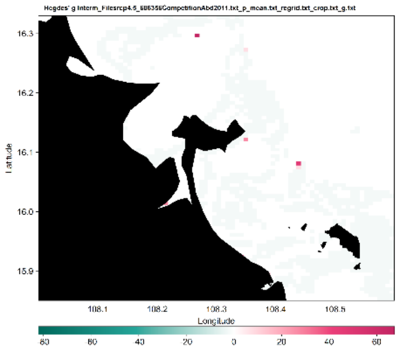

Figure 36: *Acanthopagrus latus* Hedge's g between 2011-2020 and 2040-2049 under RCP4.5 MSY1. Green areas indicate predicted decreases in abundance, pink areas indicate predicted increases in abundance

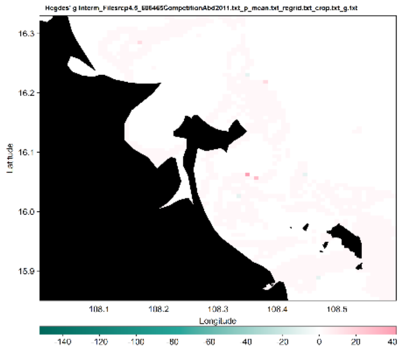

Figure 37: *Epinephelus coioides* Hedge's g between 2011-2020 and 2040-2049 under RCP4.5 MSY1. Green areas indicate predicted decreases in abundance, pink areas indicate predicted increases in abundance

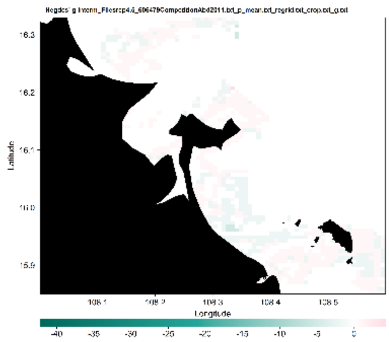

Figure 38: *Saurida tumbil* Hedge's g between 2011-2020 and 2040-2049 under RCP4.5 MSY1. Green areas indicate predicted decreases in abundance, pink areas indicate predicted increases in abundance

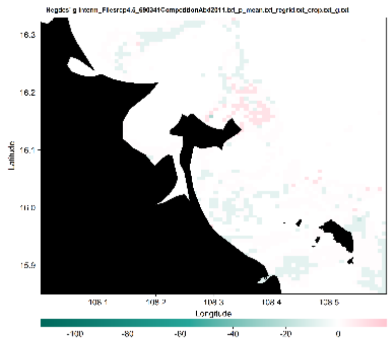

Figure 39: *Panulirus homarus* Hedge's g between 2011-2020 and 2040-2049 under RCP4.5 MSY1. Green areas indicate predicted decreases in abundance, pink areas indicate predicted increases in abundance

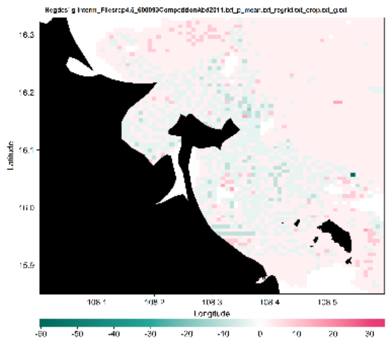

Figure 40: *Auxis rochei* Hedge's g between 2011-2020 and 2040-2049 under RCP4.5 MSY1. Green areas indicate predicted decreases in abundance, pink areas indicate predicted increases in abundance

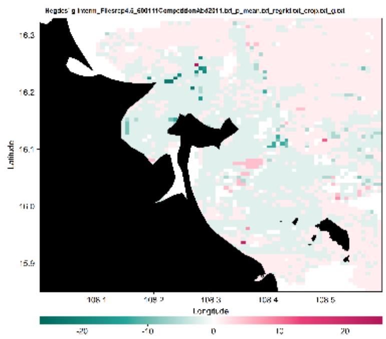

Figure 41: *Rastrelliger kanagurta* Hedge's g between 2011-2020 and 2040-2049 under RCP4.5 MSY1. Green areas indicate predicted decreases in abundance, pink areas indicate predicted increases in abundance

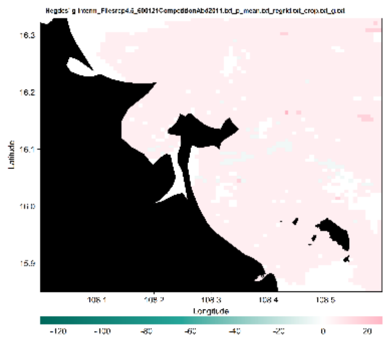

Figure 42: *Scomberomorus commersoni* Hedge's g between 2011-2020 and 2040-2049 under RCP4.5 MSY1. Green areas indicate predicted decreases in abundance, pink areas indicate predicted increases in abundance

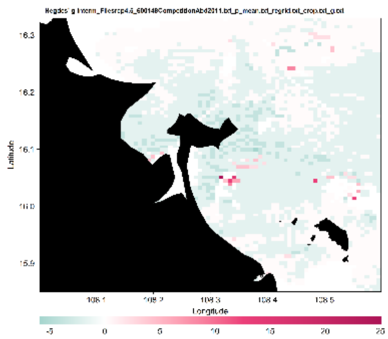

Figure 43: *Thunnus tonggol* Hedge's g between 2011-2020 and 2040-2049 under RCP4.5 MSY1. Green areas indicate predicted decreases in abundance, pink areas indicate predicted increases in abundance

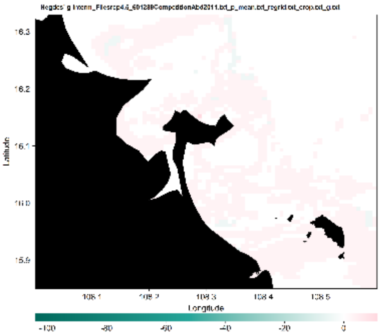

Figure 44: *Trichiurus lepturus* Hedge’s g between 2011-2020 and 2040-2049 under RCP4.5 MSY1. Green areas indicate predicted decreases in abundance, pink areas indicate predicted increases in abundance

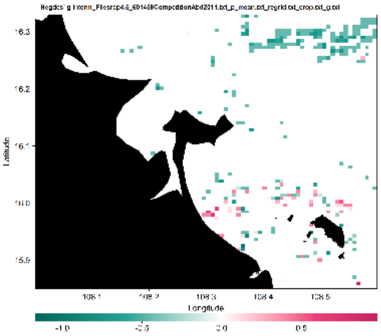

Figure 45: *Spratelloides gracilis* Hedge’s g between 2011-2020 and 2040-2049 under RCP4.5 MSY1. Green areas indicate predicted decreases in abundance, pink areas indicate predicted increases in abundance

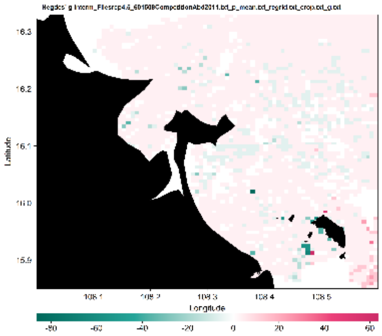

Figure 46: *Sardinella gibbosa* Hedge’s g between 2011-2020 and 2040-2049 under RCP4.5 MSY1. Green areas indicate predicted decreases in abundance, pink areas indicate predicted increases in abundance

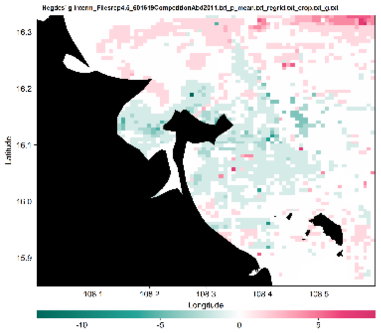

Figure 47: *Anodontostoma chacunda* Hedge’s g between 2011-2020 and 2040-2049 under RCP4.5 MSY1. Green areas indicate predicted decreases in abundance, pink areas indicate predicted increases in abundance

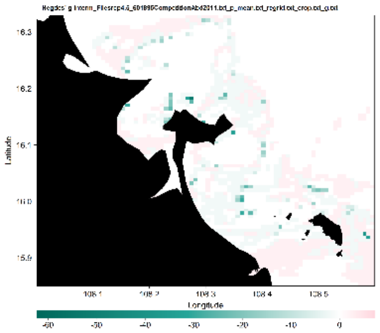

Figure 48: *Caranx ignobilis* Hedge’s g between 2011-2020 and 2040-2049 under RCP4.5 MSY1. Green areas indicate predicted decreases in abundance, pink areas indicate predicted increases in abundance

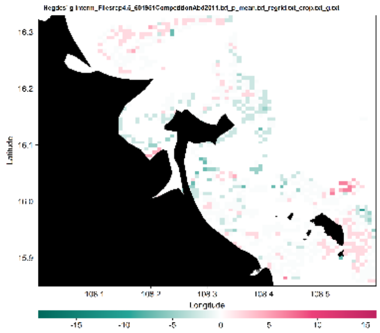

Figure 49: *Scomberoides lysan* Hedge’s g between 2011-2020 and 2040-2049 under RCP4.5 MSY1. Green areas indicate predicted decreases in abundance, pink areas indicate predicted increases in abundance

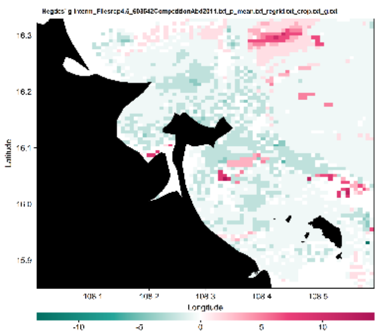

Figure 50: *Rachycentron canadum* Hedge’s g between 2011-2020 and 2040-2049 under RCP4.5 MSY1. Green areas indicate predicted decreases in abundance, pink areas indicate predicted increases in abundance

3. Changes under RCP8.5 and no fishing effort, contrasting the present decade with the 2040s.

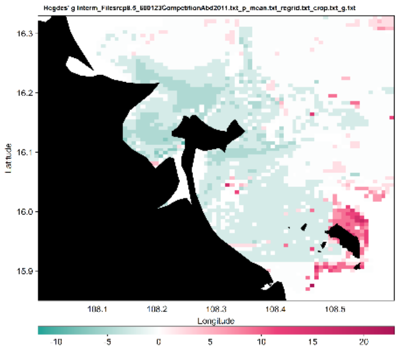

Figure 51: *Siganus guttatus* Hedge's g between 2011-2020 and 2040-2049 under RCP8.5 MSY0. Green areas indicate predicted decreases in abundance, pink areas indicate predicted increases in abundance

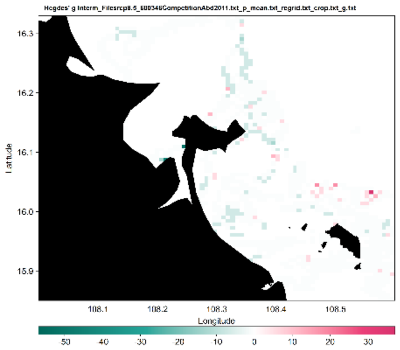

Figure 52: *Lates calcarifer* Hedge's g between 2011-2020 and 2040-2049 under RCP8.5 MSY0. Green areas indicate predicted decreases in abundance, pink areas indicate predicted increases in abundance

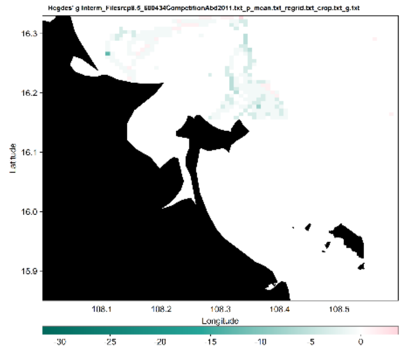

Figure 53: *Pennahia argentata* Hedge's g between 2011-2020 and 2040-2049 under RCP8.5 MSY0. Green areas indicate predicted decreases in abundance, pink areas indicate predicted increases in abundance

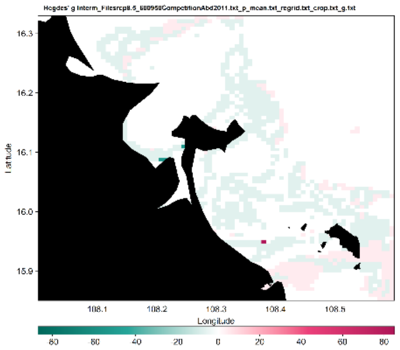

Figure 54: *Platycephalus indicus* Hedge's g between 2011-2020 and 2040-2049 under RCP8.5 MSY0. Green areas indicate predicted decreases in abundance, pink areas indicate predicted increases in abundance

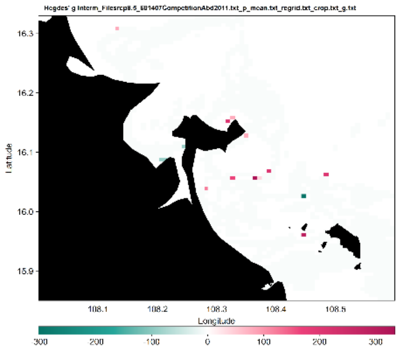

Figure 55: *Lutjanus argentimaculatus* Hedge's g between 2011-2020 and 2040-2049 under RCP8.5 MSY0. Green areas indicate predicted decreases in abundance, pink areas indicate predicted increases in abundance

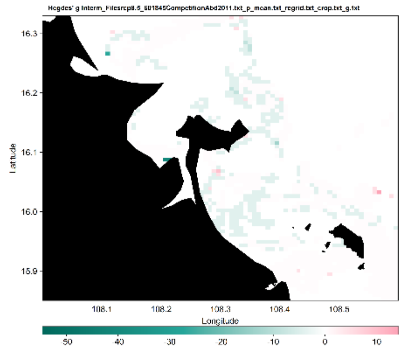

Figure 56: *Lethrinus microdon* Hedge's g between 2011-2020 and 2040-2049 under RCP8.5 MSY0. Green areas indicate predicted decreases in abundance, pink areas indicate predicted increases in abundance

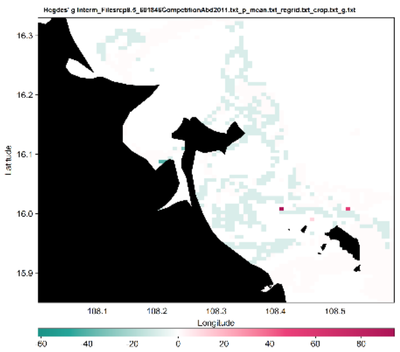

Figure 57: *Lethrinus nebulosus* Hedge's g between 2011-2020 and 2040-2049 under RCP8.5 MSY0. Green areas indicate predicted decreases in abundance, pink areas indicate predicted increases in abundance

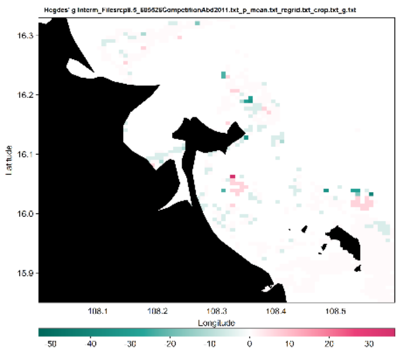

Figure 58: *Acanthopagrus berda* Hedge's g between 2011-2020 and 2040-2049 under RCP8.5 MSY0. Green areas indicate predicted decreases in abundance, pink areas indicate predicted increases in abundance

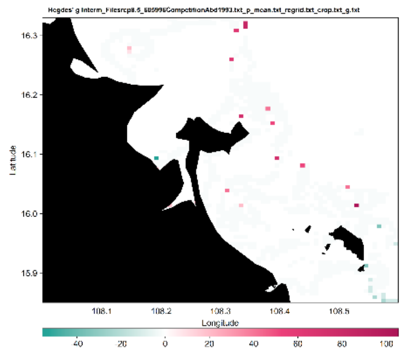

Figure 59: *Mulloidichthys flavolineatus* Hedge's g between 2011-2020 and 2040-2049 under RCP8.5 MSY0. Green areas indicate predicted decreases in abundance, pink areas indicate predicted increases in abundance

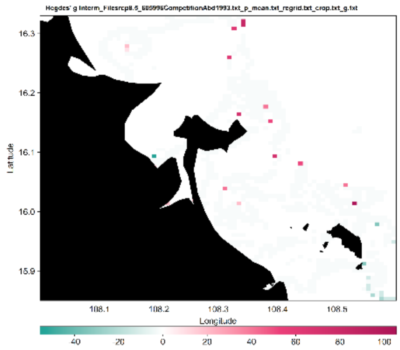

Figure 60: *Gerres oyena* Hedge's g between 2011-2020 and 2040-2049 under RCP8.5 MSY0. Green areas indicate predicted decreases in abundance, pink areas indicate predicted increases in abundance

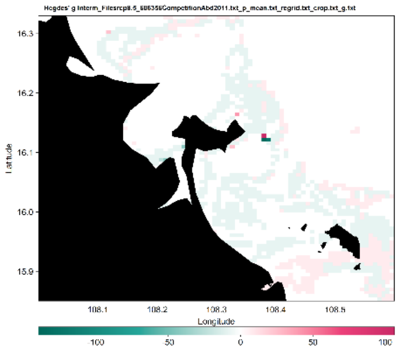

Figure 61: *Acanthopagrus latus* Hedge's g between 2011-2020 and 2040-2049 under RCP8.5 MSY0. Green areas indicate predicted decreases in abundance, pink areas indicate predicted increases in abundance

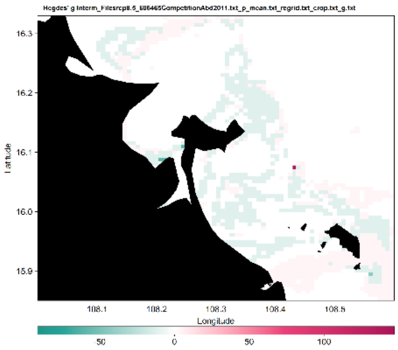

Figure 62: *Epinephelus coioides* Hedge's g between 2011-2020 and 2040-2049 under RCP8.5 MSY0. Green areas indicate predicted decreases in abundance, pink areas indicate predicted increases in abundance

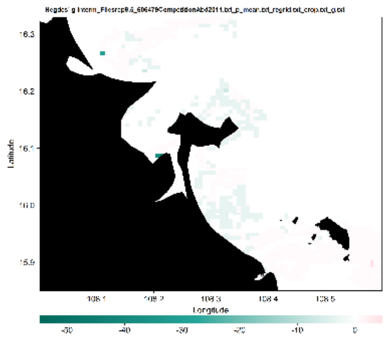

Figure 63: *Saurida tumbil* Hedge's g between 2011-2020 and 2040-2049 under RCP8.5 MSY0. Green areas indicate predicted decreases in abundance, pink areas indicate predicted increases in abundance

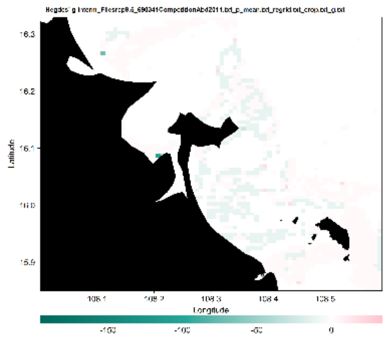

Figure 64: *Panulirus homarus* Hedge's g between 2011-2020 and 2040-2049 under RCP8.5 MSY0. Green areas indicate predicted decreases in abundance, pink areas indicate predicted increases in abundance

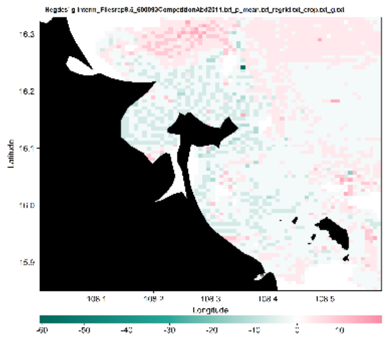

Figure 65: *Auxis rochei* Hedge's g between 2011-2020 and 2040-2049 under RCP8.5 MSY0. Green areas indicate predicted decreases in abundance, pink areas indicate predicted increases in abundance

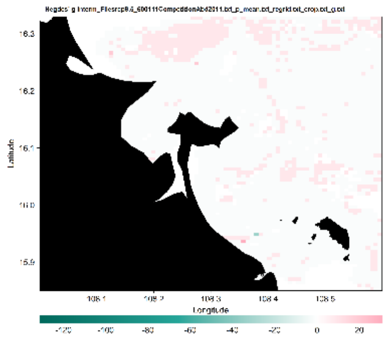

Figure 66: *Rastrelliger kanagurta* Hedge's g between 2011-2020 and 2040-2049 under RCP8.5 MSY0. Green areas indicate predicted decreases in abundance, pink areas indicate predicted increases in abundance

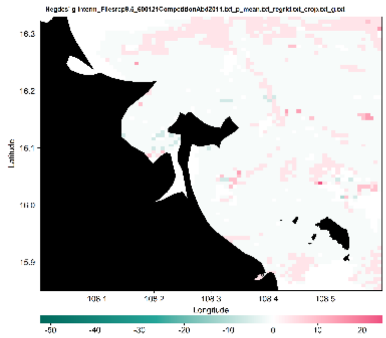

Figure 67: *Scomberomorus commersoni* Hedge's g between 2011-2020 and 2040-2049 under RCP8.5 MSY0. Green areas indicate predicted decreases in abundance, pink areas indicate predicted increases in abundance

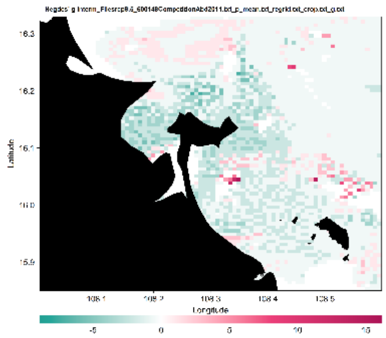

Figure 68: *Thunnus tonggol*Hedge's g between 2011-2020 and 2040-2049 under RCP8.5 MSY0. Green areas indicate predicted decreases in abundance, pink areas indicate predicted increases in abundance

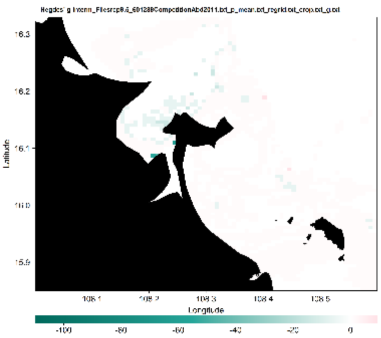

Figure 69: *Trichiurus lepturus* Hedge's g between 2011-2020 and 2040-2049 under RCP8.5 MSY0. Green areas indicate predicted decreases in abundance, pink areas indicate predicted increases in abundance

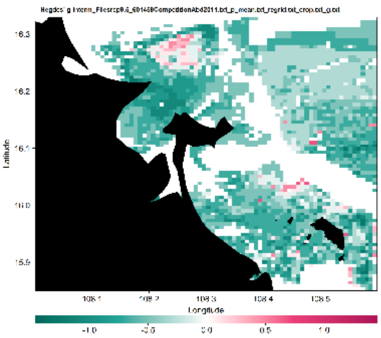

Figure 70: *Spratelloides gracilis* Hedge's g between 2011-2020 and 2040-2049 under RCP8.5 MSY0. Green areas indicate predicted decreases in abundance, pink areas indicate predicted increases in abundance

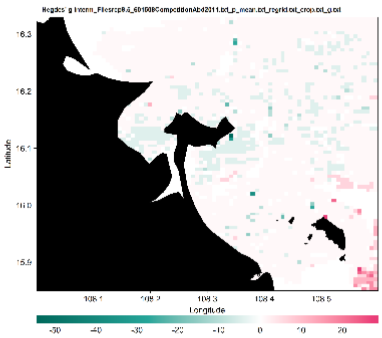

Figure 71: *Sardinella gibbosa* Hedge's g between 2011-2020 and 2040-2049 under RCP8.5 MSY0. Green areas indicate predicted decreases in abundance, pink areas indicate predicted increases in abundance

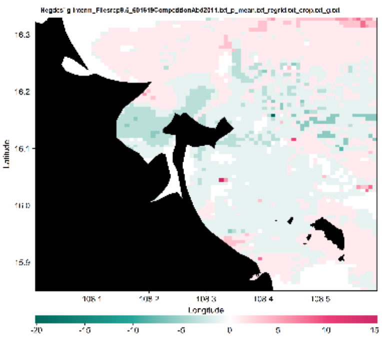

Figure 72: *Anodontostoma chacunda* Hedge's g between 2011-2020 and 2040-2049 under RCP8.5 MSY0. Green areas indicate predicted decreases in abundance, pink areas indicate predicted increases in abundance

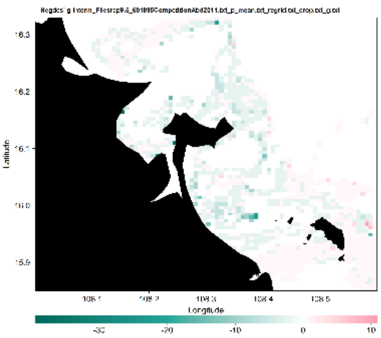

Figure 73: *Caranx ignobilis* Hedge's g between 2011-2020 and 2040-2049 under RCP8.5 MSY0. Green areas indicate predicted decreases in abundance, pink areas indicate predicted increases in abundance

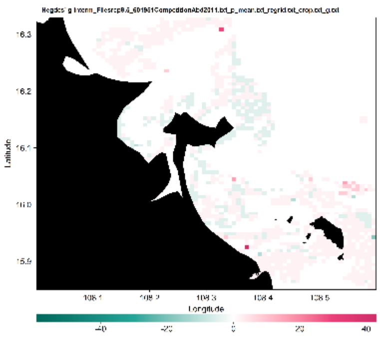

Figure 74: *Scomberoides lysan* Hedge's g between 2011-2020 and 2040-2049 under RCP8.5 MSY0. Green areas indicate predicted decreases in abundance, pink areas indicate predicted increases in abundance

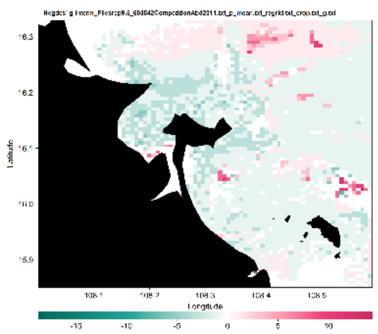

Figure 75: *Rachycentron canadum* Hedge's g between 2011-2020 and 2040-2049 under RCP8.5 MSY0. Green areas indicate predicted decreases in abundance, pink areas indicate predicted increases in abundance

4. **Changes under RCP8.5 and fishing at Maximum Sustainable Yield, contrasting the present decade with the 2040s.**

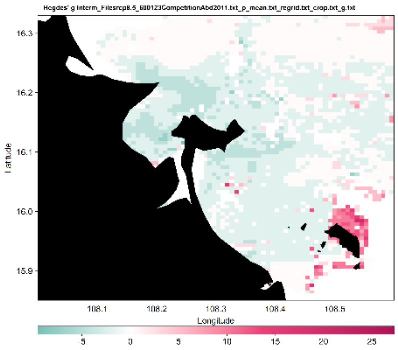

Figure 76: *Siganus guttatus* Hedge's g between 2011-2020 and 2040-2049 under RCP8.5 MSY1. Green areas indicate predicted decreases in abundance, pink areas indicate predicted increases in abundance

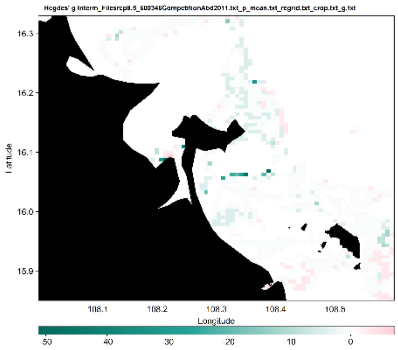

Figure 77: *Lates calcarifer* Hedge's g between 2011-2020 and 2040-2049 under RCP8.5 MSY1. Green areas indicate predicted decreases in abundance, pink areas indicate predicted increases in abundance

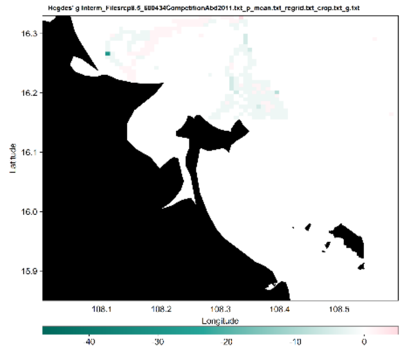

Figure 78: *Pennahia argentata* Hedge's g between 2011-2020 and 2040-2049 under RCP8.5 MSY1. Green areas indicate predicted decreases in abundance, pink areas indicate predicted increases in abundance

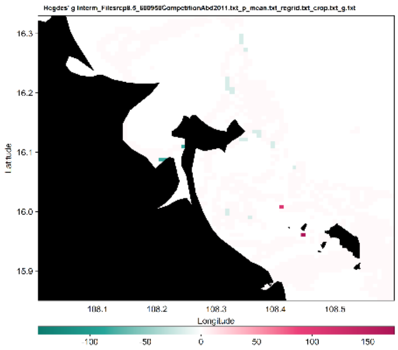

Figure 79: *Platycephalus indicus* Hedge's g between 2011-2020 and 2040-2049 under RCP8.5 MSY1. Green areas indicate predicted decreases in abundance, pink areas indicate predicted increases in abundance

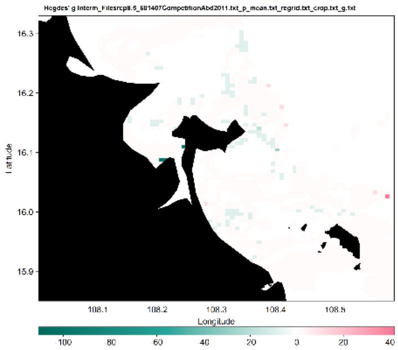

Figure 80: *Lutjanus argentimaculatus* Hedge's g between 2011-2020 and 2040-2049 under RCP8.5 MSY1. Green areas indicate predicted decreases in abundance, pink areas indicate predicted increases in abundance

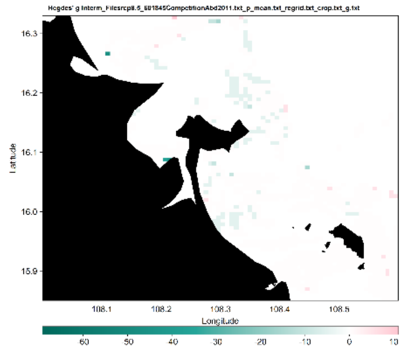

Figure 81: *Lethrinus microdon* Hedge's g between 2011-2020 and 2040-2049 under RCP8.5 MSY1. Green areas indicate predicted decreases in abundance, pink areas indicate predicted increases in abundance

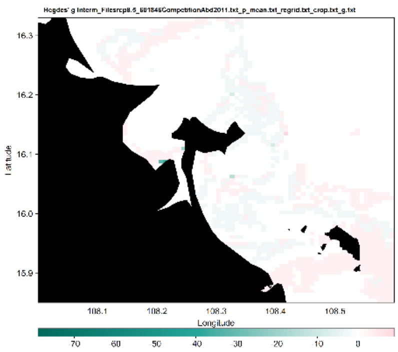

Figure 82: *Lethrinus nebulosus* Hedge's g between 2011-2020 and 2040-2049 under RCP8.5 MSY1. Green areas indicate predicted decreases in abundance, pink areas indicate predicted increases in abundance

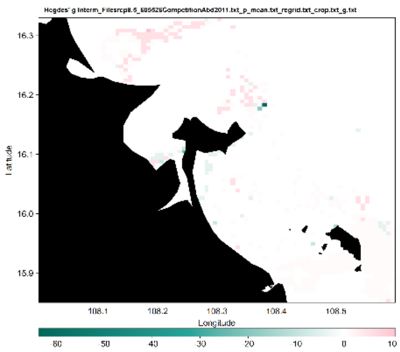

Figure 83: *Acanthopagrus berda* Hedge's g between 2011-2020 and 2040-2049 under RCP8.5 MSY1. Green areas indicate predicted decreases in abundance, pink areas indicate predicted increases in abundance

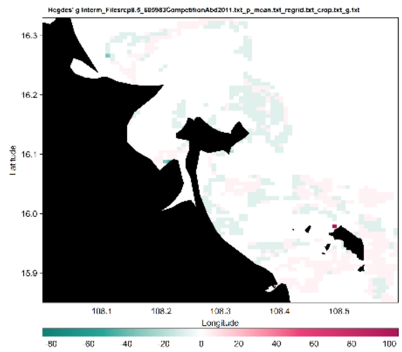

Figure 84: *Mulloidichthys flavolineatus* Hedge's g between 2011-2020 and 2040-2049 under RCP8.5 MSY1. Green areas indicate predicted decreases in abundance, pink areas indicate predicted increases in abundance

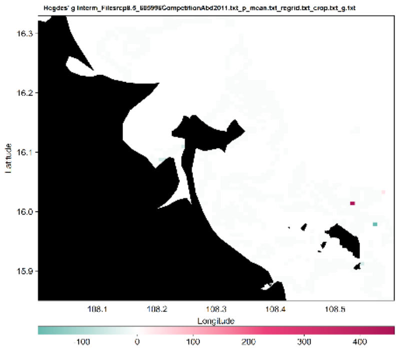

Figure 85: *Gerres oyena* Hedge's g between 2011-2020 and 2040-2049 under RCP8.5 MSY1. Green areas indicate predicted decreases in abundance, pink areas indicate predicted increases in abundance

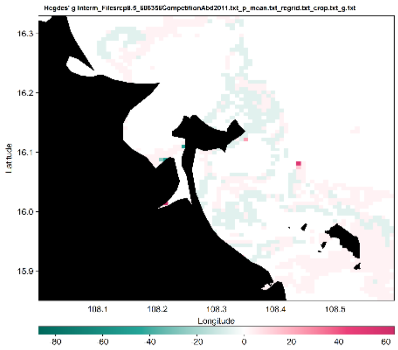

Figure 86: *Acanthopagrus latus* Hedge's g between 2011-2020 and 2040-2049 under RCP8.5 MSY1. Green areas indicate predicted decreases in abundance, pink areas indicate predicted increases in abundance

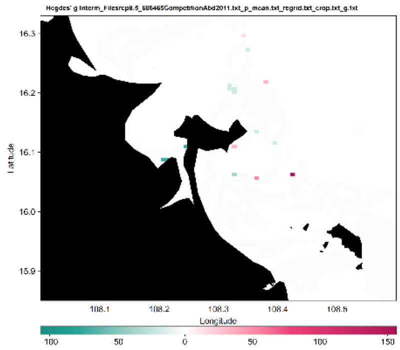

Figure 87: *Epinephelus coioides* Hedge's g between 2011-2020 and 2040-2049 under RCP8.5 MSY1. Green areas indicate predicted decreases in abundance, pink areas indicate predicted increases in abundance

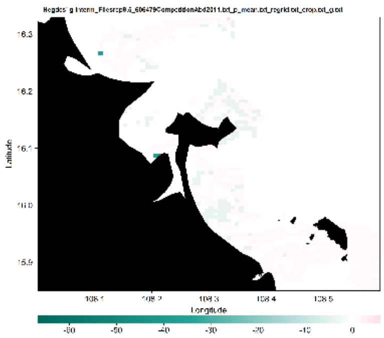

Figure 88: *Saurida tumbil* Hedge's g between 2011-2020 and 2040-2049 under RCP8.5 MSY1. Green areas indicate predicted decreases in abundance, pink areas indicate predicted increases in abundance

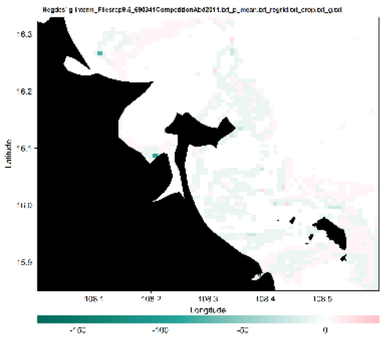

Figure 89: *Panulirus homarus* Hedge's g between 2011-2020 and 2040-2049 under RCP8.5 MSY1. Green areas indicate predicted decreases in abundance, pink areas indicate predicted increases in abundance

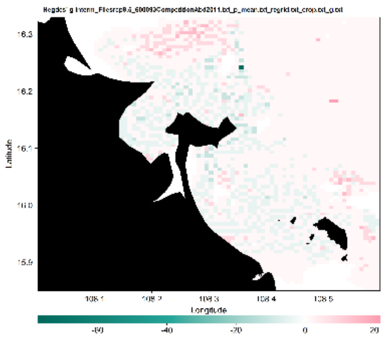

Figure 90: *Auxis rochei* Hedge's g between 2011-2020 and 2040-2049 under RCP8.5 MSY1. Green areas indicate predicted decreases in abundance, pink areas indicate predicted increases in abundance

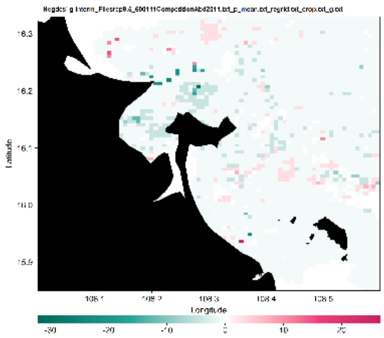

Figure 91: *Rastrelliger kanagurta* Hedge's g between 2011-2020 and 2040-2049 under RCP8.5 MSY1. Green areas indicate predicted decreases in abundance, pink areas indicate predicted increases in abundance

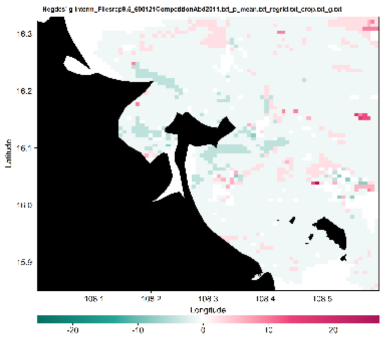

Figure 92: *Scomberomorus commersoni* Hedge's g between 2011-2020 and 2040-2049 under RCP8.5 MSY1. Green areas indicate predicted decreases in abundance, pink areas indicate predicted increases in abundance

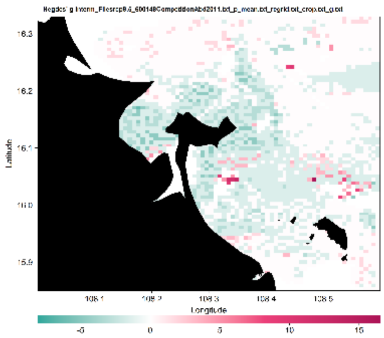

Figure 93: *Thunnus tonggol*Hedge's g between 2011-2020 and 2040-2049 under RCP8.5 MSY1. Green areas indicate predicted decreases in abundance, pink areas indicate predicted increases in abundance

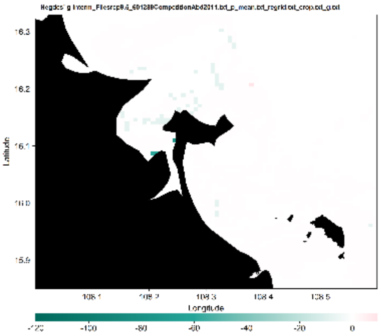

Figure 94: *Trichiurus lepturus* Hedge's g between 2011-2020 and 2040-2049 under RCP8.5 MSY1. Green areas indicate predicted decreases in abundance, pink areas indicate predicted increases in abundance

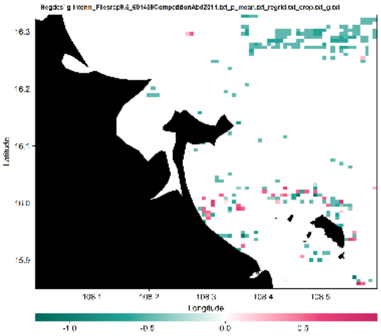

Figure 95: *Spratelloides gracilis* Hedge's g between 2011-2020 and 2040-2049 under RCP8.5 MSY1. Green areas indicate predicted decreases in abundance, pink areas indicate predicted increases in abundance

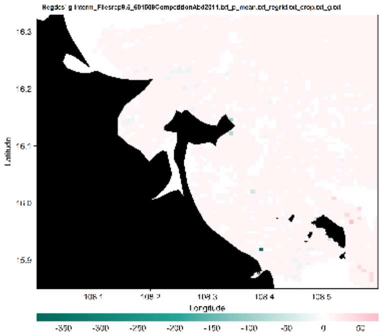

Figure 96: *Sardinella gibbosa* Hedge's g between 2011-2020 and 2040-2049 under RCP8.5 MSY1. Green areas indicate predicted decreases in abundance, pink areas indicate predicted increases in abundance

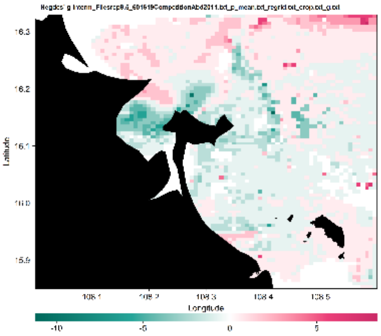

Figure 97: *Anodontostoma chacunda* Hedge's g between 2011-2020 and 2040-2049 under RCP8.5 MSY1. Green areas indicate predicted decreases in abundance, pink areas indicate predicted increases in abundance

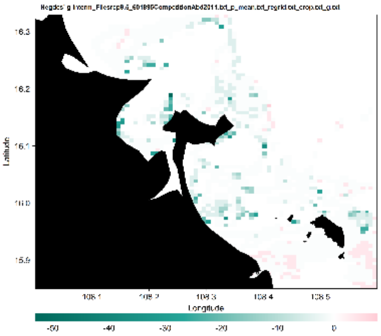

Figure 98: *Caranx ignobilis* Hedge's g between 2011-2020 and 2040-2049 under RCP8.5 MSY1. Green areas indicate predicted decreases in abundance, pink areas indicate predicted increases in abundance

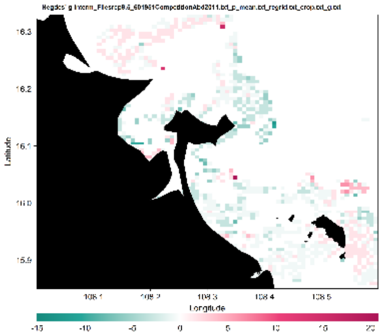

Figure 99: *Scomberoides lysan* Hedge's g between 2011-2020 and 2040-2049 under RCP8.5 MSY1. Green areas indicate predicted decreases in abundance, pink areas indicate predicted increases in abundance

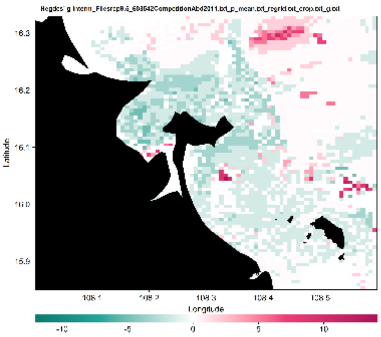

Figure 100: *Rachycentron canadum* Hedge's g between 2011-2020 and 2040-2049 under RCP8.5 MSY1. Green areas indicate predicted decreases in abundance, pink areas indicate predicted increases in abundance

5. Changes under RCP4.5 and no fishing effort, contrasting the present decade with the 2060s.

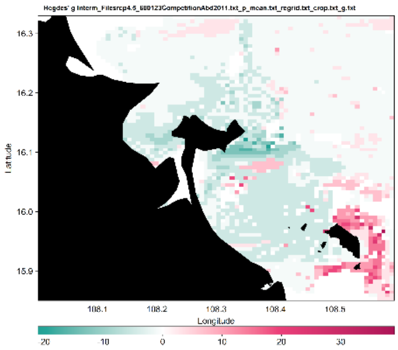

Figure 101: *Siganus guttatus* Hedge's g between 2011-2020 and 2060-2069 under RCP4.5 MSY0. Green areas indicate predicted decreases in abundance, pink areas indicate predicted increases in abundance

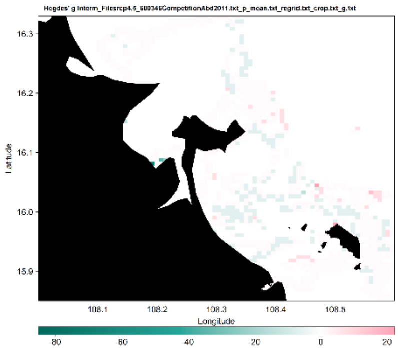

Figure 102: *Lates calcarifer* Hedge's g between 2011-2020 and 2060-2069 under RCP4.5 MSY0. Green areas indicate predicted decreases in abundance, pink areas indicate predicted increases in abundance

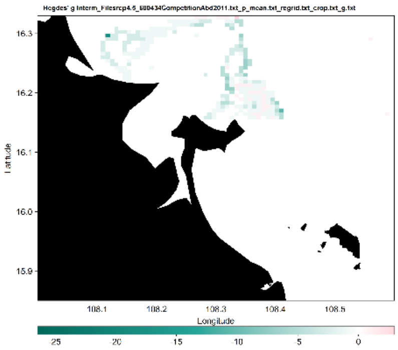

Figure 103: *Pennahia argentata* Hedge's g between 2011-2020 and 2060-2069 under RCP4.5 MSY0. Green areas indicate predicted decreases in abundance, pink areas indicate predicted increases in abundance

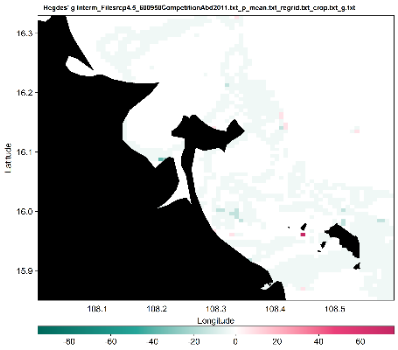

Figure 104: *Platycephalus indicus* Hedge's g between 2011-2020 and 2060-2069 under RCP4.5 MSY0. Green areas indicate predicted decreases in abundance, pink areas indicate predicted increases in abundance

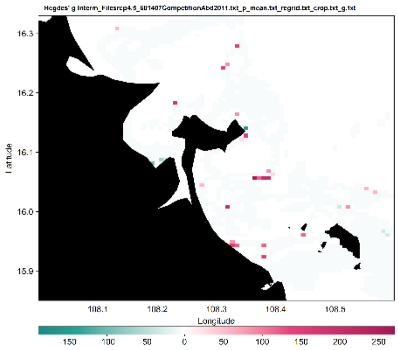

Figure 105: *Lutjanus argentimaculatus* Hedge's g between 2011-2020 and 2060-2069 under RCP4.5 MSY0. Green areas indicate predicted decreases in abundance, pink areas indicate predicted increases in abundance

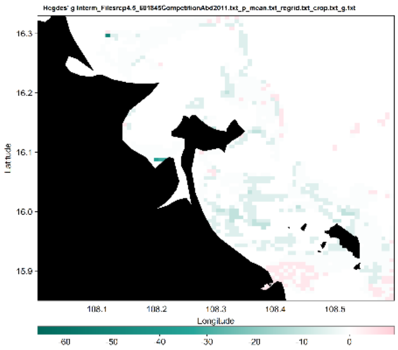

Figure 106: *Lethrinus microdon* Hedge's g between 2011-2020 and 2060-2069 under RCP4.5 MSY0. Green areas indicate predicted decreases in abundance, pink areas indicate predicted increases in abundance

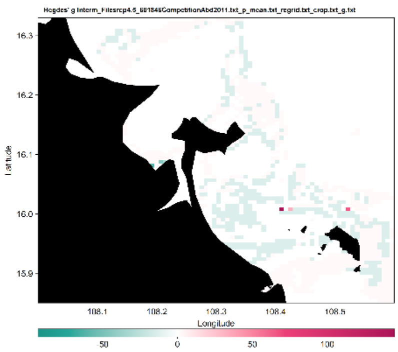

Figure 107: *Lethrinus nebulosus* Hedge's g between 2011-2020 and 2060-2069 under RCP4.5 MSY0. Green areas indicate predicted decreases in abundance, pink areas indicate predicted increases in abundance

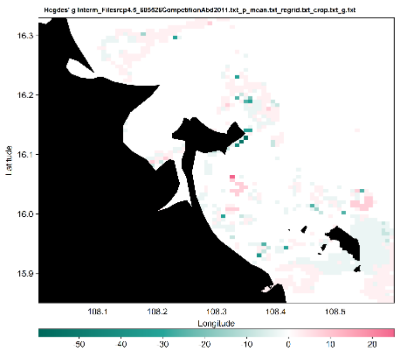

Figure 108: *Acanthopagrus berda* Hedge's g between 2011-2020 and 2060-2069 under RCP4.5 MSY0. Green areas indicate predicted decreases in abundance, pink areas indicate predicted increases in abundance

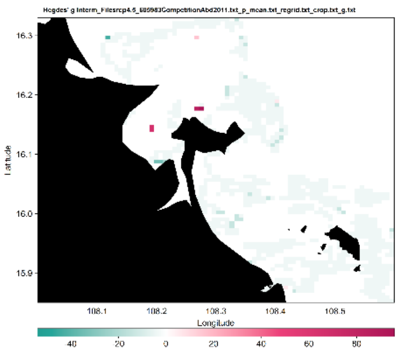

Figure 109: *Mulloidichthys flavolineatus* Hedge's g between 2011-2020 and 2060-2069 under RCP4.5 MSY0. Green areas indicate predicted decreases in abundance, pink areas indicate predicted increases in abundance

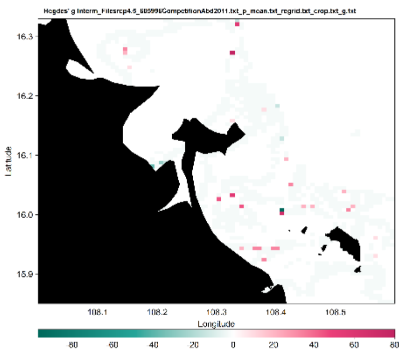

Figure 110: *Gerres oyena* Hedge's g between 2011-2020 and 2060-2069 under RCP4.5 MSY0. Green areas indicate predicted decreases in abundance, pink areas indicate predicted increases in abundance

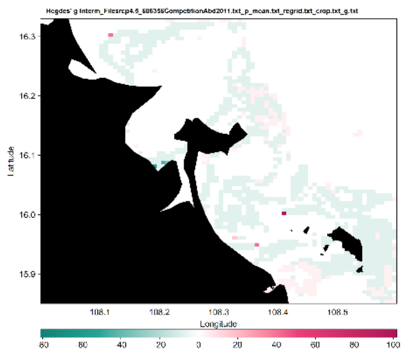

Figure 111: *Acanthopagrus latus* Hedge's g between 2011-2020 and 2060-2069 under RCP4.5 MSY0. Green areas indicate predicted decreases in abundance, pink areas indicate predicted increases in abundance

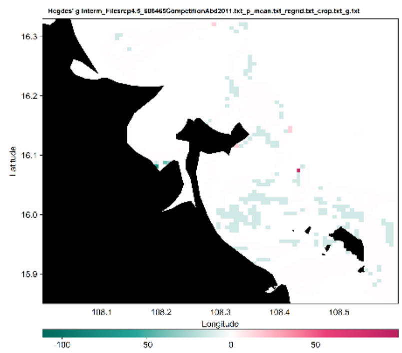

Figure 112: *Epinephelus coioides* Hedge's g between 2011-2020 and 2060-2069 under RCP4.5 MSY0. Green areas indicate predicted decreases in abundance, pink areas indicate predicted increases in abundance

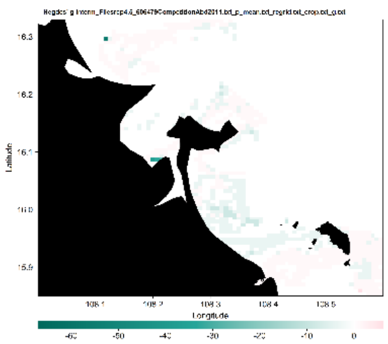

Figure 113: *Saurida tumbil* Hedge's g between 2011-2020 and 2060-2069 under RCP4.5 MSY0. Green areas indicate predicted decreases in abundance, pink areas indicate predicted increases in abundance

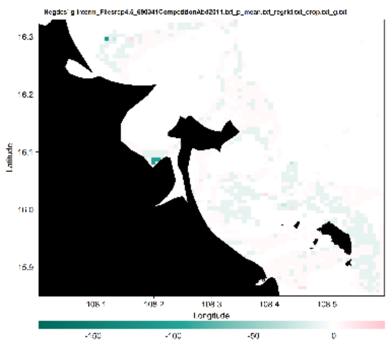

Figure 114: *Panulirus homarus* Hedge's g between 2011-2020 and 2060-2069 under RCP4.5 MSY0. Green areas indicate predicted decreases in abundance, pink areas indicate predicted increases in abundance

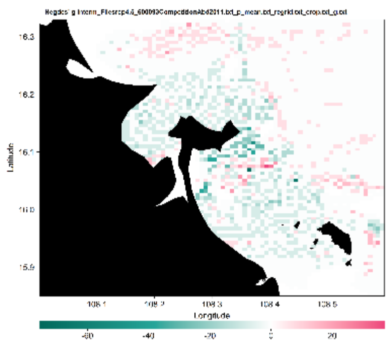

Figure 115: *Auxis rochei* Hedge's g between 2011-2020 and 2060-2069 under RCP4.5 MSY0. Green areas indicate predicted decreases in abundance, pink areas indicate predicted increases in abundance

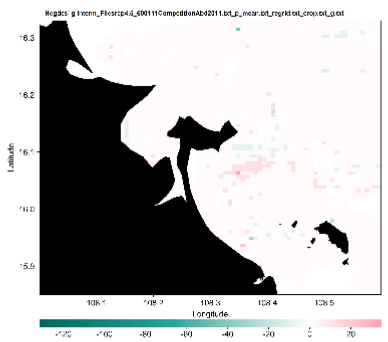

Figure 116: *Rastrelliger kanagurta* Hedge's g between 2011-2020 and 2060-2069 under RCP4.5 MSY0. Green areas indicate predicted decreases in abundance, pink areas indicate predicted increases in abundance

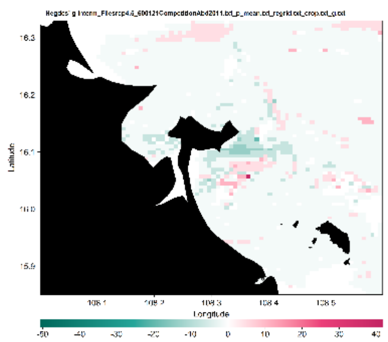

Figure 117: *Scomberomorus commersoni* Hedge's g between 2011-2020 and 2060-2069 under RCP4.5 MSY0. Green areas indicate predicted decreases in abundance, pink areas indicate predicted increases in abundance

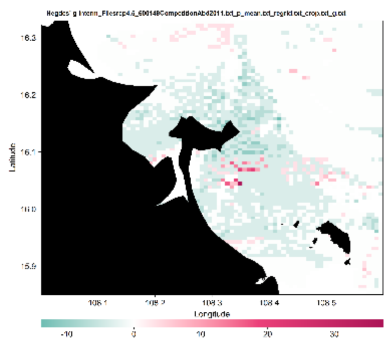

Figure 118: *Thunnus tonggol*Hedge's g between 2011-2020 and 2060-2069 under RCP4.5 MSY0. Green areas indicate predicted decreases in abundance, pink areas indicate predicted increases in abundance

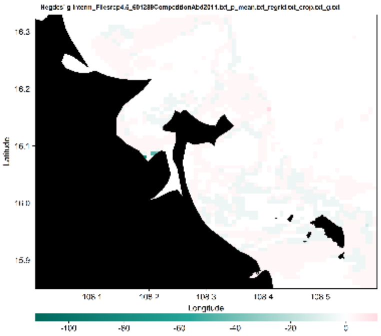

Figure 119: *Trichiurus lepturus* Hedge's g between 2011-2020 and 2060-2069 under RCP4.5 MSY0. Green areas indicate predicted decreases in abundance, pink areas indicate predicted increases in abundance

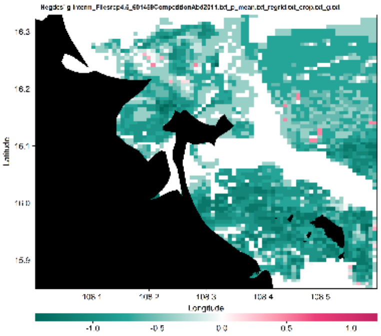

Figure 120: *Spratelloides gracilis* Hedge's g between 2011-2020 and 2060-2069 under RCP4.5 MSY0. Green areas indicate predicted decreases in abundance, pink areas indicate predicted increases in abundance

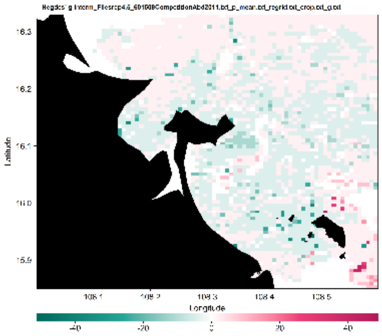

Figure 121: *Sardinella gibbosa* Hedge's g between 2011-2020 and 2060-2069 under RCP4.5 MSY0. Green areas indicate predicted decreases in abundance, pink areas indicate predicted increases in abundance

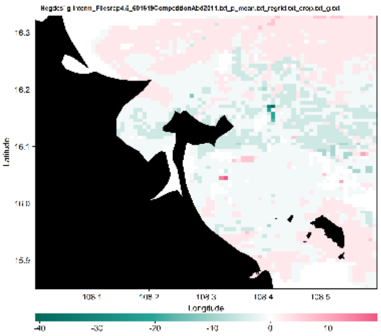

Figure 122: *Anodontostoma chacunda* Hedge's g between 2011-2020 and 2060-2069 under RCP4.5 MSY0. Green areas indicate predicted decreases in abundance, pink areas indicate predicted increases in abundance

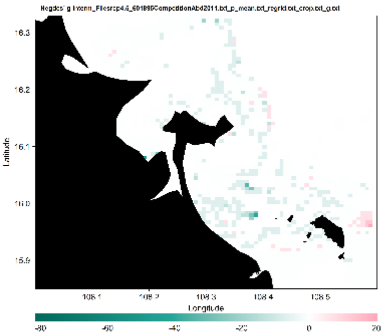

Figure 123: *Caranx ignobilis* Hedge's g between 2011-2020 and 2060-2069 under RCP4.5 MSY0. Green areas indicate predicted decreases in abundance, pink areas indicate predicted increases in abundance

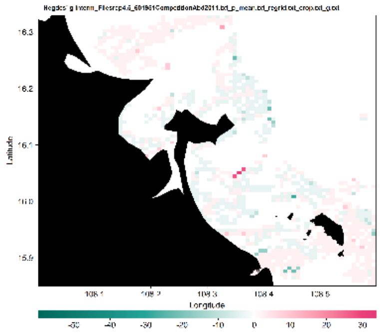

Figure 124: *Scomberoides lysan* Hedge's g between 2011-2020 and 2060-2069 under RCP4.5 MSY0. Green areas indicate predicted decreases in abundance, pink areas indicate predicted increases in abundance

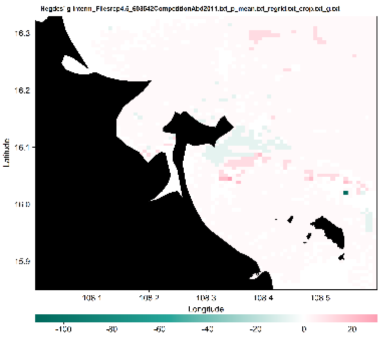

Figure 125: *Rachycentron canadum* Hedge's g between 2011-2020 and 2060-2069 under RCP4.5 MSY0. Green areas indicate predicted decreases in abundance, pink areas indicate predicted increases in abundance

6. **Changes under RCP4.5 and fishing at Maximum Sustainable Yield, contrasting the present decade with the 2060s.**

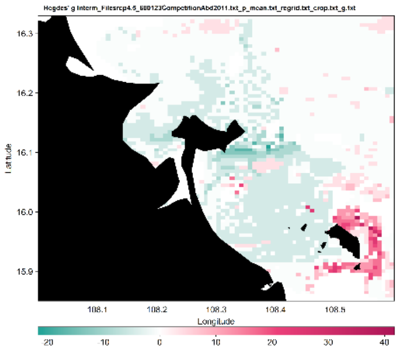

Figure 126: *Siganus guttatus* Hedge's g between 2011-2020 and 2060-2069 under RCP4.5 MSY1. Green areas indicate predicted decreases in abundance, pink areas indicate predicted increases in abundance

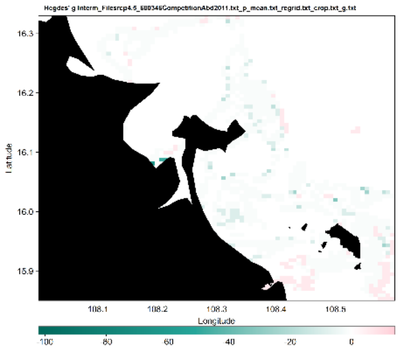

Figure 127: *Lates calcarifer* Hedge's g between 2011-2020 and 2060-2069 under RCP4.5 MSY1. Green areas indicate predicted decreases in abundance, pink areas indicate predicted increases in abundance

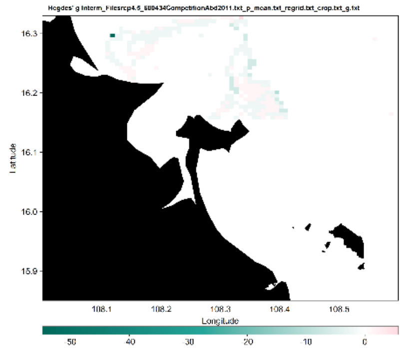

Figure 128: *Pennahia argentata* Hedge's g between 2011-2020 and 2060-2069 under RCP4.5 MSY1. Green areas indicate predicted decreases in abundance, pink areas indicate predicted increases in abundance

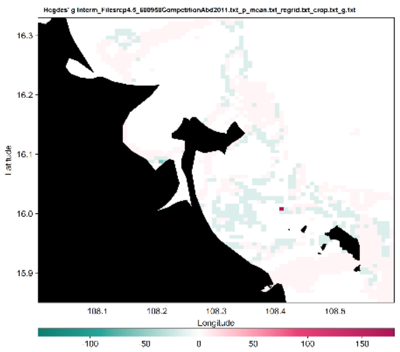

Figure 129: *Platycephalus indicus* Hedge's g between 2011-2020 and 2060-2069 under RCP4.5 MSY1. Green areas indicate predicted decreases in abundance, pink areas indicate predicted increases in abundance

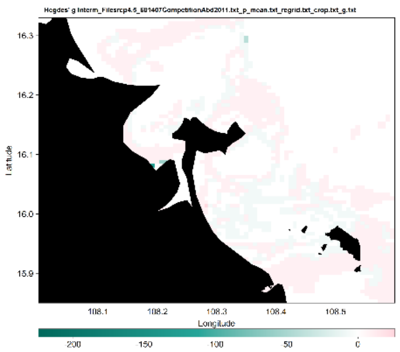

Figure 130: *Lutjanus argentimaculatus* Hedge's g between 2011-2020 and 2060-2069 under RCP4.5 MSY1. Green areas indicate predicted decreases in abundance, pink areas indicate predicted increases in abundance

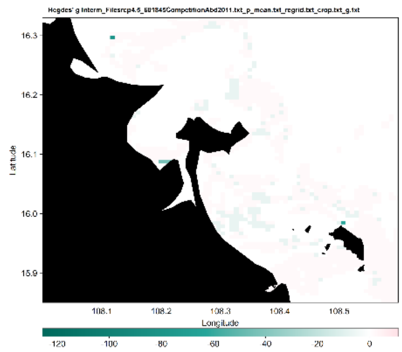

Figure 131: *Lethrinus microdon* Hedge's g between 2011-2020 and 2060-2069 under RCP4.5 MSY1. Green areas indicate predicted decreases in abundance, pink areas indicate predicted increases in abundance

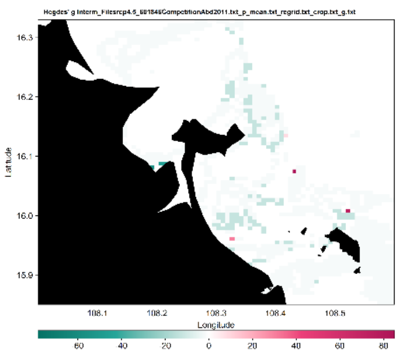

Figure 132: *Lethrinus nebulosus* Hedge's g between 2011-2020 and 2060-2069 under RCP4.5 MSY1. Green areas indicate predicted decreases in abundance, pink areas indicate predicted increases in abundance

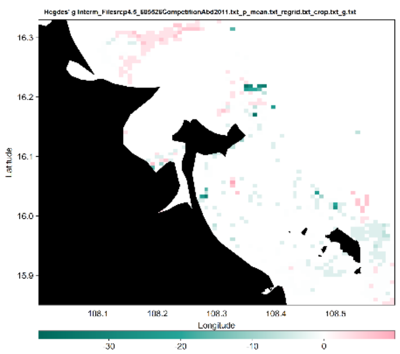

Figure 133: *Acanthopagrus berda* Hedge's g between 2011-2020 and 2060-2069 under RCP4.5 MSY1. Green areas indicate predicted decreases in abundance, pink areas indicate predicted increases in abundance

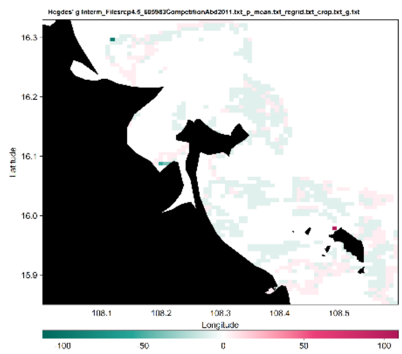

Figure 134: *Mulloidichthys flavolineatus* Hedge's g between 2011-2020 and 2060-2069 under RCP4.5 MSY1. Green areas indicate predicted decreases in abundance, pink areas indicate predicted increases in abundance

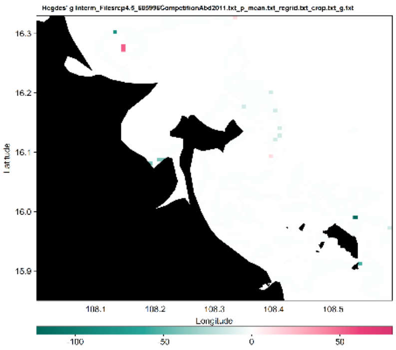

Figure 135: *Gerres oyena* Hedge's g between 2011-2020 and 2060-2069 under RCP4.5 MSY1. Green areas indicate predicted decreases in abundance, pink areas indicate predicted increases in abundance

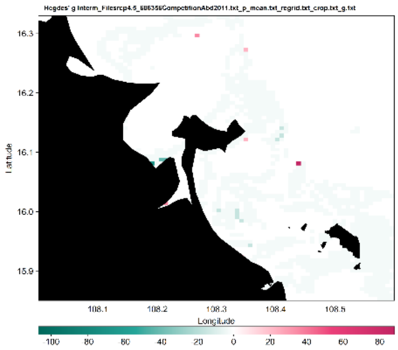

Figure 136: *Acanthopagrus latus* Hedge's g between 2011-2020 and 2060-2069 under RCP4.5 MSY1. Green areas indicate predicted decreases in abundance, pink areas indicate predicted increases in abundance

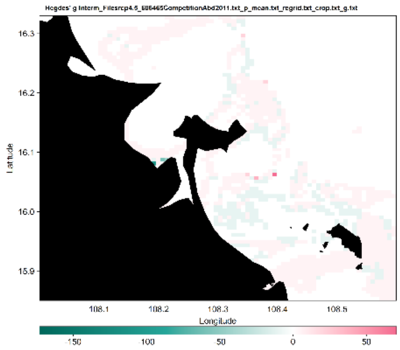

Figure 137: *Epinephelus coioides* Hedge's g between 2011-2020 and 2060-2069 under RCP4.5 MSY1. Green areas indicate predicted decreases in abundance, pink areas indicate predicted increases in abundance

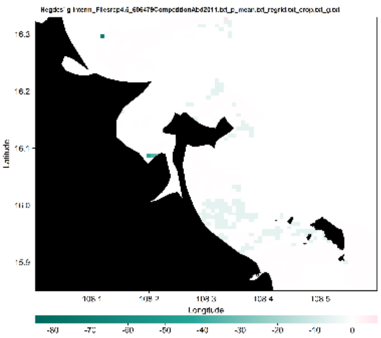

Figure 138: *Saurida tumbil* Hedge's g between 2011-2020 and 2060-2069 under RCP4.5 MSY1. Green areas indicate predicted decreases in abundance, pink areas indicate predicted increases in abundance

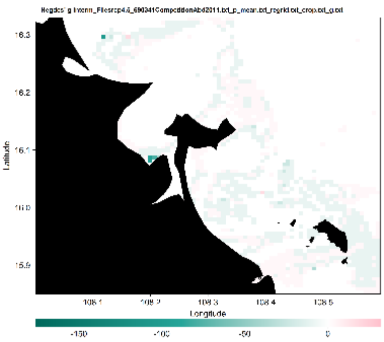

Figure 139: *Panulirus homarus* Hedge's g between 2011-2020 and 2060-2069 under RCP4.5 MSY1. Green areas indicate predicted decreases in abundance, pink areas indicate predicted increases in abundance

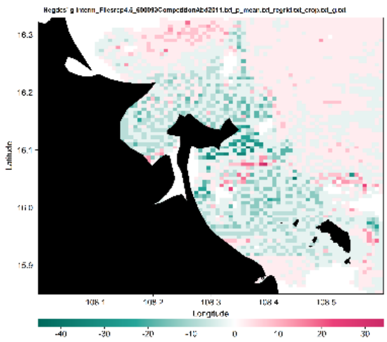

Figure 140: *Auxis rochei* Hedge's g between 2011-2020 and 2060-2069 under RCP4.5 MSY1. Green areas indicate predicted decreases in abundance, pink areas indicate predicted increases in abundance

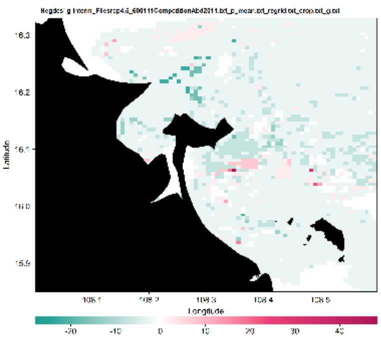

Figure 141: *Rastrelliger kanagurta* Hedge's g between 2011-2020 and 2060-2069 under RCP4.5 MSY1. Green areas indicate predicted decreases in abundance, pink areas indicate predicted increases in abundance

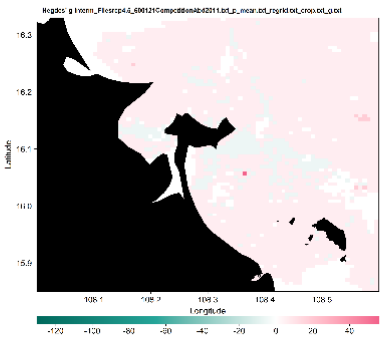

Figure 142: *Scomberomorus commersoni* Hedge's g between 2011-2020 and 2060-2069 under RCP4.5 MSY1. Green areas indicate predicted decreases in abundance, pink areas indicate predicted increases in abundance

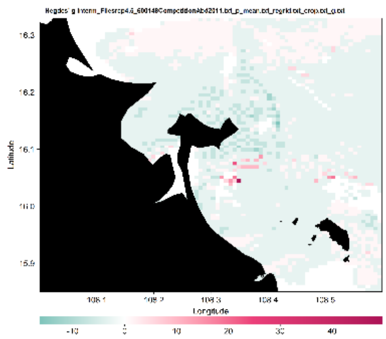

Figure 143: *Thunnus tonggol* Hedge's g between 2011-2020 and 2060-2069 under RCP4.5 MSY1. Green areas indicate predicted decreases in abundance, pink areas indicate predicted increases in abundance

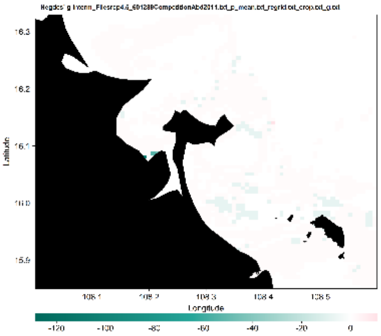

Figure 144: *Trichiurus lepturus* Hedge's g between 2011-2020 and 2060-2069 under RCP4.5 MSY1. Green areas indicate predicted decreases in abundance, pink areas indicate predicted increases in abundance

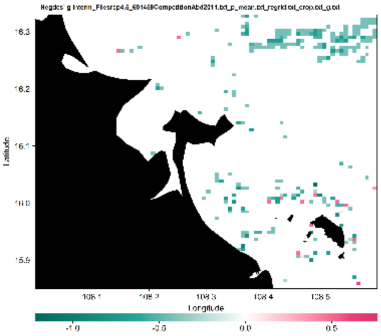

Figure 145: *Spratelloides gracilis* Hedge's g between 2011-2020 and 2060-2069 under RCP4.5 MSY1. Green areas indicate predicted decreases in abundance, pink areas indicate predicted increases in abundance

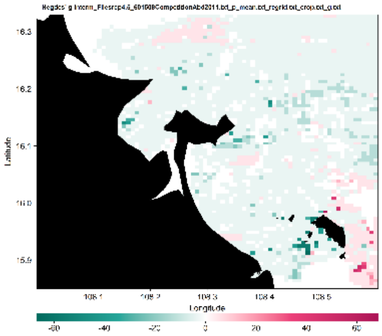

Figure 146: *Sardinella gibbosa* Hedge's g between 2011-2020 and 2060-2069 under RCP4.5 MSY1. Green areas indicate predicted decreases in abundance, pink areas indicate predicted increases in abundance

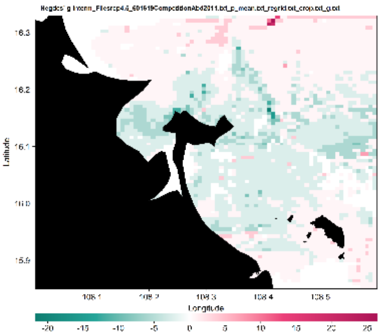

Figure 147: *Anodontostoma chacunda* Hedge's g between 2011-2020 and 2060-2069 under RCP4.5 MSY1. Green areas indicate predicted decreases in abundance, pink areas indicate predicted increases in abundance

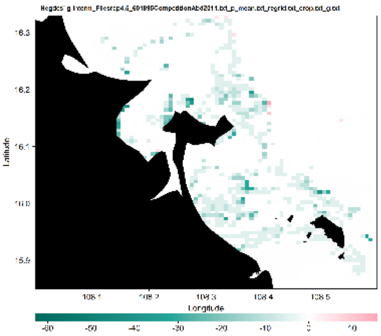

Figure 148: *Caranx ignobilis* Hedge's g between 2011-2020 and 2060-2069 under RCP4.5 MSY1. Green areas indicate predicted decreases in abundance, pink areas indicate predicted increases in abundance

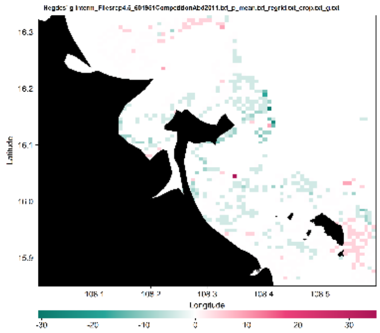

Figure 149: *Scomberoides lysan* Hedge's g between 2011-2020 and 2060-2069 under RCP4.5 MSY1. Green areas indicate predicted decreases in abundance, pink areas indicate predicted increases in abundance

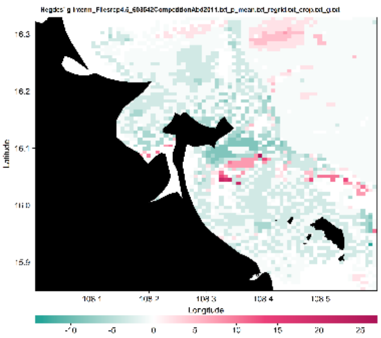

Figure 150: *Rachycentron canadum* Hedge's g between 2011-2020 and 2060-2069 under RCP4.5 MSY1. Green areas indicate predicted decreases in abundance, pink areas indicate predicted increases in abundance

7. Changes under RCP8.5 and no fishing effort, contrasting the present decade with the 2060s.

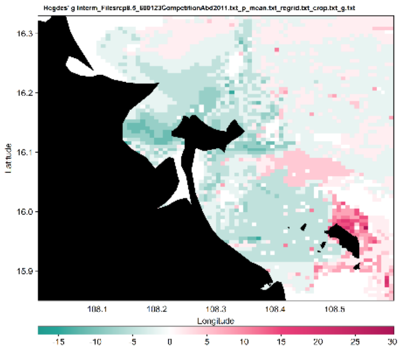

Figure 151: *Siganus guttatus* Hedge's g between 2011-2020 and 2060-2069 under RCP8.5 MSY0. Green areas indicate predicted decreases in abundance, pink areas indicate predicted increases in abundance

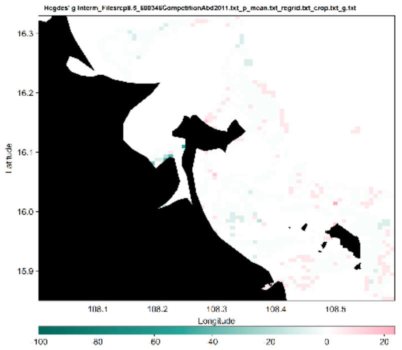

Figure 152: *Lates calcarifer* Hedge's g between 2011-2020 and 2060-2069 under RCP8.5 MSY0. Green areas indicate predicted decreases in abundance, pink areas indicate predicted increases in abundance

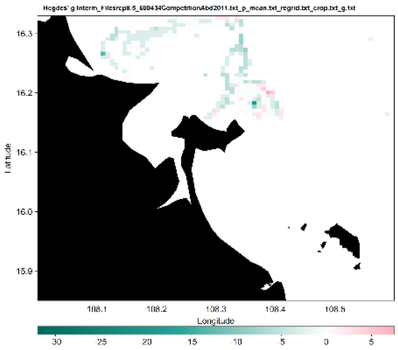

Figure 153: *Pennahia argentata* Hedge's g between 2011-2020 and 2060-2069 under RCP8.5 MSY0. Green areas indicate predicted decreases in abundance, pink areas indicate predicted increases in abundance

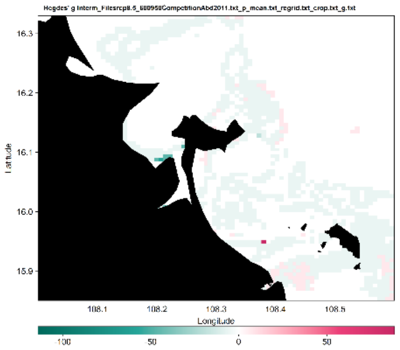

Figure 154: *Platycephalus indicus* Hedge's g between 2011-2020 and 2060-2069 under RCP8.5 MSY0. Green areas indicate predicted decreases in abundance, pink areas indicate predicted increases in abundance

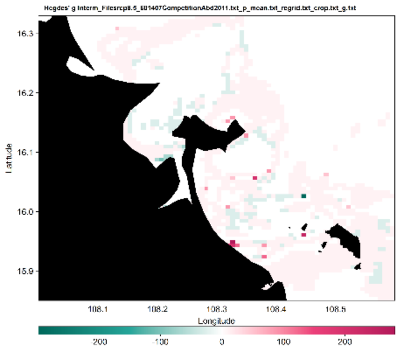

Figure 155: *Lutjanus argentimaculatus* Hedge's g between 2011-2020 and 2060-2069 under RCP8.5 MSY0. Green areas indicate predicted decreases in abundance, pink areas indicate predicted increases in abundance

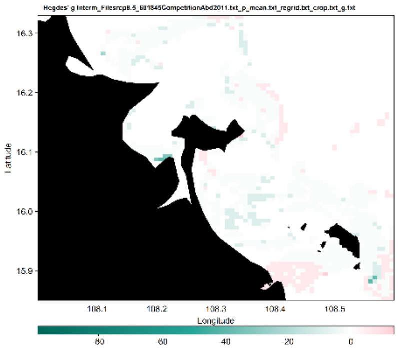

Figure 156: *Lethrinus microdon* Hedge's g between 2011-2020 and 2060-2069 under RCP8.5 MSY0. Green areas indicate predicted decreases in abundance, pink areas indicate predicted increases in abundance

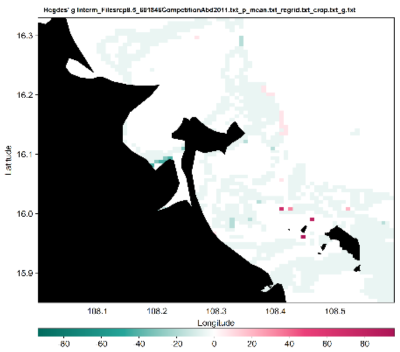

Figure 157: *Lethrinus nebulosus* Hedge's g between 2011-2020 and 2060-2069 under RCP8.5 MSY0. Green areas indicate predicted decreases in abundance, pink areas indicate predicted increases in abundance

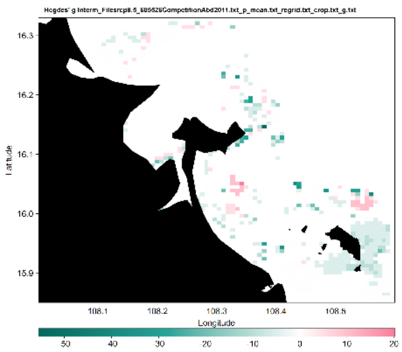

Figure 158: *Acanthopagrus berda* Hedge's g between 2011-2020 and 2060-2069 under RCP8.5 MSY0. Green areas indicate predicted decreases in abundance, pink areas indicate predicted increases in abundance

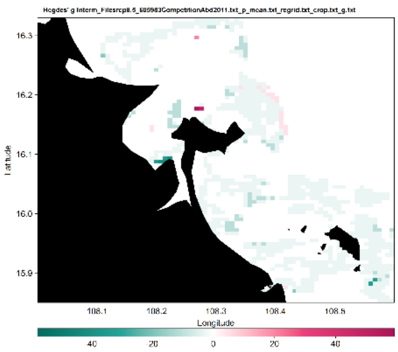

Figure 159: *Mulloidichthys flavolineatus* Hedge's g between 2011-2020 and 2060-2069 under RCP8.5 MSY0. Green areas indicate predicted decreases in abundance, pink areas indicate predicted increases in abundance

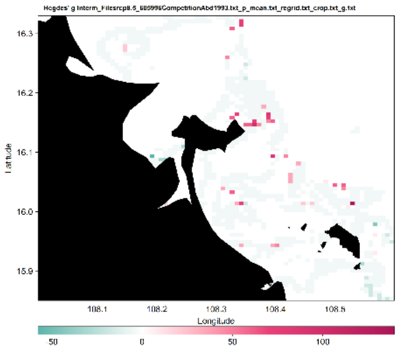

Figure 160: *Gerres oyena* Hedge's g between 2011-2020 and 2060-2069 under RCP8.5 MSY0. Green areas indicate predicted decreases in abundance, pink areas indicate predicted increases in abundance

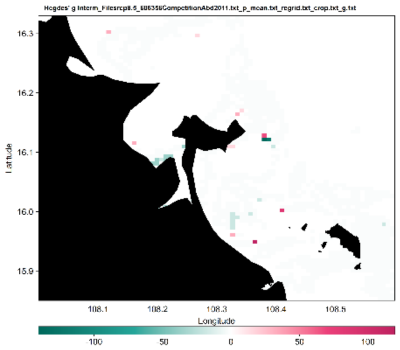

Figure 161: *Acanthopagrus latus* Hedge's g between 2011-2020 and 2060-2069 under RCP8.5 MSY0. Green areas indicate predicted decreases in abundance, pink areas indicate predicted increases in abundance

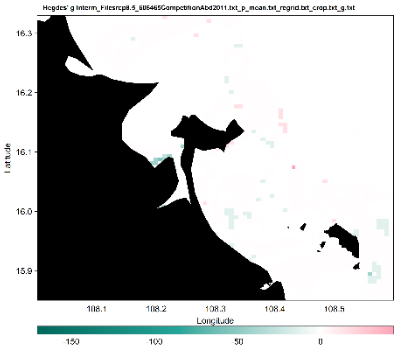

Figure 162: *Epinephelus coioides* Hedge's g between 2011-2020 and 2060-2069 under RCP8.5 MSY0. Green areas indicate predicted decreases in abundance, pink areas indicate predicted increases in abundance

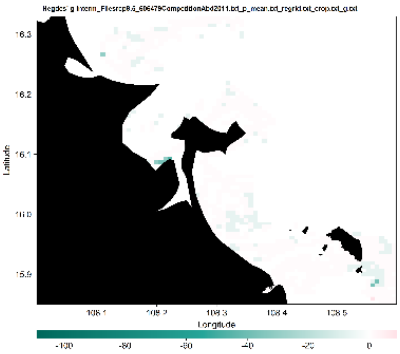

Figure 163: *Saurida tumbil* Hedge's g between 2011-2020 and 2060-2069 under RCP8.5 MSY0. Green areas indicate predicted decreases in abundance, pink areas indicate predicted increases in abundance

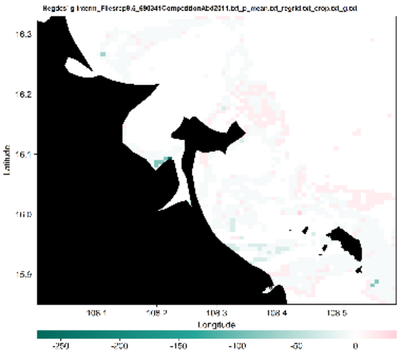

Figure 164: *Panulirus homarus* Hedge's g between 2011-2020 and 2060-2069 under RCP8.5 MSY0. Green areas indicate predicted decreases in abundance, pink areas indicate predicted increases in abundance

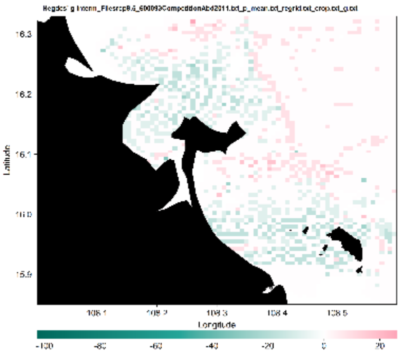

Figure 165: *Auxis rochei* Hedge's g between 2011-2020 and 2060-2069 under RCP8.5 MSY0. Green areas indicate predicted decreases in abundance, pink areas indicate predicted increases in abundance

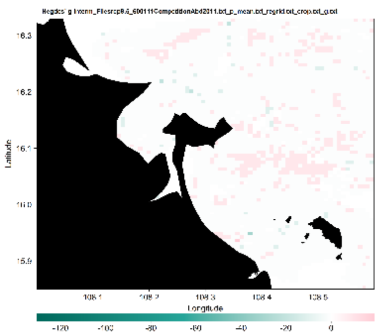

Figure 166: *Rastrelliger kanagurta* Hedge's g between 2011-2020 and 2060-2069 under RCP8.5 MSY0. Green areas indicate predicted decreases in abundance, pink areas indicate predicted increases in abundance

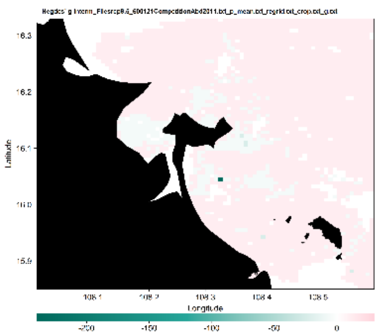

Figure 167: *Scomberomorus commersoni* Hedge's g between 2011-2020 and 2060-2069 under RCP8.5 MSY0. Green areas indicate predicted decreases in abundance, pink areas indicate predicted increases in abundance

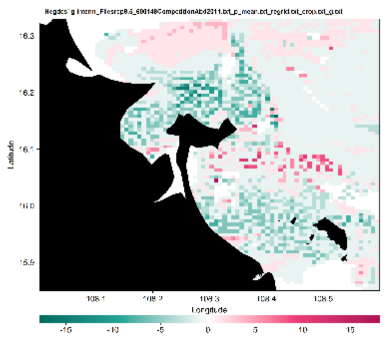

Figure 168: *Thunnus tonggol*Hedge's g between 2011-2020 and 2060-2069 under RCP8.5 MSY0. Green areas indicate predicted decreases in abundance, pink areas indicate predicted increases in abundance

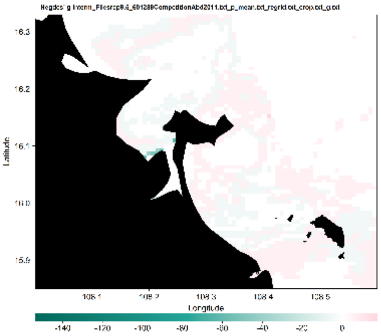

Figure 169: *Trichiurus lepturus* Hedge's g between 2011-2020 and 2060-2069 under RCP8.5 MSY0. Green areas indicate predicted decreases in abundance, pink areas indicate predicted increases in abundance

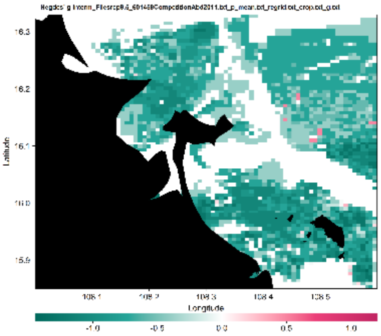

Figure 170: *Spratelloides gracilis* Hedge's g between 2011-2020 and 2060-2069 under RCP8.5 MSY0. Green areas indicate predicted decreases in abundance, pink areas indicate predicted increases in abundance

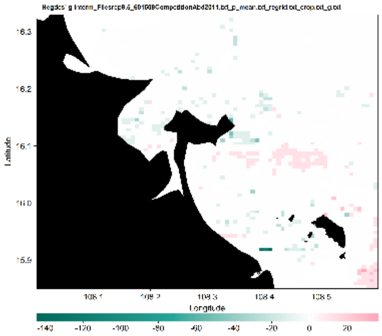

Figure 171: *Sardinella gibbosa* Hedge's g between 2011-2020 and 2060-2069 under RCP8.5 MSY0. Green areas indicate predicted decreases in abundance, pink areas indicate predicted increases in abundance

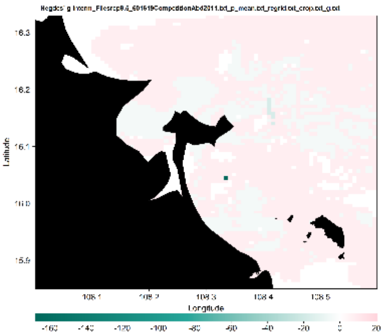

Figure 172: *Anodontostoma chacunda* Hedge's g between 2011-2020 and 2060-2069 under RCP8.5 MSY0. Green areas indicate predicted decreases in abundance, pink areas indicate predicted increases in abundance

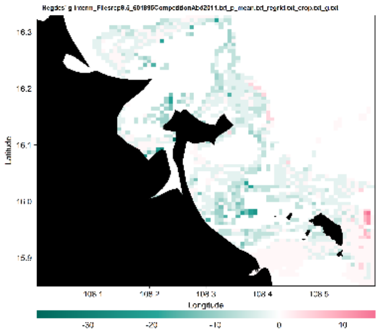

Figure 173: *Caranx ignobilis* Hedge's g between 2011-2020 and 2060-2069 under RCP8.5 MSY0. Green areas indicate predicted decreases in abundance, pink areas indicate predicted increases in abundance

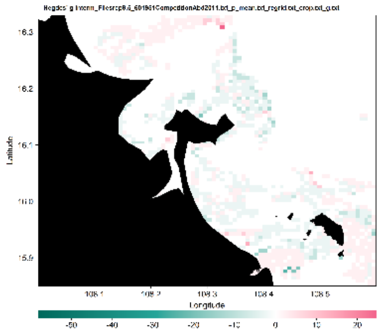

Figure 174: *Scomberoides lysan* Hedge's g between 2011-2020 and 2060-2069 under RCP8.5 MSY0. Green areas indicate predicted decreases in abundance, pink areas indicate predicted increases in abundance

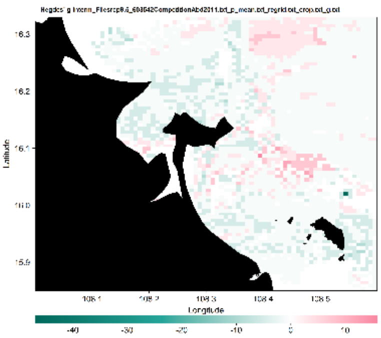

Figure 175: *Rachycentron canadum* Hedge's g between 2011-2020 and 2060-2069 under RCP8.5 MSY0. Green areas indicate predicted decreases in abundance, pink areas indicate predicted increases in abundance

8. Changes under RCP8.5 and fishing at Maximum Sustainable Yield, contrasting the present decade with the 2060s.

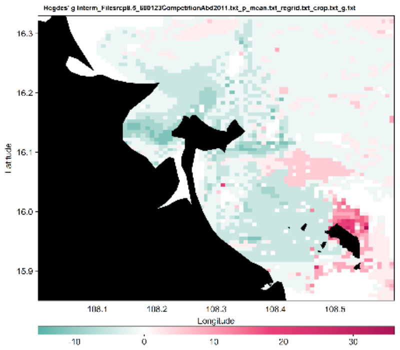

Figure 176: *Siganus guttatus* Hedge’s g between 2011-2020 and 2060-2069 under RCP8.5 MSY1. Green areas indicate predicted decreases in abundance, pink areas indicate predicted increases in abundance

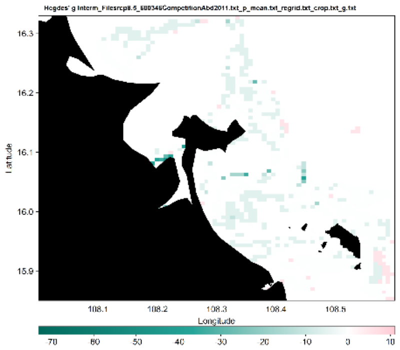

Figure 177: *Lates calcarifer* Hedge’s g between 2011-2020 and 2060-2069 under RCP8.5 MSY1. Green areas indicate predicted decreases in abundance, pink areas indicate predicted increases in abundance

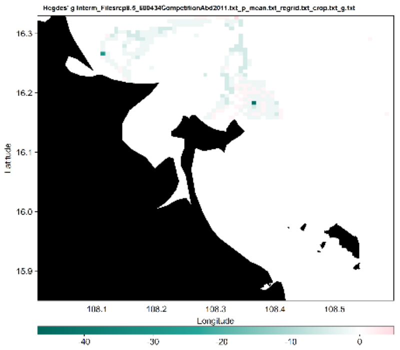

Figure 178: *Pennahia argentata* Hedge’s g between 2011-2020 and 2060-2069 under RCP8.5 MSY1. Green areas indicate predicted decreases in abundance, pink areas indicate predicted increases in abundance

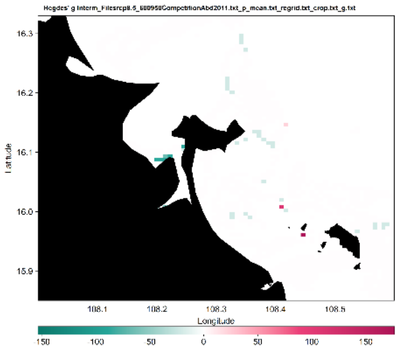

Figure 179: *Platycephalus indicus* Hedge’s g between 2011-2020 and 2060-2069 under RCP8.5 MSY1. Green areas indicate predicted decreases in abundance, pink areas indicate predicted increases in abundance

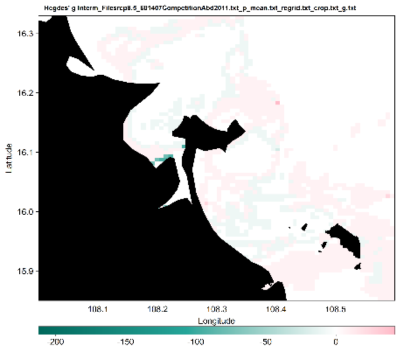

Figure 180: *Lutjanus argentimaculatus* Hedge’s g between 2011-2020 and 2060-2069 under RCP8.5 MSY1. Green areas indicate predicted decreases in abundance, pink areas indicate predicted increases in abundance

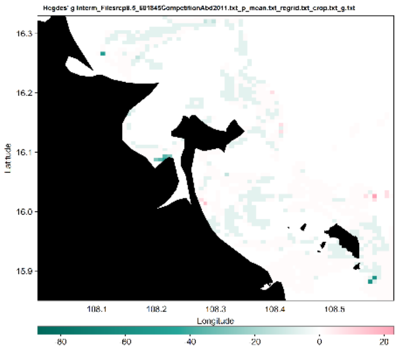

Figure 181: *Lethrinus microdon* Hedge’s g between 2011-2020 and 2060-2069 under RCP8.5 MSY1. Green areas indicate predicted decreases in abundance, pink areas indicate predicted increases in abundance

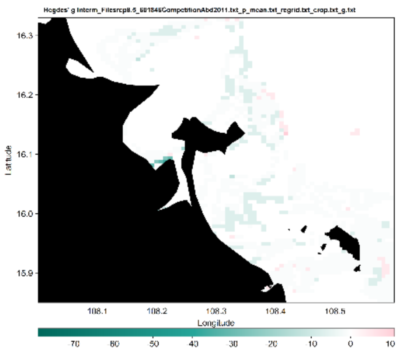

Figure 182: *Lethrinus nebulosus* Hedge’s g between 2011-2020 and 2060-2069 under RCP8.5 MSY1. Green areas indicate predicted decreases in abundance, pink areas indicate predicted increases in abundance

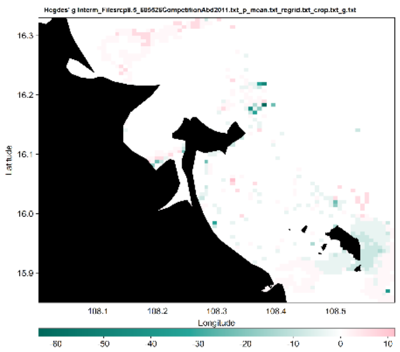

Figure 183: *Acanthopagrus berda* Hedge’s g between 2011-2020 and 2060-2069 under RCP8.5 MSY1. Green areas indicate predicted decreases in abundance, pink areas indicate predicted increases in abundance

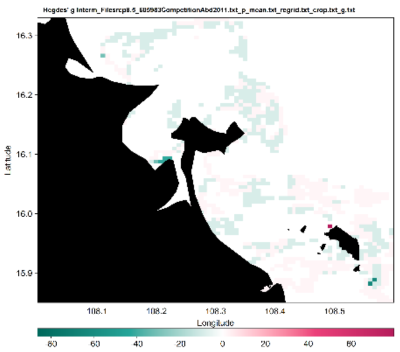

Figure 184: *Mulloidichthys flavolineatus* Hedge’s g between 2011-2020 and 2060-2069 under RCP8.5 MSY1. Green areas indicate predicted decreases in abundance, pink areas indicate predicted increases in abundance

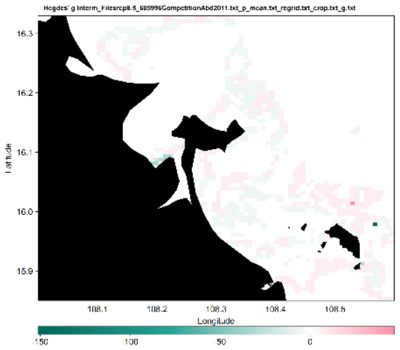

Figure 185: *Gerres oyena* Hedge's g between 2011-2020 and 2060-2069 under RCP8.5 MSY1. Green areas indicate predicted decreases in abundance, pink areas indicate predicted increases in abundance

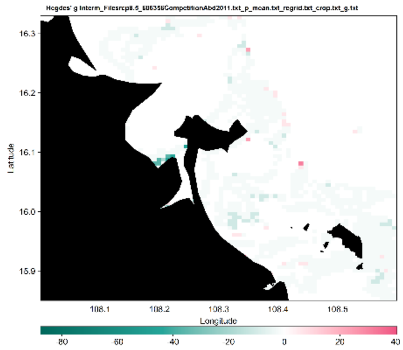

Figure 186: *Acanthopagrus latus* Hedge's g between 2011-2020 and 2060-2069 under RCP8.5 MSY1. Green areas indicate predicted decreases in abundance, pink areas indicate predicted increases in abundance

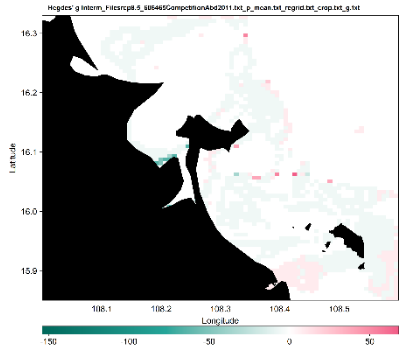

Figure 187: *Epinephelus coioides* Hedge's g between 2011-2020 and 2060-2069 under RCP8.5 MSY1. Green areas indicate predicted decreases in abundance, pink areas indicate predicted increases in abundance

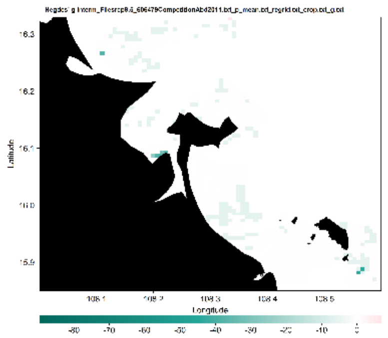

Figure 188: *Saurida tumbil* Hedge's g between 2011-2020 and 2060-2069 under RCP8.5 MSY1. Green areas indicate predicted decreases in abundance, pink areas indicate predicted increases in abundance

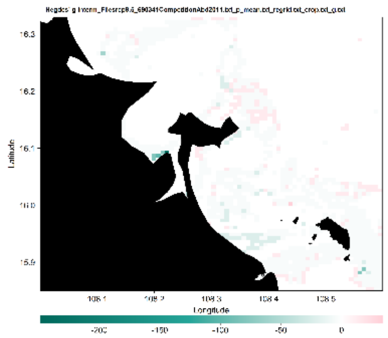

Figure 189: *Panulirus homarus* Hedge's g between 2011-2020 and 2060-2069 under RCP8.5 MSY1. Green areas indicate predicted decreases in abundance, pink areas indicate predicted increases in abundance

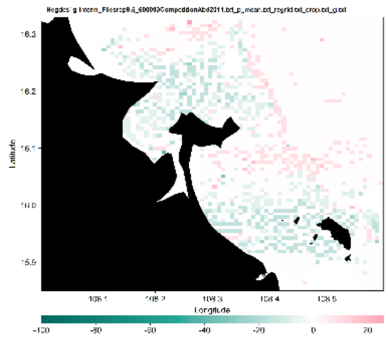

Figure 190: *Auxis rochei* Hedge's g between 2011-2020 and 2060-2069 under RCP8.5 MSY1. Green areas indicate predicted decreases in abundance, pink areas indicate predicted increases in abundance

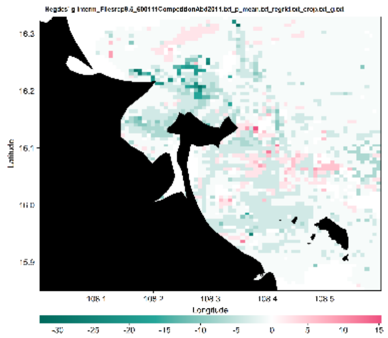

Figure 191: *Rastrelliger kanagurta* Hedge's g between 2011-2020 and 2060-2069 under RCP8.5 MSY1. Green areas indicate predicted decreases in abundance, pink areas indicate predicted increases in abundance

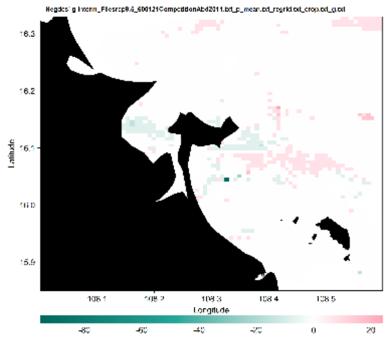

Figure 192: *Scomberomorus commersoni* Hedge's g between 2011-2020 and 2060-2069 under RCP8.5 MSY1. Green areas indicate predicted decreases in abundance, pink areas indicate predicted increases in abundance

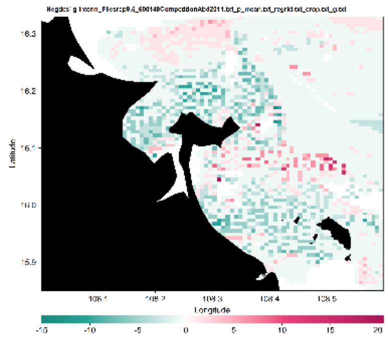

Figure 193: *Thunnus tonggol*Hedge's g between 2011-2020 and 2060-2069 under RCP8.5 MSY1. Green areas indicate predicted decreases in abundance, pink areas indicate predicted increases in abundance

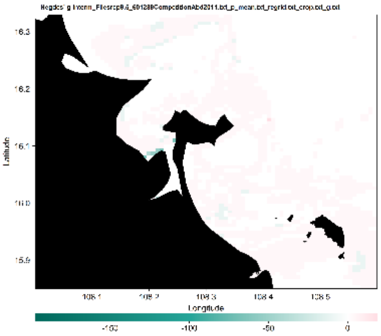

Figure 194: *Trichiurus lepturus* Hedge's g between 2011-2020 and 2060-2069 under RCP8.5 MSY1. Green areas indicate predicted decreases in abundance, pink areas indicate predicted increases in abundance

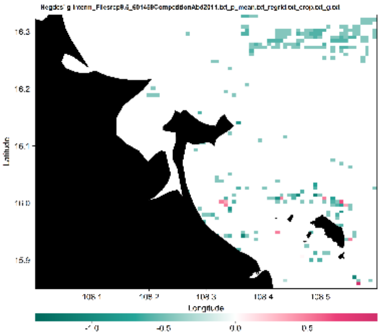

Figure 195: *Spratelloides gracilis* Hedge's g between 2011-2020 and 2060-2069 under RCP8.5 MSY1. Green areas indicate predicted decreases in abundance, pink areas indicate predicted increases in abundance

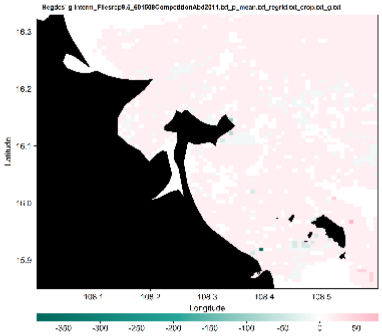

Figure 196: *Sardinella gibbosa* Hedge's g between 2011-2020 and 2060-2069 under RCP8.5 MSY1. Green areas indicate predicted decreases in abundance, pink areas indicate predicted increases in abundance

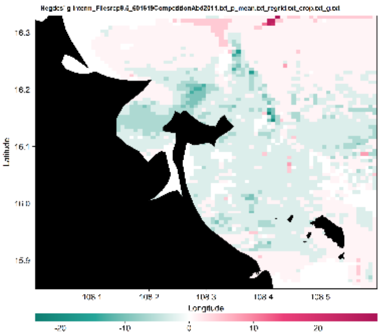

Figure 197: *Anodontostoma chacunda* Hedge's g between 2011-2020 and 2060-2069 under RCP8.5 MSY1. Green areas indicate predicted decreases in abundance, pink areas indicate predicted increases in abundance

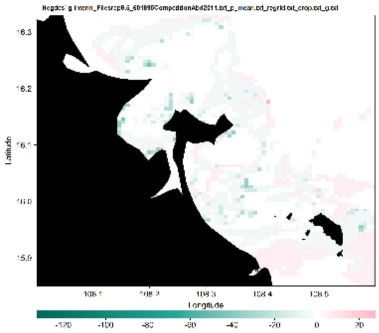

Figure 198: *Caranx ignobilis* Hedge's g between 2011-2020 and 2060-2069 under RCP8.5 MSY1. Green areas indicate predicted decreases in abundance, pink areas indicate predicted increases in abundance

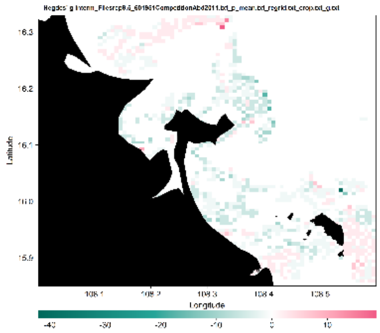

Figure 199: *Scomberoides lysan* Hedge's g between 2011-2020 and 2060-2069 under RCP8.5 MSY1. Green areas indicate predicted decreases in abundance, pink areas indicate predicted increases in abundance

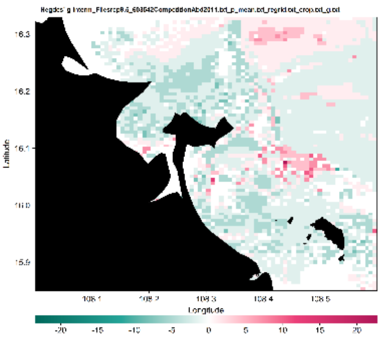

Figure 200: *Rachycentron canadum* Hedge's g between 2011-2020 and 2060-2069 under RCP8.5 MSY1. Green areas indicate predicted decreases in abundance, pink areas indicate predicted increases in abundance

9. Changes to biogeochemical layers under RCP4.5 contrasting the present decade with the 2040s

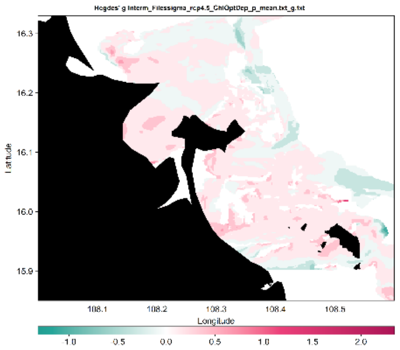

Figure 201: Mean euphotic zone total chlorophyll-a (mg m^{-2}) Hedge's g between 2011-2020 and 2040-2049 under RCP4.5. Green areas indicate where the variable will conform to expected long term climate trends, pink areas indicate the reverse.

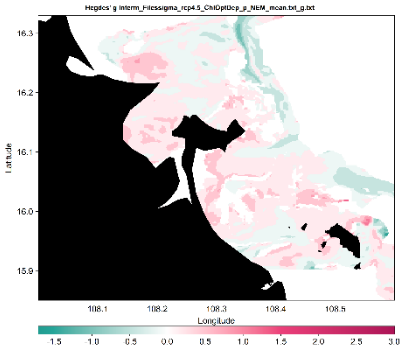

Figure 202: Mean euphotic zone total chlorophyll-a (mg m^{-2}) Hedge's g between 2011-2020 and 2040-2049 under RCP4.5 during the NEM. Green areas indicate where the variable will conform to expected long term climate trends, pink areas indicate the reverse

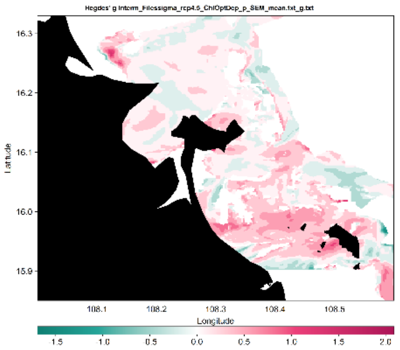

Figure 203: Mean euphotic zone total chlorophyll-a (mg m^{-2}) Hedge's g between 2011-2020 and 2040-2049 under RCP4.5 during the SWM. Green areas indicate where the variable will conform to expected long term climate trends, pink areas indicate the reverse

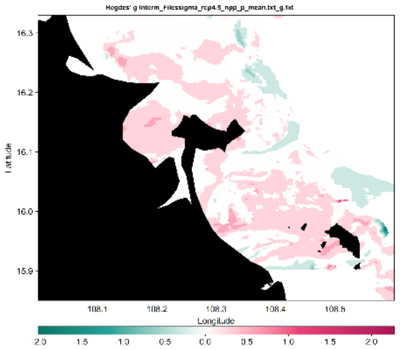

Figure 204: Net primary production (mg C m^{-2} day^{-1}) Hedge's g between 2011-2020 and 2040-2049 under RCP4.5. Green areas indicate where the variable will conform to expected long term climate trends, pink areas indicate the reverse

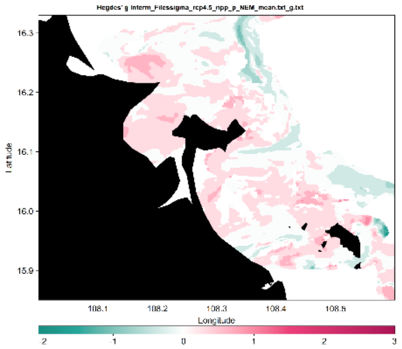

Figure 205: Net primary production (mg C m^{-2} day^{-1}) Hedge's g between 2011-2020 and 2040-2049 under RCP4.5 during the NEM. Green areas indicate where the variable will conform to expected long term climate trends, pink areas indicate the reverse

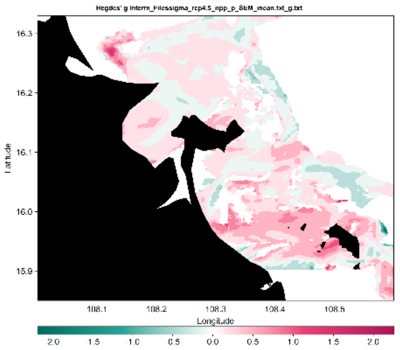

Figure 206: Net primary production (mg C m^{-2} day^{-1}) Hedge's g between 2011-2020 and 2040-2049 under RCP4.5 during the SWM. Green areas indicate where the variable will conform to expected long term climate trends, pink areas indicate the reverse

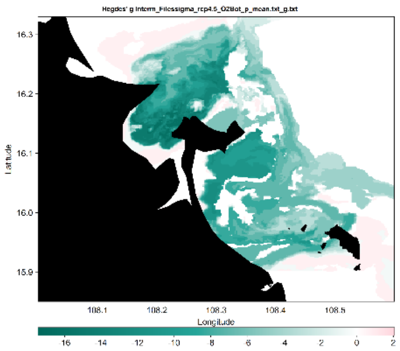

Figure 207: Bottom layer dissolved oxygen (mmol m^{-3}) Hedge's g between 2011-2020 and 2040-2049 under RCP4.5. Green areas indicate where the variable will conform to expected long term climate trends, pink areas indicate the reverse

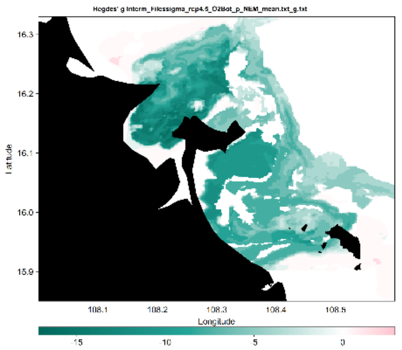

Figure 208: Bottom layer dissolved oxygen (mmol m^{-3}) Hedge's g between 2011-2020 and 2040-2049 under RCP4.5 during the NEM. Green areas indicate where the variable will conform to expected long term climate trends, pink areas indicate the reverse

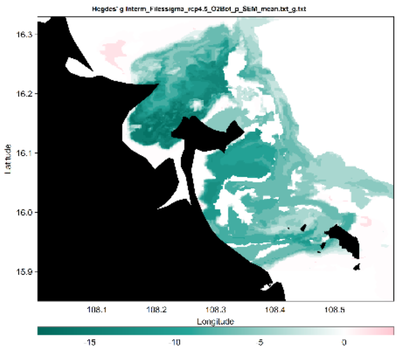

Figure 209: Bottom layer dissolved oxygen (mmol m^{-3}) Hedge's g between 2011-2020 and 2040-2049 under RCP4.5 during the SWM. Green areas indicate where the variable will conform to expected long term climate trends, pink areas indicate the reverse

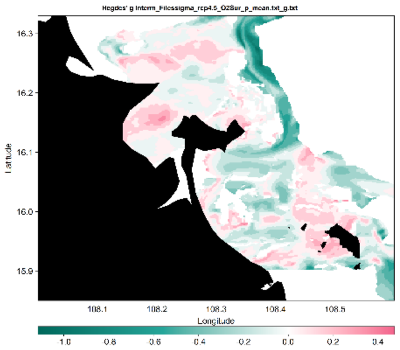

Figure 210: Surface dissolved oxygen (mmol m^{-3}) Hedge's g between 2011-2020 and 2040-2049 under RCP4.5. Green areas indicate where the variable will conform to expected long term climate trends, pink areas indicate the reverse

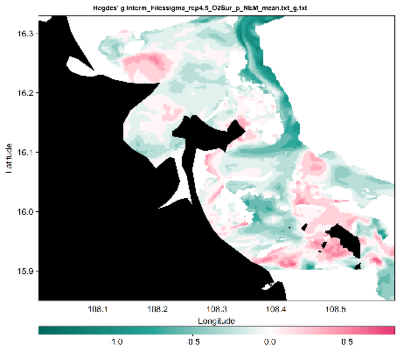

Figure 211: Surface dissolved oxygen (mmol m^{-3}) Hedge's g between 2011-2020 and 2040-2049 under RCP4.5 during the NEM. Green areas indicate where the variable will conform to expected long term climate trends, pink areas indicate the reverse

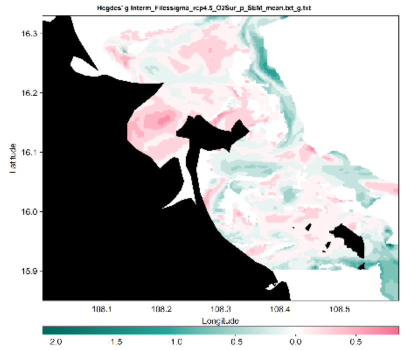

Figure 212: Surface dissolved oxygen (mmol m^{-3}) Hedge's g between 2011-2020 and 2040-2049 under RCP4.5 during the SWM. Green areas indicate where the variable will conform to expected long term climate trends, pink areas indicate the reverse

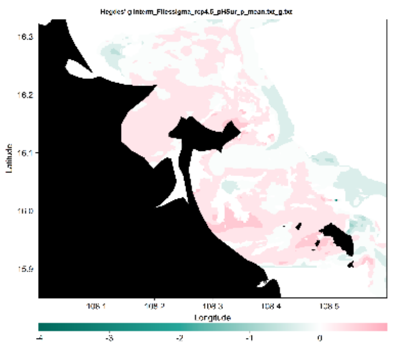

Figure 213: Surface pH Hedge's g between 2011-2020 and 2040-2049 under RCP4.5. Green areas indicate where the variable will conform to expected long term climate trends, pink areas indicate the reverse

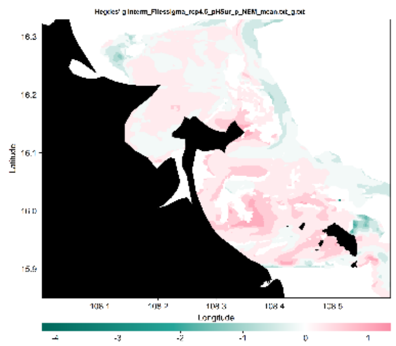

Figure 214: Surface pH Hedge's g between 2011-2020 and 2040-2049 under RCP4.5 during the NEM. Green areas indicate where the variable will conform to expected long term climate trends, pink areas indicate the reverse

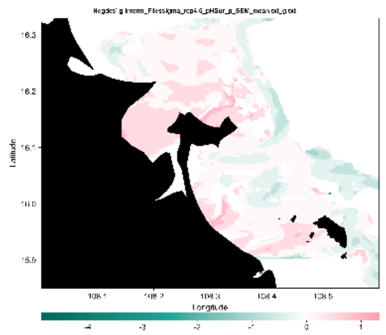

Figure 215: Surface pH Hedge's g between 2011-2020 and 2040-2049 under RCP4.5 during the SWM. Green areas indicate where the variable will conform to expected long term climate trends, pink areas indicate the reverse

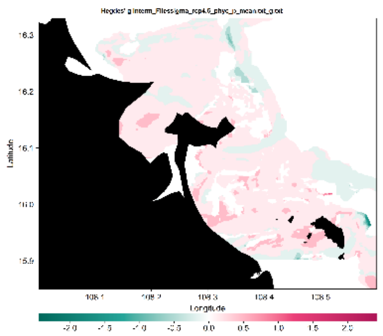

Figure 216: Phytoplankton carbon (mg C m^{-2}) Hedge's g between 2011-2020 and 2040-2049 under RCP4.5. Green areas indicate where the variable will conform to expected long term climate trends, pink areas indicate the reverse

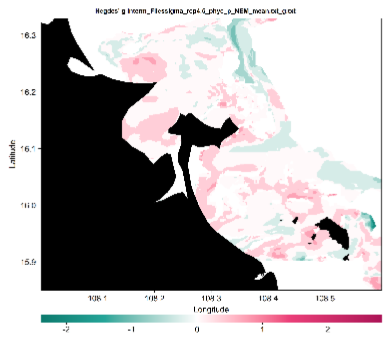

Figure 217: Phytoplankton carbon (mg C m^{-2}) Hedge's g between 2011-2020 and 2040-2049 under RCP4.5 during the NEM. Green areas indicate where the variable will conform to expected long term climate trends, pink areas indicate the reverse

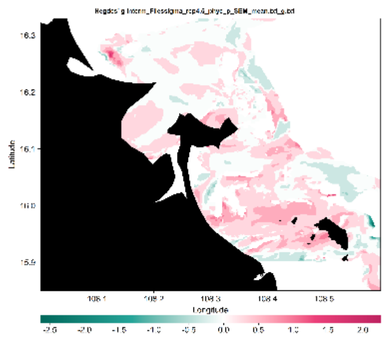

Figure 218: Phytoplankton carbon (mg C m^{-2}) Hedge's g between 2011-2020 and 2040-2049 under RCP4.5 during the SWM. Green areas indicate where the variable will conform to expected long term climate trends, pink areas indicate the reverse

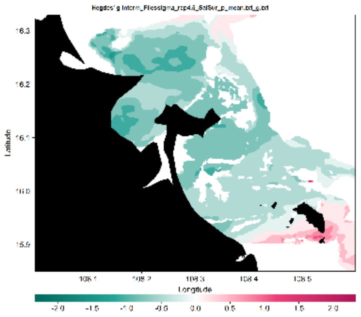

Figure 219: Surface salinity (psu) Hedge's g between 2011-2020 and 2040-2049 under RCP4.5. Green areas indicate where the variable will conform to expected long term climate trends, pink areas indicate the reverse

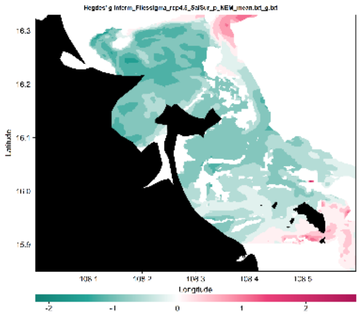

Figure 220: Surface salinity (psu) Hedge's g between 2011-2020 and 2040-2049 under RCP4.5 during the NEM. Green areas indicate where the variable will conform to expected long term climate trends, pink areas indicate the reverse

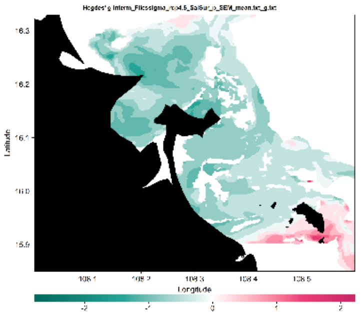

Figure 221: Surface salinity (psu) Hedge's g between 2011-2020 and 2040-2049 under RCP4.5 during the SWM. Green areas indicate where the variable will conform to expected long term climate trends, pink areas indicate the reverse

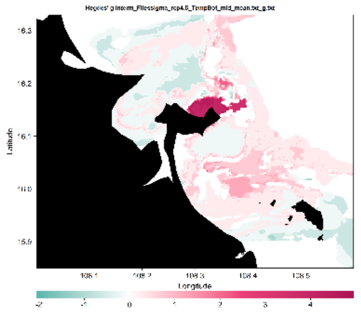

Figure 222: Bottom layer temperature (°C) Hedge's g between 2011-2020 and 2040-2049 under RCP4.5. Green areas indicate where the variable will conform to expected long term climate trends, pink areas indicate the reverse

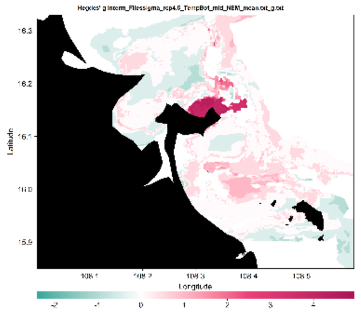

Figure 223: Bottom layer temperature (°C) Hedge's g between 2011-2020 and 2040-2049 under RCP4.5 during the NEM. Green areas indicate where the variable will conform to expected long term climate trends, pink areas indicate the reverse

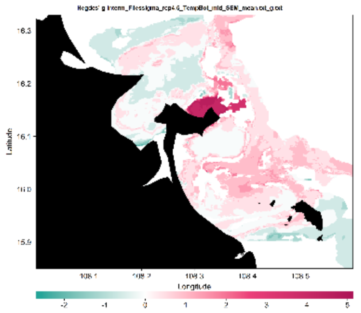

Figure 224: Bottom layer temperature (°C) Hedge's g between 2011-2020 and 2040-2049 under RCP4.5 during the SWM. Green areas indicate where the variable will conform to expected long term climate trends, pink areas indicate the reverse

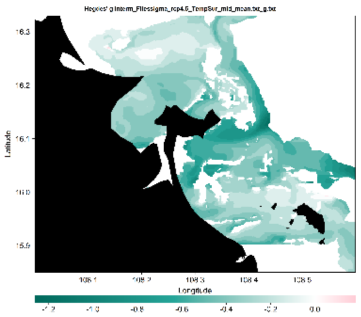

Figure 225: Surface temperature (°C) Hedge's g between 2011-2020 and 2040-2049 under RCP4.5. Green areas indicate where the variable will conform to expected long term climate trends, pink areas indicate the reverse

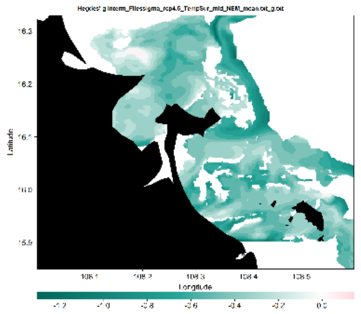

Figure 226: Surface temperature (°C) Hedge's g between 2011-2020 and 2040-2049 under RCP4.5 during the NEM. Green areas indicate where the variable will conform to expected long term climate trends, pink areas indicate the reverse

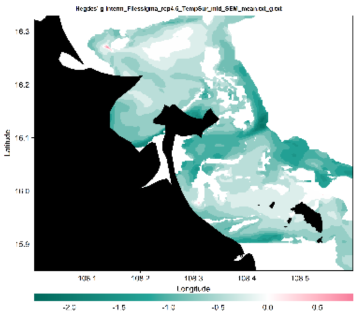

Figure 227: Surface temperature (°C) Hedge's g between 2011-2020 and 2040-2049 under RCP4.5 during the SWM. Green areas indicate where the variable will conform to expected long term climate trends, pink areas indicate the reverse

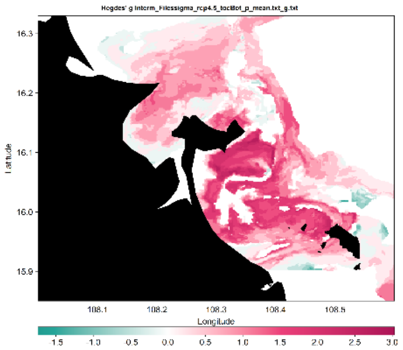

Figure 228: Bottom layer non-living organic carbon (mg C m^{-3}) Hedge's g between 2011-2020 and 2040-2049 under RCP4.5. Green areas indicate where the variable will conform to expected long term climate trends, pink areas indicate the reverse

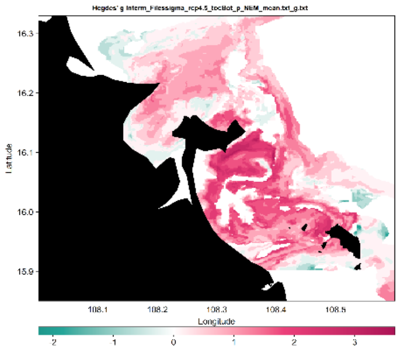

Figure 229: Bottom layer non-living organic carbon (mg C m^{-3}) Hedge's g between 2011-2020 and 2040-2049 under RCP4.5 during the NEM. Green areas indicate where the variable will conform to expected long term climate trends, pink areas indicate the reverse

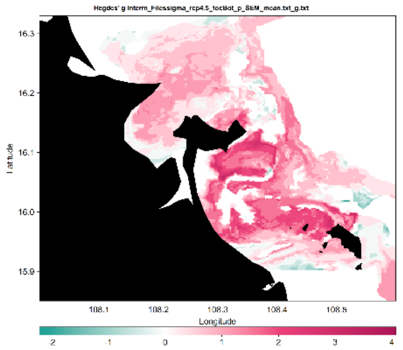

Figure 230: Bottom layer non-living organic carbon (mg C m^{-3}) Hedge's g between 2011-2020 and 2040-2049 under RCP4.5 during the SWM. Green areas indicate where the variable will conform to expected long term climate trends, pink areas indicate the reverse

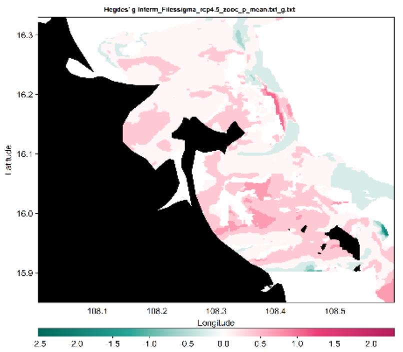

Figure 231: Zooplankton carbon (mg C m^{-2}) Hedge's g between 2011-2020 and 2040-2049 under RCP4.5. Green areas indicate where the variable will conform to expected long term climate trends, pink areas indicate the reverse

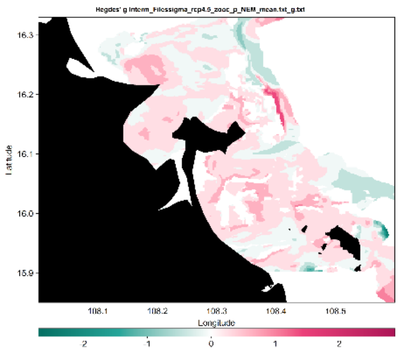

Figure 232: Zooplankton carbon (mg C m^{-2}) Hedge's g between 2011-2020 and 2040-2049 under RCP4.5 during the NEM. Green areas indicate where the variable will conform to expected long term climate trends, pink areas indicate the reverse

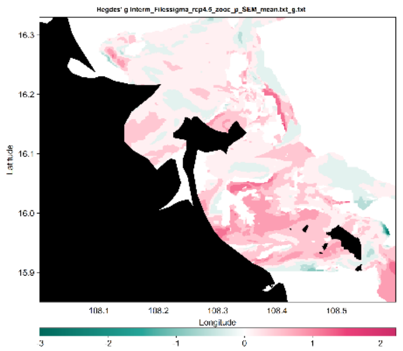

Figure 233: Zooplankton carbon (mg C m^{-2}) Hedge's g between 2011-2020 and 2040-2049 under RCP4.5 during the SWM. Green areas indicate where the variable will conform to expected long term climate trends, pink areas indicate the reverse

10. Changes to biogeochemical layers under RCP8.5 contrasting the present decade with the 2040s

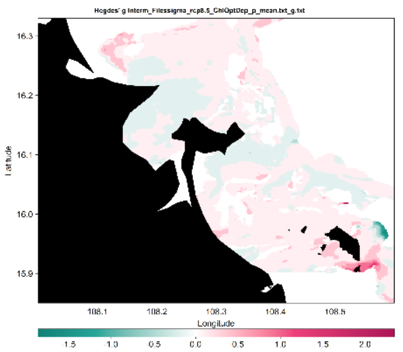

Figure 234: Mean euphotic zone total chlorophyll-a (mg m^{-2}) Hedge's g between 2011-2020 and 2040-2049 under RCP8.5. Green areas indicate where the variable will conform to expected long term climate trends, pink areas indicate the reverse.

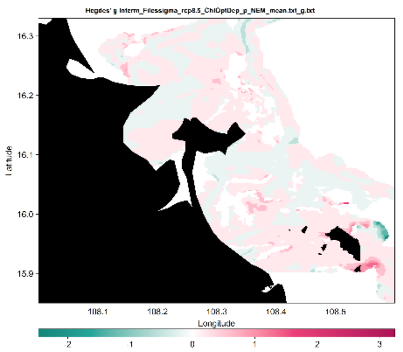

Figure 235: Mean euphotic zone total chlorophyll-a (mg m^{-2}) Hedge's g between 2011-2020 and 2040-2049 under RCP8.5 during the NEM. Green areas indicate where the variable will conform to expected long term climate trends, pink areas indicate the reverse

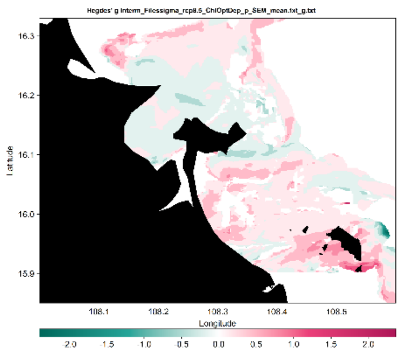

Figure 236: Mean euphotic zone total chlorophyll-a (mg m^{-2}) Hedge's g between 2011-2020 and 2040-2049 under RCP8.5 during the SWM. Green areas indicate where the variable will conform to expected long term climate trends, pink areas indicate the reverse

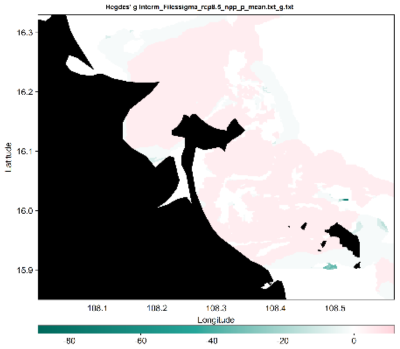

Figure 237: Net primary production (mg C m^{-2} day^{-1}) Hedge's g between 2011-2020 and 2040-2049 under RCP8.5. Green areas indicate where the variable will conform to expected long term climate trends, pink areas indicate the reverse

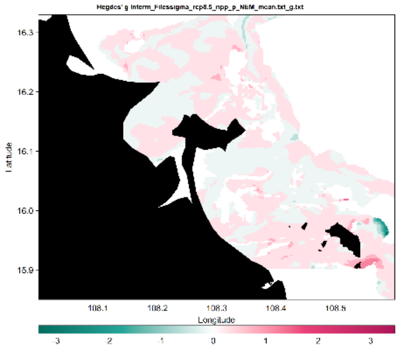

Figure 238: Net primary production (mg C m^{-2} day^{-1}) Hedge's g between 2011-2020 and 2040-2049 under RCP8.5 during the NEM. Green areas indicate where the variable will conform to expected long term climate trends, pink areas indicate the reverse

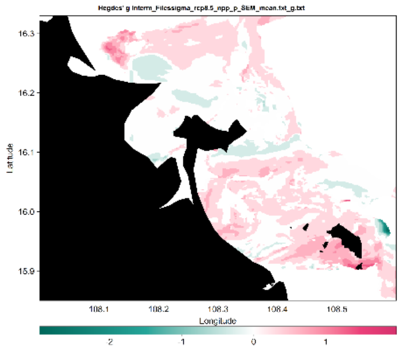

Figure 239: Net primary production(mg C m^{-2} day^{-1}) Hedge's g between 2011-2020 and 2040-2049 under RCP8.5 during the SWM. Green areas indicate where the variable will conform to expected long term climate trends, pink areas indicate the reverse

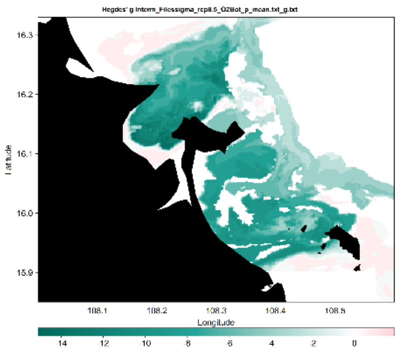

Figure 240: Bottom layer dissolved oxygen (mmol m^{-3}) Hedge's g between 2011-2020 and 2040-2049 under RCP8.5. Green areas indicate where the variable will conform to expected long term climate trends, pink areas indicate the reverse

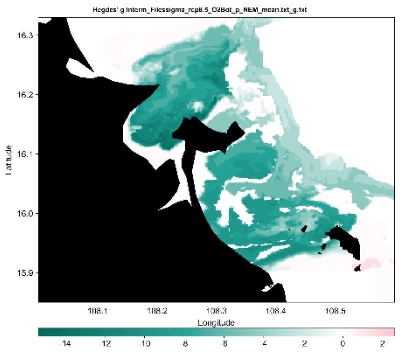

Figure 241: Bottom layer dissolved oxygen (mmol m^{-3}) Hedge's g between 2011-2020 and 2040-2049 under RCP8.5 during the NEM. Green areas indicate where the variable will conform to expected long term climate trends, pink areas indicate the reverse

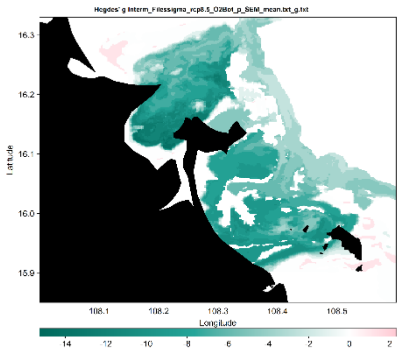

Figure 242: Bottom layer dissolved oxygen (mmol m^{-3}) Hedge's g between 2011-2020 and 2040-2049 under RCP8.5 during the SWM. Green areas indicate where the variable will conform to expected long term climate trends, pink areas indicate the reverse

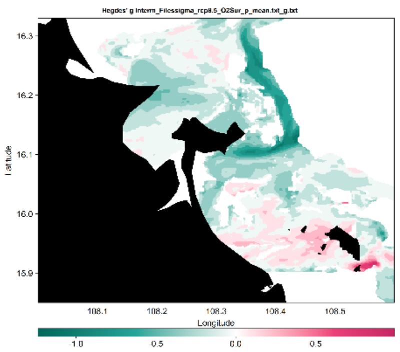

Figure 243: Surface dissolved oxygen (mmol m^{-3}) Hedge's g between 2011-2020 and 2040-2049 under RCP8.5. Green areas indicate where the variable will conform to expected long term climate trends, pink areas indicate the reverse

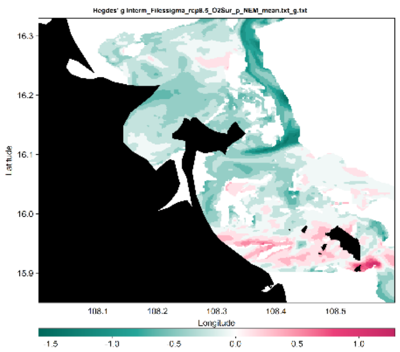

Figure 244: Surface dissolved oxygen (mmol m^{-3}) Hedge's g between 2011-2020 and 2040-2049 under RCP8.5 during the NEM. Green areas indicate where the variable will conform to expected long term climate trends, pink areas indicate the reverse

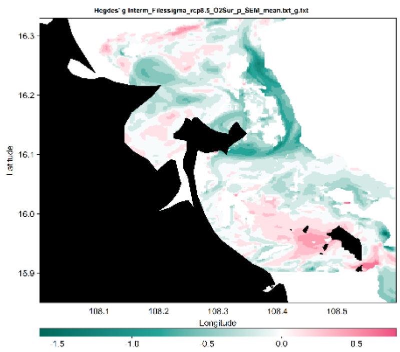

Figure 245: Surface dissolved oxygen (mmol m^{-3}) Hedge's g between 2011-2020 and 2040-2049 under RCP8.5 during the SWM. Green areas indicate where the variable will conform to expected long term climate trends, pink areas indicate the reverse

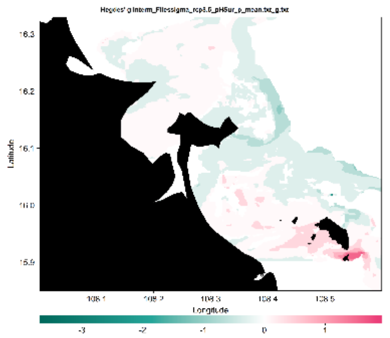

Figure 246: Surface pH Hedge’s g between 2011-2020 and 2040-2049 under RCP8.5. Green areas indicate where the variable will conform to expected long term climate trends, pink areas indicate the reverse

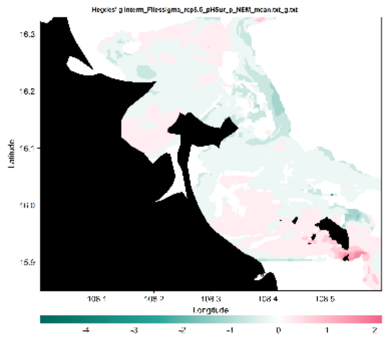

Figure 247: Surface pH Hedge’s g between 2011-2020 and 2040-2049 under RCP8.5 during the NEM. Green areas indicate where the variable will conform to expected long term climate trends, pink areas indicate the reverse

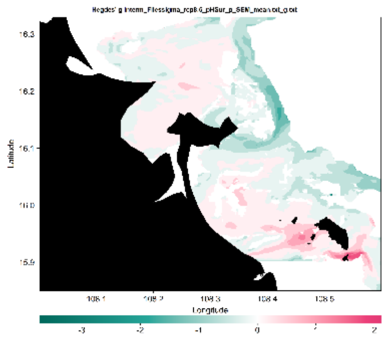

Figure 248: Surface pH Hedge’s g between 2011-2020 and 2040-2049 under RCP8.5 during the SWM. Green areas indicate where the variable will conform to expected long term climate trends, pink areas indicate the reverse

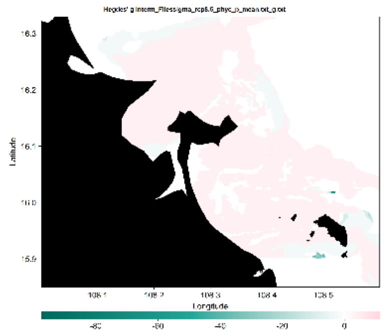

Figure 249: Phytoplankton carbon (mg C m^{-2}) Hedge’s g between 2011-2020 and 2040-2049 under RCP8.5. Green areas indicate where the variable will conform to expected long term climate trends, pink areas indicate the reverse

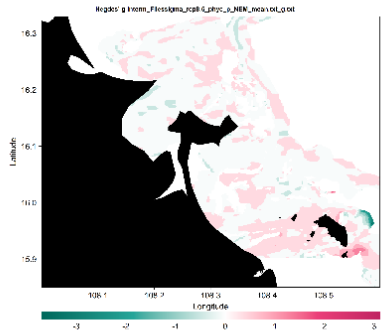

Figure 250: Phytoplankton carbon (mg C m^{-2}) Hedge’s g between 2011-2020 and 2040-2049 under RCP8.5 during the NEM. Green areas indicate where the variable will conform to expected long term climate trends, pink areas indicate the reverse

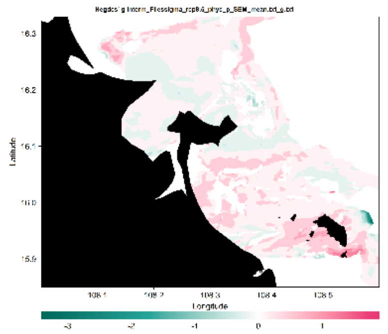

Figure 251: Phytoplankton carbon (mg C m^{-2}) Hedge’s g between 2011-2020 and 2040-2049 under RCP8.5 during the SWM. Green areas indicate where the variable will conform to expected long term climate trends, pink areas indicate the reverse

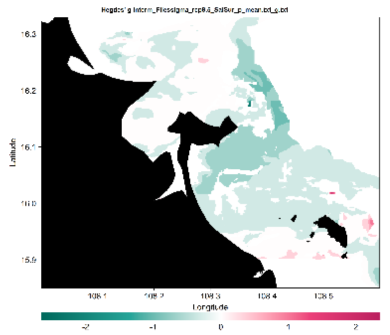

Figure 252: Surface salinity (psu) Hedge’s g between 2011-2020 and 2040-2049 under RCP8.5. Green areas indicate where the variable will conform to expected long term climate trends, pink areas indicate the reverse

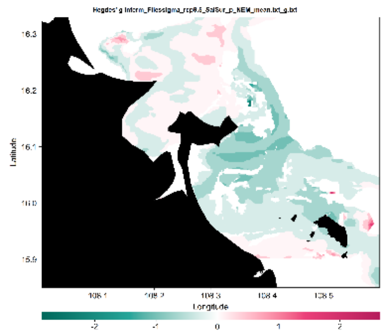

Figure 253: Surface salinity (psu) Hedge’s g between 2011-2020 and 2040-2049 under RCP8.5 during the NEM. Green areas indicate where the variable will conform to expected long term climate trends, pink areas indicate the reverse

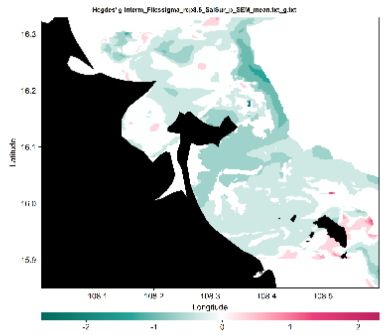

Figure 254: Surface salinity (psu) Hedge’s g between 2011-2020 and 2040-2049 under RCP8.5 during the SWM. Green areas indicate where the variable will conform to expected long term climate trends, pink areas indicate the reverse

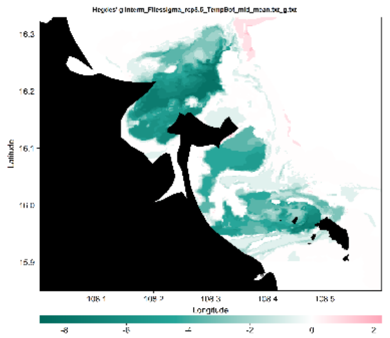

Figure 255: Bottom layer temperature (°C) Hedge’s g between 2011-2020 and 2040-2049 under RCP8.5. Green areas indicate where the variable will conform to expected long term climate trends, pink areas indicate the reverse

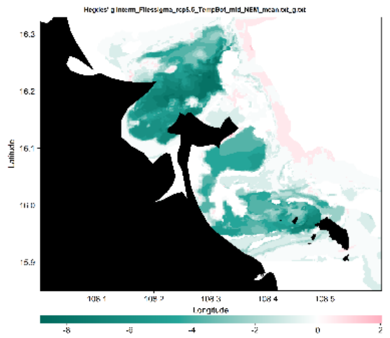

Figure 256: Bottom layer temperature (°C) Hedge’s g between 2011-2020 and 2040-2049 under RCP8.5 during the NEM. Green areas indicate where the variable will conform to expected long term climate trends, pink areas indicate the reverse

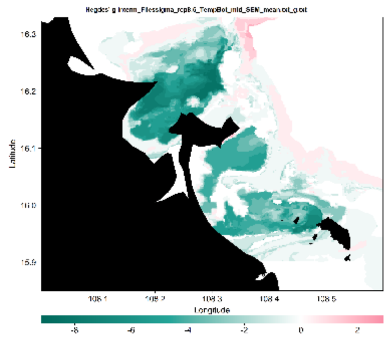

Figure 257: Bottom layer temperature (°C) Hedge’s g between 2011-2020 and 2040-2049 under RCP8.5 during the SWM. Green areas indicate where the variable will conform to expected long term climate trends, pink areas indicate the reverse

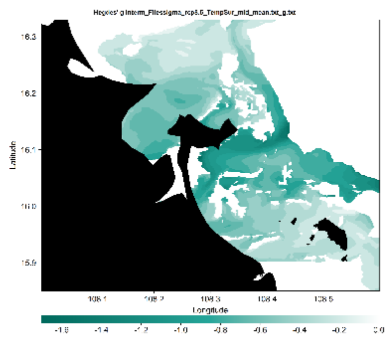

Figure 258: Surface temperature (°C) Hedge’s g between 2011-2020 and 2040-2049 under RCP8.5. Green areas indicate where the variable will conform to expected long term climate trends, pink areas indicate the reverse

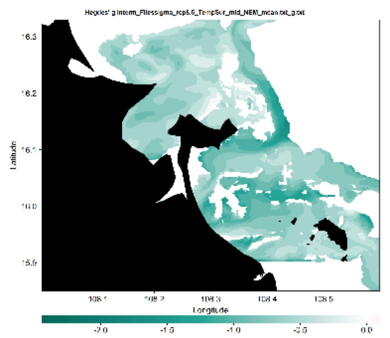

Figure 259: Surface temperature (°C) Hedge’s g between 2011-2020 and 2040-2049 under RCP8.5 during the NEM. Green areas indicate where the variable will conform to expected long term climate trends, pink areas indicate the reverse

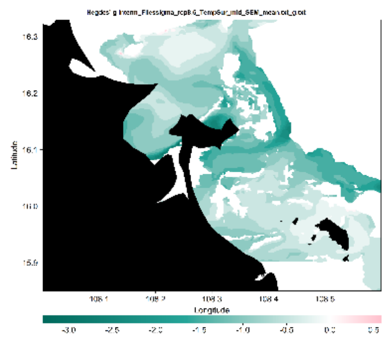

Figure 260: Surface temperature (°C) Hedge’s g between 2011-2020 and 2040-2049 under RCP8.5 during the SWM. Green areas indicate where the variable will conform to expected long term climate trends, pink areas indicate the reverse

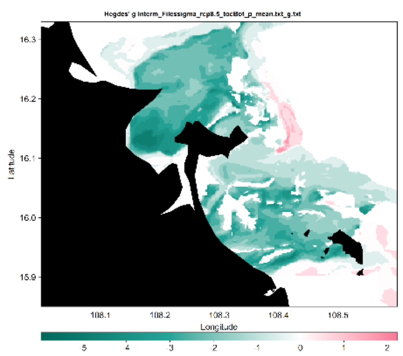

Figure 261: Bottom layer non-living organic carbon (mg C m^{-3}) Hedge’s g between 2011-2020 and 2040-2049 under RCP8.5. Green areas indicate where the variable will conform to expected long term climate trends, pink areas indicate the reverse

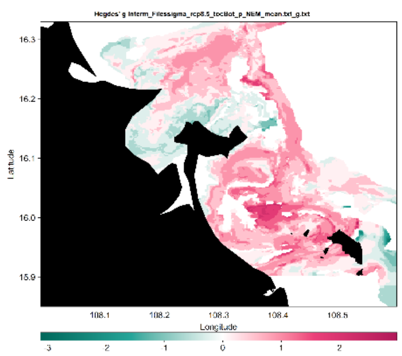

Figure 262: Bottom layer non-living organic carbon (mg C m^{-3}) Hedge’s g between 2011-2020 and 2040-2049 under RCP8.5 during the NEM. Green areas indicate where the variable will conform to expected long term climate trends, pink areas indicate the reverse

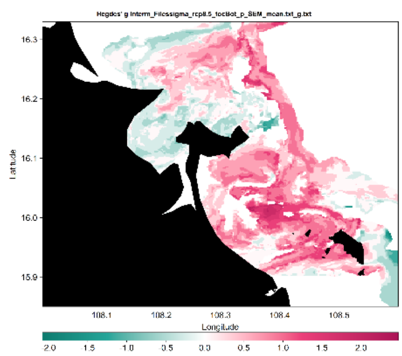

Figure 263: Bottom layer non-living organic carbon (mg C m^{-3}) Hedge’s g between 2011-2020 and 2040-2049 under RCP8.5 during the SWM. Green areas indicate where the variable will conform to expected long term climate trends, pink areas indicate the reverse

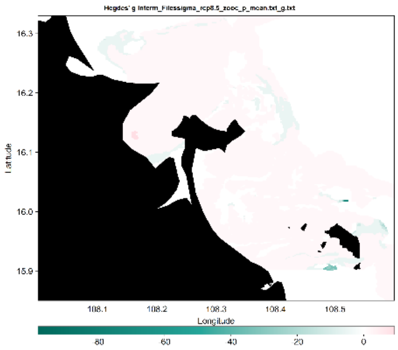

Figure 264: Zooplankton carbon (mg C m^{-2}) Hedge's g between 2011-2020 and 2040-2049 under RCP8.5. Green areas indicate where the variable will conform to expected long term climate trends, pink areas indicate the reverse

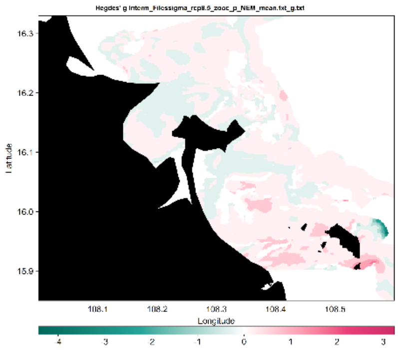

Figure 265: Zooplankton carbon (mg C m^{-2}) Hedge's g between 2011-2020 and 2040-2049 under RCP8.5 during the NEM. Green areas indicate where the variable will conform to expected long term climate trends, pink areas indicate the reverse

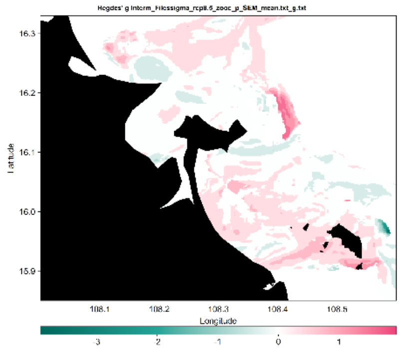

Figure 266: Zooplankton carbon (mg C m^{-2}) Hedge's g between 2011-2020 and 2040-2049 under RCP8.5 during the SWM. Green areas indicate where the variable will conform to expected long term climate trends, pink areas indicate the reverse

11. Changes to biogeochemical layers under RCP4.5 contrasting the present decade with the 2060s

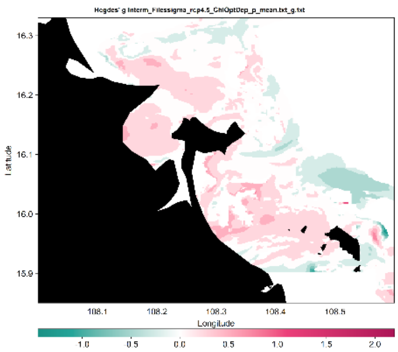

Figure 267: Mean euphotic zone total chlorophyll-a (mg m^{-2}) Hedge's g between 2011-2020 and 2060-2069 under RCP4.5. Green areas indicate where the variable will conform to expected long term climate trends, pink areas indicate the reverse.

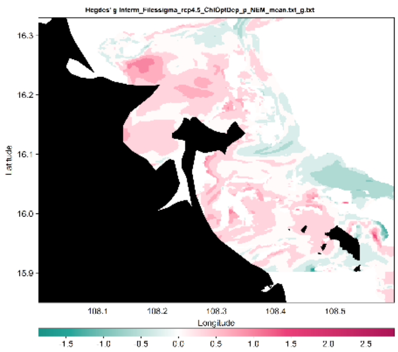

Figure 268: Mean euphotic zone total chlorophyll-a (mg m^{-2}) Hedge's g between 2011-2020 and 2060-2069 under RCP4.5 during the NEM. Green areas indicate where the variable will conform to expected long term climate trends, pink areas indicate the reverse

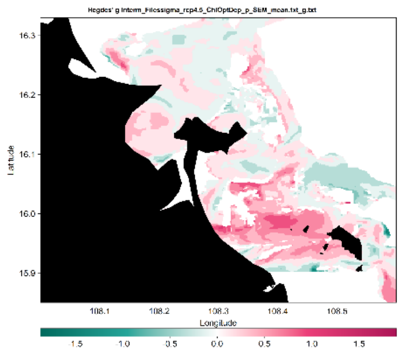

Figure 269: Mean euphotic zone total chlorophyll-a (mg m^{-2}) Hedge's g between 2011-2020 and 2060-2069 under RCP4.5 during the SWM. Green areas indicate where the variable will conform to expected long term climate trends, pink areas indicate the reverse

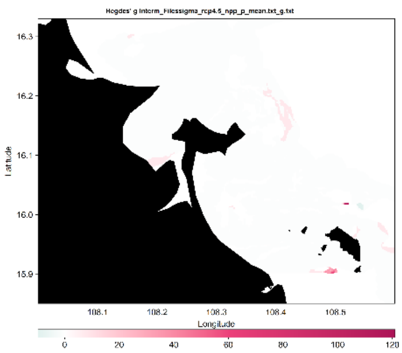

Figure 270: Net primary production (mg C m^{-2} day^{-1}) Hedge's g between 2011-2020 and 2060-2069 under RCP4.5. Green areas indicate where the variable will conform to expected long term climate trends, pink areas indicate the reverse

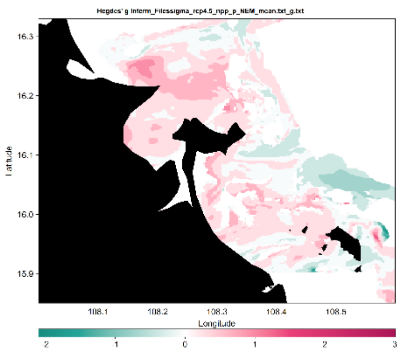

Figure 271: Net primary production (mg C m^{-2} day^{-1}) Hedge's g between 2011-2020 and 2060-2069 under RCP4.5 during the NEM. Green areas indicate where the variable will conform to expected long term climate trends, pink areas indicate the reverse

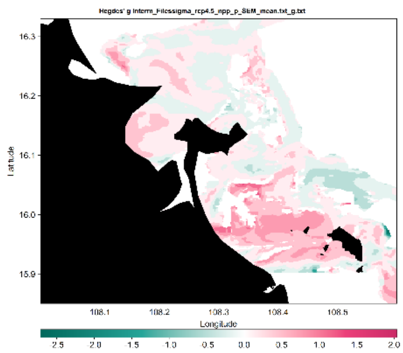

Figure 272: Net primary production (mg C m^{-2} day^{-1}) Hedge's g between 2011-2020 and 2060-2069 under RCP4.5 during the SWM. Green areas indicate where the variable will conform to expected long term climate trends, pink areas indicate the reverse

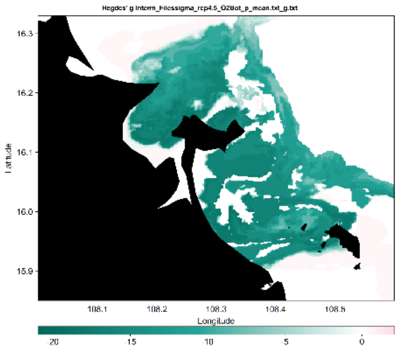

Figure 273: Bottom layer dissolved oxygen (mmol m^{-3}) Hedge's g between 2011-2020 and 2060-2069 under RCP4.5. Green areas indicate where the variable will conform to expected long term climate trends, pink areas indicate the reverse

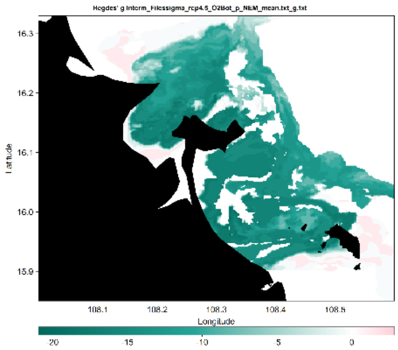

Figure 274: Bottom layer dissolved oxygen (mmol m^{-3}) Hedge's g between 2011-2020 and 2060-2069 under RCP4.5 during the NEM. Green areas indicate where the variable will conform to expected long term climate trends, pink areas indicate the reverse

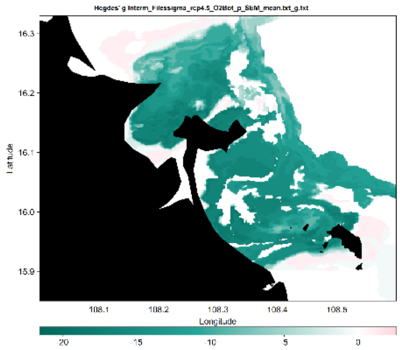

Figure 275: Bottom layer dissolved oxygen (mmol m^{-3}) Hedge's g between 2011-2020 and 2060-2069 under RCP4.5 during the SWM. Green areas indicate where the variable will conform to expected long term climate trends, pink areas indicate the reverse

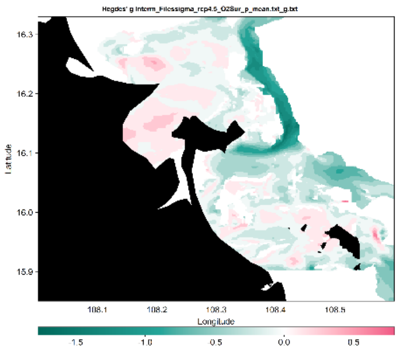

Figure 276: Surface dissolved oxygen (mmol m^{-3}) Hedge's g between 2011-2020 and 2060-2069 under RCP4.5. Green areas indicate where the variable will conform to expected long term climate trends, pink areas indicate the reverse

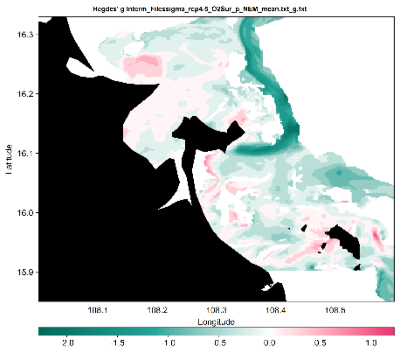

Figure 277: Surface dissolved oxygen (mmol m^{-3}) Hedge's g between 2011-2020 and 2060-2069 under RCP4.5 during the NEM. Green areas indicate where the variable will conform to expected long term climate trends, pink areas indicate the reverse

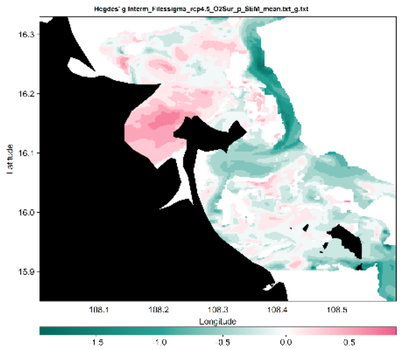

Figure 278: Surface dissolved oxygen (mmol m^{-3}) Hedge's g between 2011-2020 and 2060-2069 under RCP4.5 during the SWM. Green areas indicate where the variable will conform to expected long term climate trends, pink areas indicate the reverse

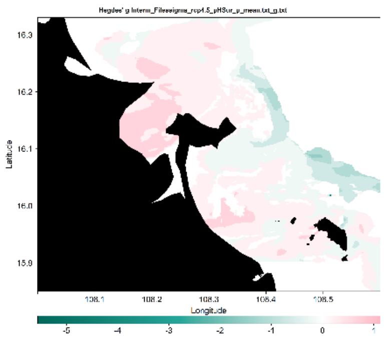

Figure 279: Surface pH Hedge's g between 2011-2020 and 2060-2069 under RCP4.5. Green areas indicate where the variable will conform to expected long term climate trends, pink areas indicate the reverse

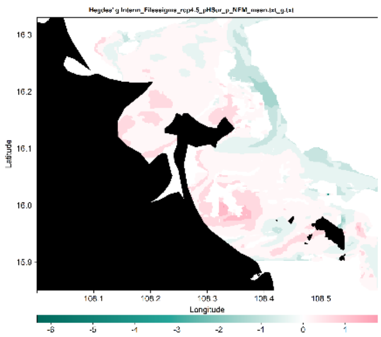

Figure 280: Surface pH Hedge's g between 2011-2020 and 2060-2069 under RCP4.5 during the NEM. Green areas indicate where the variable will conform to expected long term climate trends, pink areas indicate the reverse

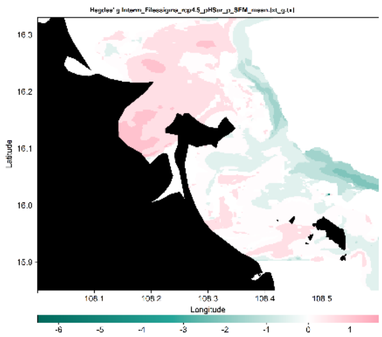

Figure 281: Surface pH Hedge's g between 2011-2020 and 2060-2069 under RCP4.5 during the SWM. Green areas indicate where the variable will conform to expected long term climate trends, pink areas indicate the reverse

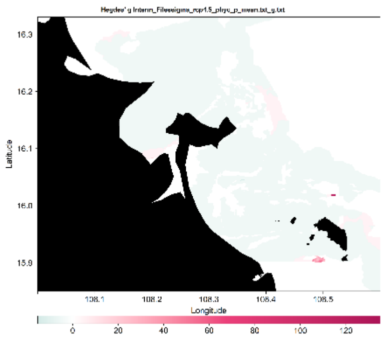

Figure 282: Phytoplankton carbon (mg C m^{-2}) Hedge's g between 2011-2020 and 2060-2069 under RCP4.5. Green areas indicate where the variable will conform to expected long term climate trends, pink areas indicate the reverse

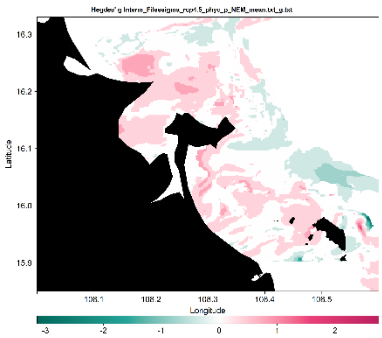

Figure 283: Phytoplankton carbon (mg C m^{-2}) Hedge's g between 2011-2020 and 2060-2069 under RCP4.5 during the NEM. Green areas indicate where the variable will conform to expected long term climate trends, pink areas indicate the reverse

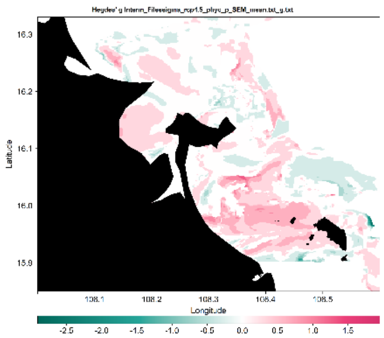

Figure 284: Phytoplankton carbon Hedge's g (mg C m^{-2}) between 2011-2020 and 2060-2069 under RCP4.5 during the SWM. Green areas indicate where the variable will conform to expected long term climate trends, pink areas indicate the reverse

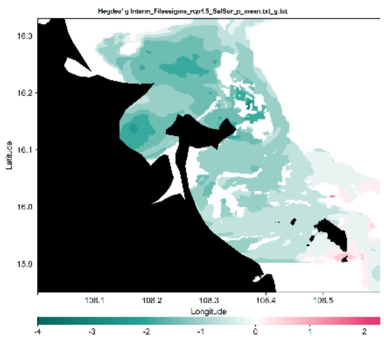

Figure 285: Surface salinity (psu) Hedge's g between 2011-2020 and 2060-2069 under RCP4.5. Green areas indicate where the variable will conform to expected long term climate trends, pink areas indicate the reverse

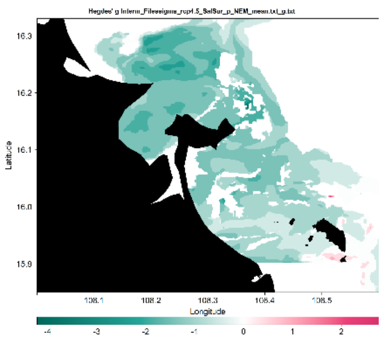

Figure 286: Surface salinity (psu) Hedge's g between 2011-2020 and 2060-2069 under RCP4.5 during the NEM. Green areas indicate where the variable will conform to expected long term climate trends, pink areas indicate the reverse

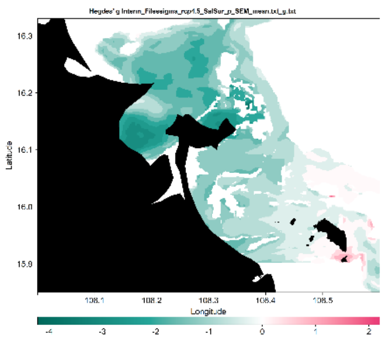

Figure 287: Surface salinity (psu) Hedge's g between 2011-2020 and 2060-2069 under RCP4.5 during the SWM. Green areas indicate where the variable will conform to expected long term climate trends, pink areas indicate the reverse

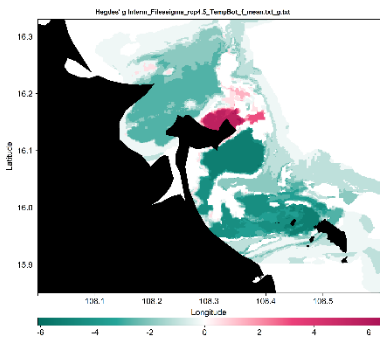

Figure 288: Bottom layer temperature (°C) Hedge's g between 2011-2020 and 2060-2069 under RCP4.5. Green areas indicate where the variable will conform to expected long term climate trends, pink areas indicate the reverse

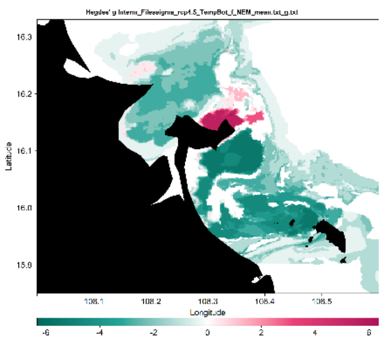

Figure 289: Bottom layer temperature (°C) Hedge's g between 2011-2020 and 2060-2069 under RCP4.5 during the NEM. Green areas indicate where the variable will conform to expected long term climate trends, pink areas indicate the reverse

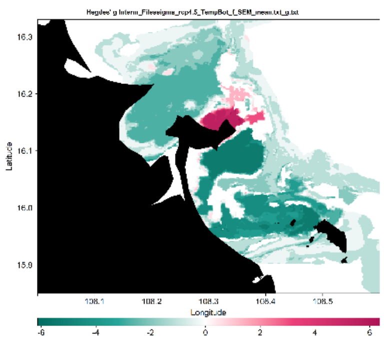

Figure 290: Bottom layer temperature (°C) Hedge's g between 2011-2020 and 2060-2069 under RCP4.5 during the SWM. Green areas indicate where the variable will conform to expected long term climate trends, pink areas indicate the reverse

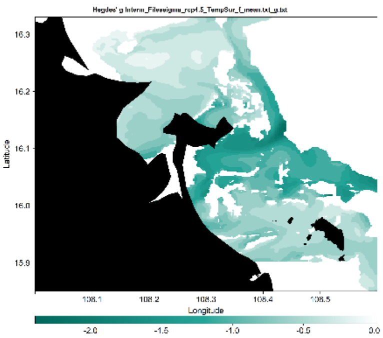

Figure 291: Surface temperature (°C) Hedge's g between 2011-2020 and 2060-2069 under RCP4.5. Green areas indicate where the variable will conform to expected long term climate trends, pink areas indicate the reverse

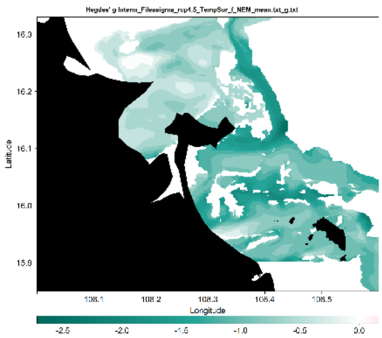

Figure 292: Surface temperature (°C) Hedge's g between 2011-2020 and 2060-2069 under RCP4.5 during the NEM. Green areas indicate where the variable will conform to expected long term climate trends, pink areas indicate the reverse

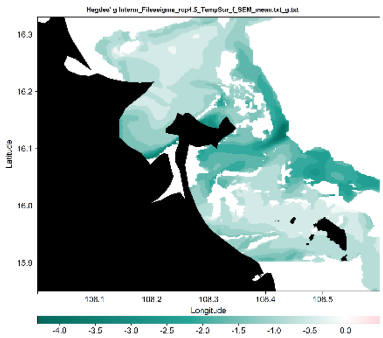

Figure 293: Surface temperature (°C) Hedge's g between 2011-2020 and 2060-2069 under RCP4.5 during the SWM. Green areas indicate where the variable will conform to expected long term climate trends, pink areas indicate the reverse

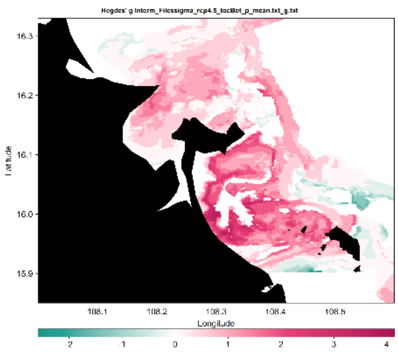

Figure 294: Bottom layer non-living organic carbon (mg C m^{-3}) Hedge's g between 2011-2020 and 2060-2069 under RCP4.5. Green areas indicate where the variable will conform to expected long term climate trends, pink areas indicate the reverse

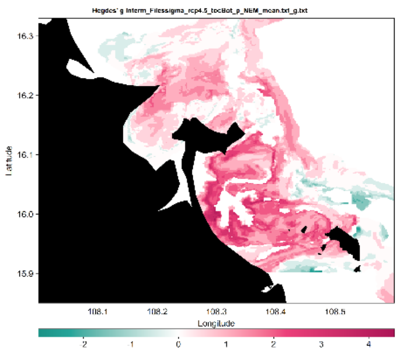

Figure 295: Bottom layer non-living organic carbon (mg C m^{-3}) Hedge's g between 2011-2020 and 2060-2069 under RCP4.5 during the NEM. Green areas indicate where the variable will conform to expected long term climate trends, pink areas indicate the reverse

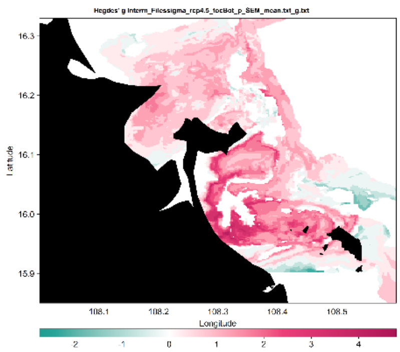

Figure 296: Bottom layer non-living organic carbon (mg C m^{-3}) Hedge's g between 2011-2020 and 2060-2069 under RCP4.5 during the SWM. Green areas indicate where the variable will conform to expected long term climate trends, pink areas indicate the reverse

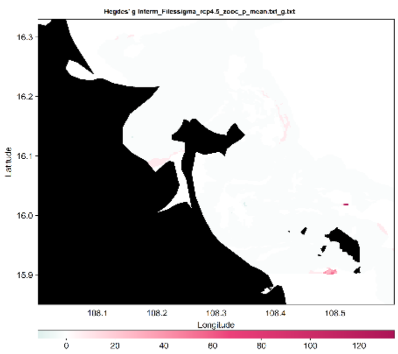

Figure 297: Zooplankton carbon (mg C m^{-2}) Hedge's g between 2011-2020 and 2060-2069 under RCP4.5. Green areas indicate where the variable will conform to expected long term climate trends, pink areas indicate the reverse

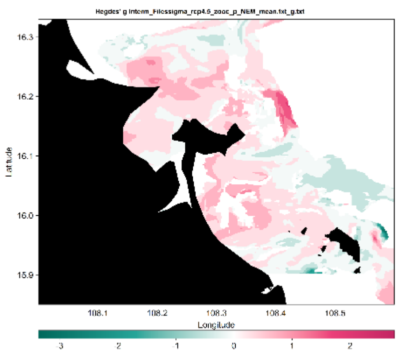

Figure 298: Zooplankton carbon (mg C m^{-2}) Hedge's g between 2011-2020 and 2060-2069 under RCP4.5 during the NEM. Green areas indicate where the variable will conform to expected long term climate trends, pink areas indicate the reverse

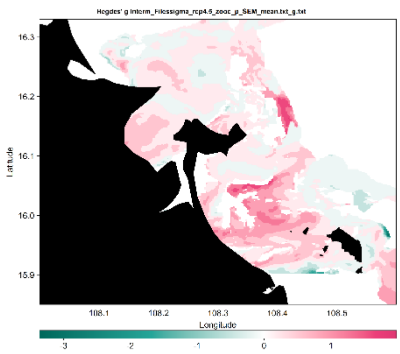

Figure 299: Zooplankton carbon (mg C m^{-2}) Hedge's g between 2011-2020 and 2060-2069 under RCP4.5 during the SWM. Green areas indicate where the variable will conform to expected long term climate trends, pink areas indicate the reverse

12. Changes to biogeochemical layers under RCP8.5 contrasting the present decade with the 2060s

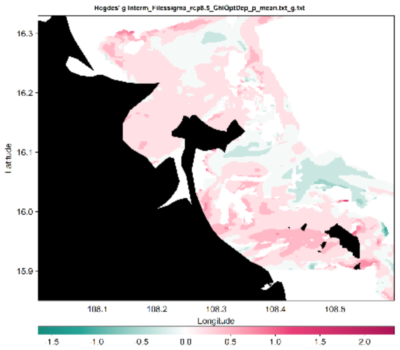

Figure 300: Mean euphotic zone total chlorophyll-a (mg m^{-2}) Hedge’s g between 2011-2020 and 2060-2069 under RCP8.5. Green areas indicate where the variable will conform to expected long term climate trends, pink areas indicate the reverse.

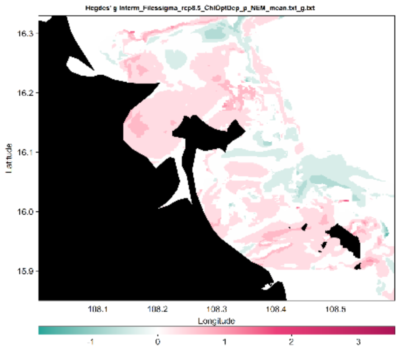

Figure 301: Mean euphotic zone total chlorophyll-a (mg m^{-2}) Hedge’s g between 2011-2020 and 2060-2069 under RCP8.5 during the NEM. Green areas indicate where the variable will conform to expected long term climate trends, pink areas indicate the reverse

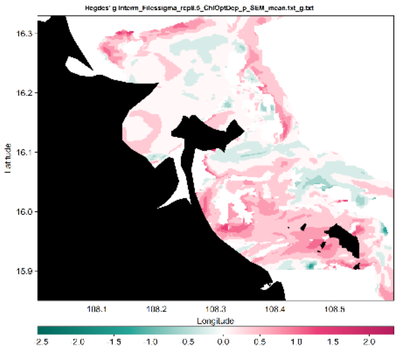

Figure 302: Mean euphotic zone total chlorophyll-a (mg m^{-2}) Hedge’s g between 2011-2020 and 2060-2069 under RCP8.5 during the SWM. Green areas indicate where the variable will conform to expected long term climate trends, pink areas indicate the reverse

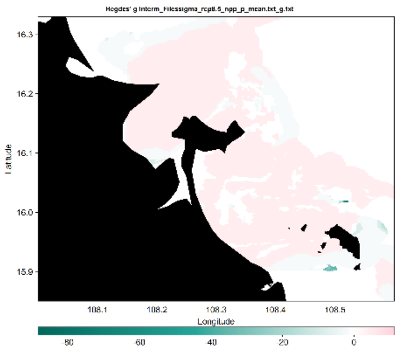

Figure 303: Net primary production (mg C m^{-2} day^{-1}) Hedge’s g between 2011-2020 and 2060-2069 under RCP8.5. Green areas indicate where the variable will conform to expected long term climate trends, pink areas indicate the reverse

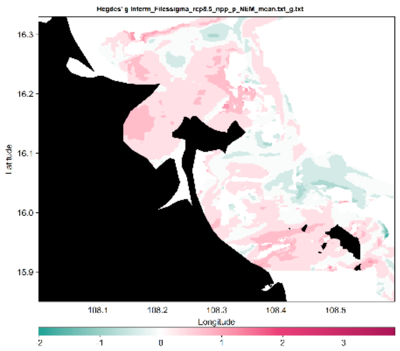

Figure 304: Net primary production (mg C m^{-2} day^{-1}) Hedge’s g between 2011-2020 and 2060-2069 under RCP8.5 during the NEM. Green areas indicate where the variable will conform to expected long term climate trends, pink areas indicate the reverse

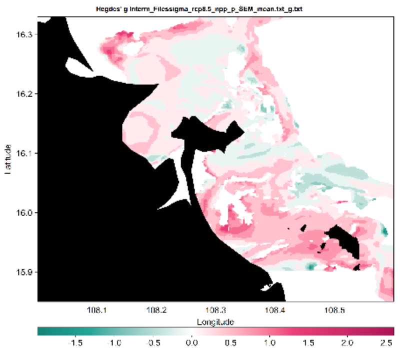

Figure 305: Net primary production(mg C m^{-2} day^{-1}) Hedge’s g between 2011-2020 and 2060-2069 under RCP8.5 during the SWM. Green areas indicate where the variable will conform to expected long term climate trends, pink areas indicate the reverse

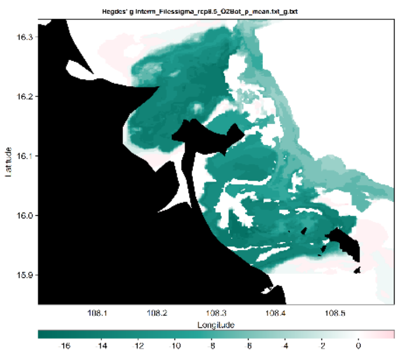

Figure 306: Bottom layer dissolved oxygen (mmol m^{-3}) Hedge’s g between 2011-2020 and 2060-2069 under RCP8.5. Green areas indicate where the variable will conform to expected long term climate trends, pink areas indicate the reverse

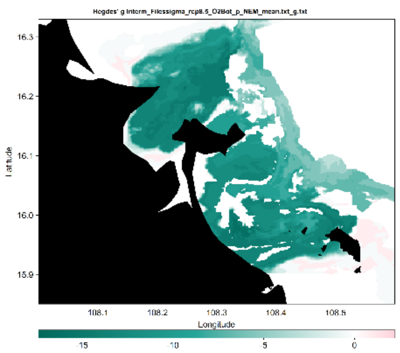

Figure 307: Bottom layer dissolved oxygen (mmol m^{-3}) Hedge’s g between 2011-2020 and 2060-2069 under RCP8.5 during the NEM. Green areas indicate where the variable will conform to expected long term climate trends, pink areas indicate the reverse

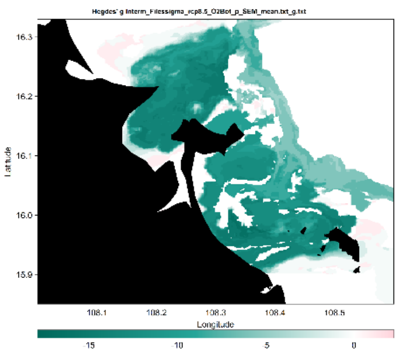

Figure 308: Bottom layer dissolved oxygen (mmol m^{-3}) Hedge’s g between 2011-2020 and 2060-2069 under RCP8.5 during the SWM. Green areas indicate where the variable will conform to expected long term climate trends, pink areas indicate the reverse

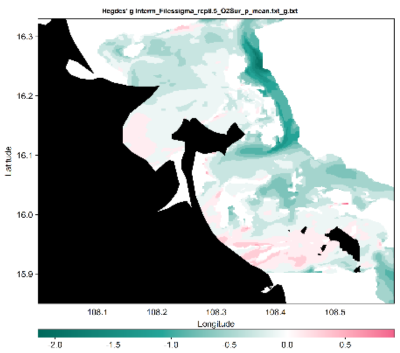

Figure 309: Surface dissolved oxygen (mmol m^{-3}) Hedge's g between 2011-2020 and 2060-2069 under RCP8.5. Green areas indicate where the variable will conform to expected long term climate trends, pink areas indicate the reverse

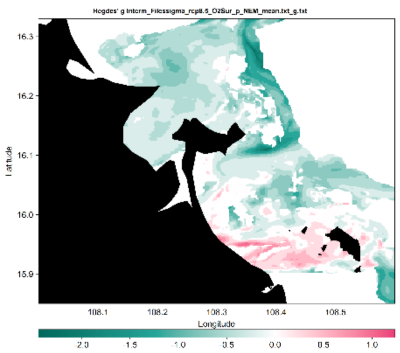

Figure 310: Surface dissolved oxygen (mmol m^{-3}) Hedge's g between 2011-2020 and 2060-2069 under RCP8.5 during the NEM. Green areas indicate where the variable will conform to expected long term climate trends, pink areas indicate the reverse

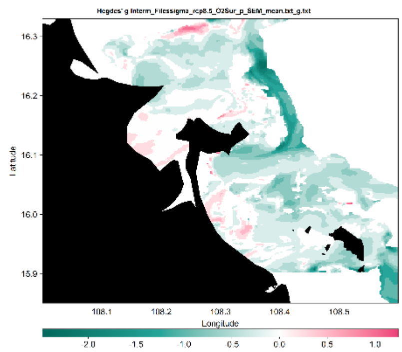

Figure 311: Surface dissolved oxygen (mmol m^{-3}) Hedge's g between 2011-2020 and 2060-2069 under RCP8.5 during the SWM. Green areas indicate where the variable will conform to expected long term climate trends, pink areas indicate the reverse

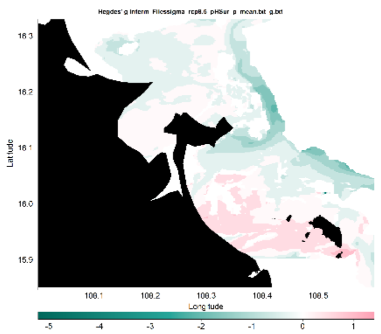

Figure 312: Surface pH Hedge's g between 2011-2020 and 2060-2069 under RCP8.5. Green areas indicate where the variable will conform to expected long term climate trends, pink areas indicate the reverse

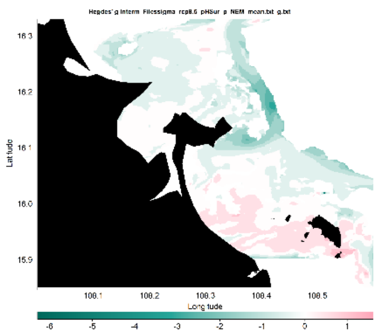

Figure 313: Surface pH Hedge's g between 2011-2020 and 2060-2069 under RCP8.5 during the NEM. Green areas indicate where the variable will conform to expected long term climate trends, pink areas indicate the reverse

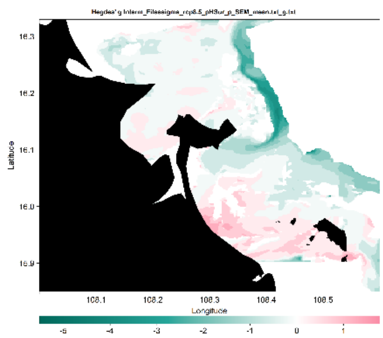

Figure 314: Surface pH Hedge's g between 2011-2020 and 2060-2069 under RCP8.5 during the SWM. Green areas indicate where the variable will conform to expected long term climate trends, pink areas indicate the reverse

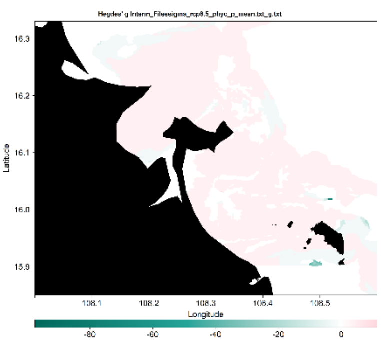

Figure 315: Phytoplankton carbon (mg C m^{-2}) Hedge's g between 2011-2020 and 2060-2069 under RCP8.5. Green areas indicate where the variable will conform to expected long term climate trends, pink areas indicate the reverse

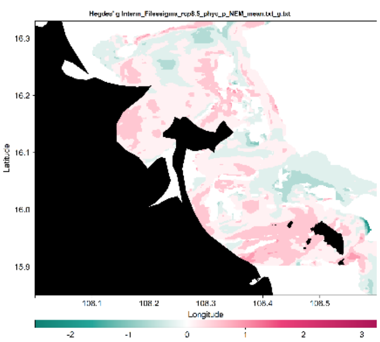

Figure 316: Phytoplankton carbon (mg C m^{-2}) Hedge's g between 2011-2020 and 2060-2069 under RCP8.5 during the NEM. Green areas indicate where the variable will conform to expected long term climate trends, pink areas indicate the reverse

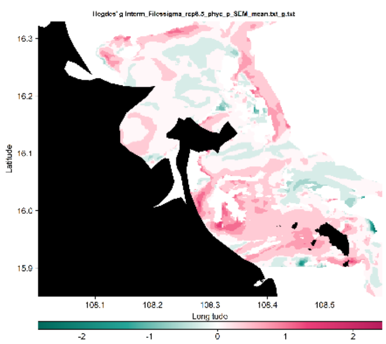

Figure 317: Phytoplankton carbon (mg C m^{-2}) Hedge's g between 2011-2020 and 2060-2069 under RCP8.5 during the SWM. Green areas indicate where the variable will conform to expected long term climate trends, pink areas indicate the reverse

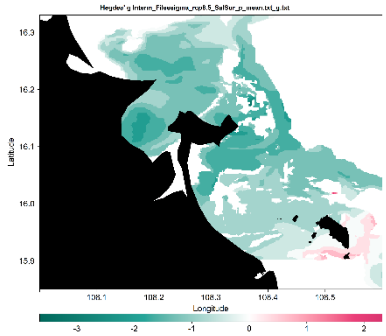

Figure 318: Surface salinity (psu) Hedge's g between 2011-2020 and 2060-2069 under RCP8.5. Green areas indicate where the variable will conform to expected long term climate trends, pink areas indicate the reverse

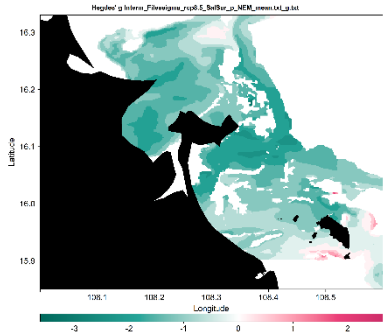

Figure 319: Surface salinity (psu) Hedge's g between 2011-2020 and 2060-2069 under RCP8.5 during the NEM. Green areas indicate where the variable will conform to expected long term climate trends, pink areas indicate the reverse

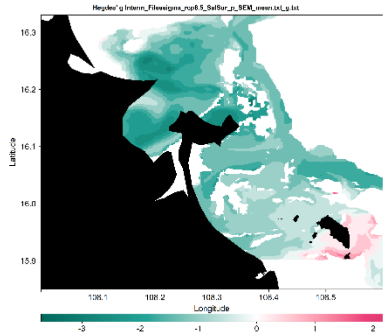

Figure 320: Surface salinity (psu) Hedge's g between 2011-2020 and 2060-2069 under RCP8.5 during the SWM. Green areas indicate where the variable will conform to expected long term climate trends, pink areas indicate the reverse

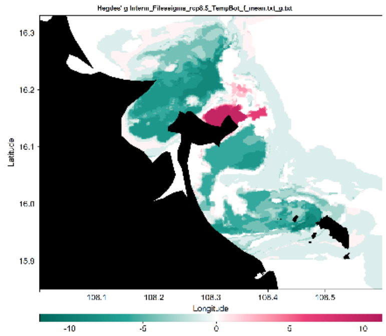

Figure 321: Bottom layer temperature (°C) Hedge's g between 2011-2020 and 2060-2069 under RCP8.5. Green areas indicate where the variable will conform to expected long term climate trends, pink areas indicate the reverse

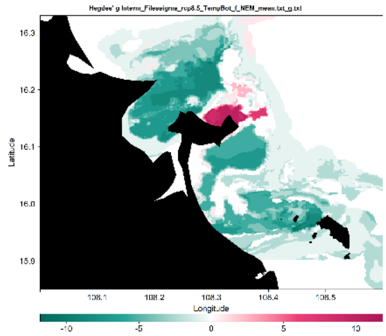

Figure 322: Bottom layer temperature (°C) Hedge's g between 2011-2020 and 2060-2069 under RCP8.5 during the NEM. Green areas indicate where the variable will conform to expected long term climate trends, pink areas indicate the reverse

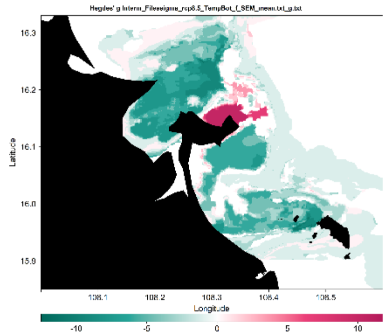

Figure 323: Bottom layer temperature (°C) Hedge's g between 2011-2020 and 2060-2069 under RCP8.5 during the SWM. Green areas indicate where the variable will conform to expected long term climate trends, pink areas indicate the reverse

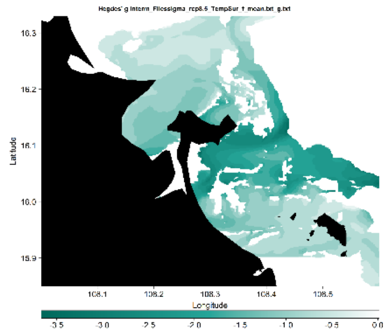

Figure 324: Surface temperature (°C) Hedge's g between 2011-2020 and 2060-2069 under RCP8.5. Green areas indicate where the variable will conform to expected long term climate trends, pink areas indicate the reverse

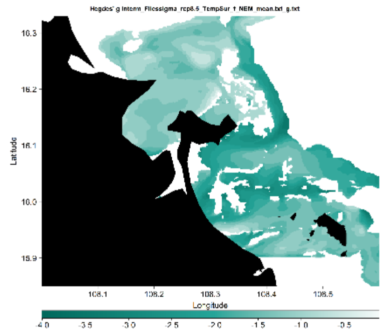

Figure 325: Surface temperature (°C) Hedge's g between 2011-2020 and 2060-2069 under RCP8.5 during the NEM. Green areas indicate where the variable will conform to expected long term climate trends, pink areas indicate the reverse

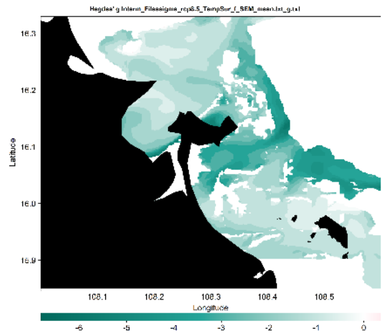

Figure 326: Surface temperature (°C) Hedge's g between 2011-2020 and 2060-2069 under RCP8.5 during the SWM. Green areas indicate where the variable will conform to expected long term climate trends, pink areas indicate the reverse

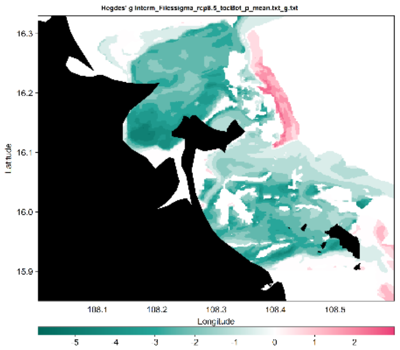

Figure 327: Bottom layer non-living organic carbon (mg C m^{-3}) Hedge’s g between 2011-2020 and 2060-2069 under RCP8.5. Green areas indicate where the variable will conform to expected long term climate trends, pink areas indicate the reverse

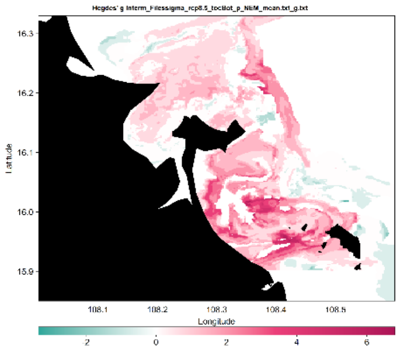

Figure 328: Bottom layer non-living organic carbon (mg C m^{-3}) Hedge’s g between 2011-2020 and 2060-2069 under RCP8.5 during the NEM. Green areas indicate where the variable will conform to expected long term climate trends, pink areas indicate the reverse

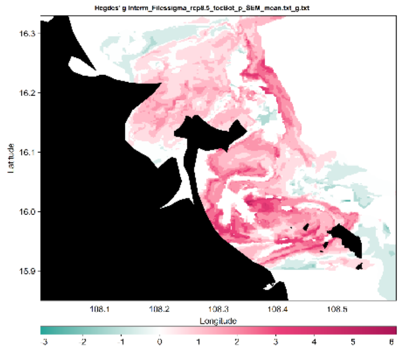

Figure 329: Bottom layer non-living organic carbon (mg C m^{-3}) Hedge’s g between 2011-2020 and 2060-2069 under RCP8.5 during the SWM. Green areas indicate where the variable will conform to expected long term climate trends, pink areas indicate the reverse

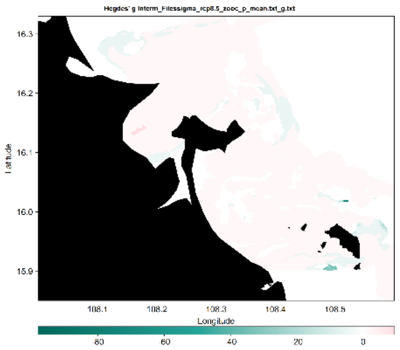

Figure 330: Zooplankton carbon (mg C m^{-2}) Hedge’s g between 2011-2020 and 2060-2069 under RCP8.5. Green areas indicate where the variable will conform to expected long term climate trends, pink areas indicate the reverse

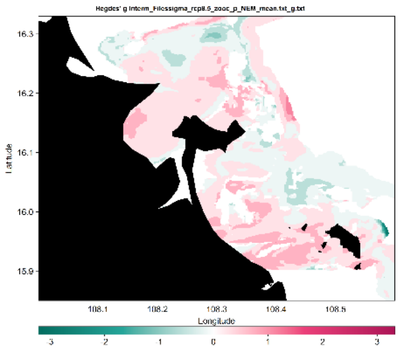

Figure 331: Zooplankton carbon (mg C m^{-2}) Hedge’s g between 2011-2020 and 2060-2069 under RCP8.5 during the NEM. Green areas indicate where the variable will conform to expected long term climate trends, pink areas indicate the reverse

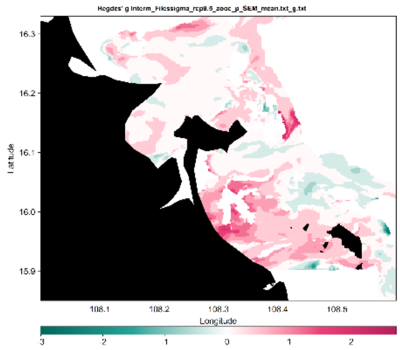

Figure 332: Zooplankton carbon (mg C m^{-2}) Hedge’s g between 2011-2020 and 2060-2069 under RCP8.5 during the SWM. Green areas indicate where the variable will conform to expected long term climate trends, pink areas indicate the reverse

13. Wider view of summary effect plots for the fishing analysis comparing the present decade to the 2040s

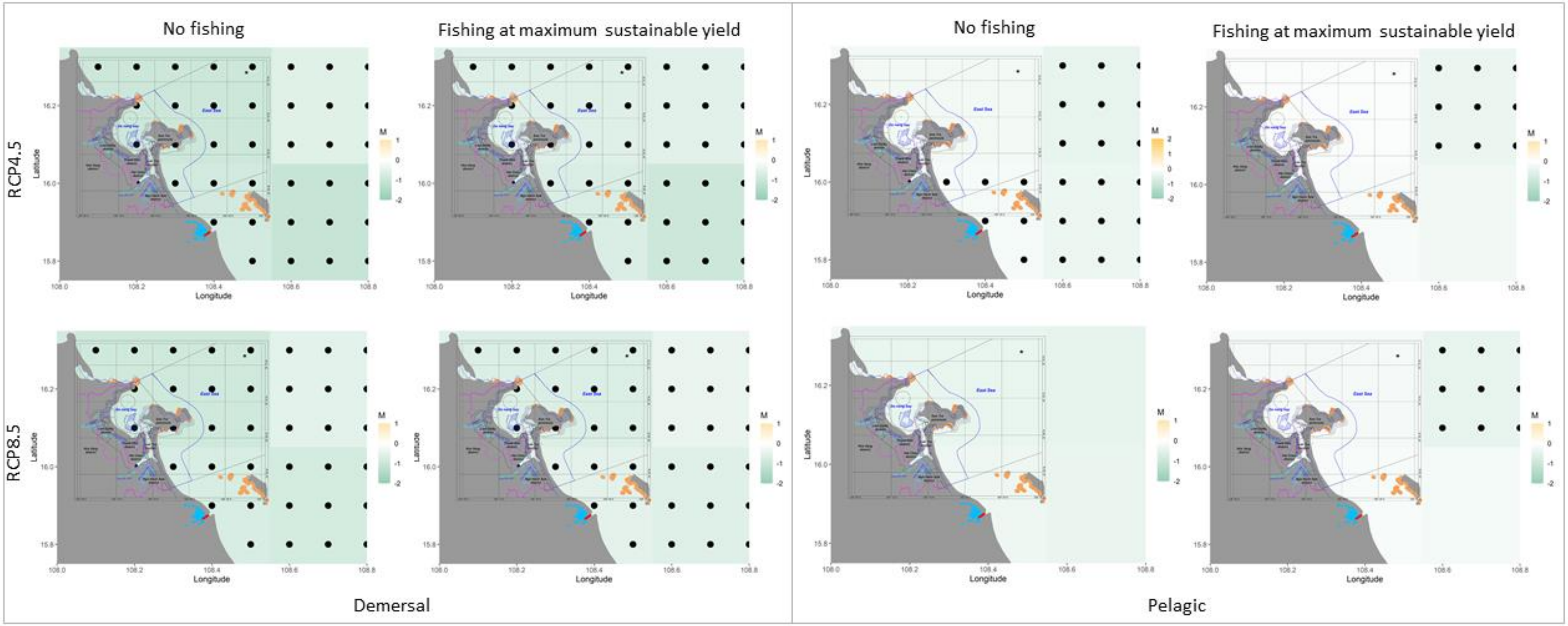

Figure 333: Climate modelling analysis results (i.e. spatial meta-analysis) for the fishing sector, comparing the present decade with the 2040s. The CUZP for Da Nang city is overlain (please see main report section 3.2). The background color ("M") indicates whether a climate trend emerges in the fish species community underpinning these fishing sector in the region. Green areas indicate the emergence of a climate trend, and this is significant where black dots overlay green (i.e. climate change hotspots). Yellow is a trend contrary to the long-term climate change trend, specific to the period of analysis, indicating improved habitat conditions. Orange are coral habitats; red are mangroves; and blue are seagrass beds. Please see the Methods (section 2) in the main report and Queirós, Talbot et al. 2021 for a detailed description of the statistical analysis framework employed.

14. Wider view of summary effect plots for the fishing analysis comparing the present decade to the 2060s

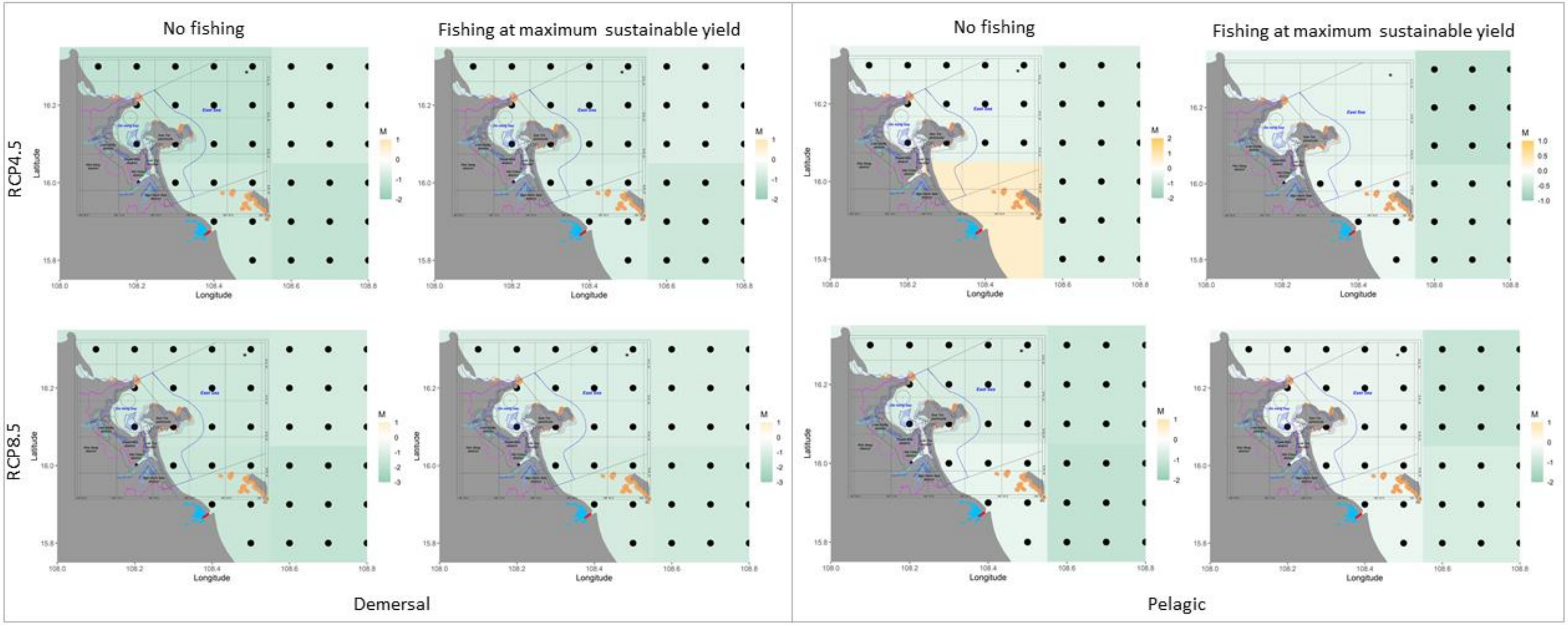

Figure 334: Climate modelling analysis results (i.e. spatial meta-analysis) for the fishing sector, comparing the present decade with the 2060s. The CUZP for Da Nang city is overlain (please see main report section 3.3). The background color ("M") indicates whether a climate trend emerges in the fish species community underpinning these fishing sector in the region. Green areas indicate the emergence of a climate trend, and this is significant where black dots overlay green (i.e. climate change hotspots). Yellow is a trend contrary to the long-term climate change trend, specific to the period of analysis, indicating improved habitat conditions. Orange are coral habitats; red are mangroves; and blue are seagrass beds. Please see the Methods (section 2) in the main report and Queirós, Talbot et al. 2021 for a detailed description of the statistical analysis framework employed.