

Methods

Characterising the socioecological landscape of MPAs

We used the library of MPAs curated by UN-WCMC and IUCN to retrieve geographic information (location and polygons) about 17,200 MPAs catalogued in the WDPA version 1.6¹. This data was also used to determine the IUCN category for each MPA, which includes seven categories describing the primary management objectives and associated level of protection (Table 1). It is important to note that such categories need to be interpreted more as a management target rather than a real exclusion of activities.

We also obtained the recorded size (km²) of each MPA and whether fishing was excluded (fully or partially). The latter information was missing for 15,273 MPAs, therefore those variables were not included in the models presented below. All variables used in the subsequent analyses are summarised in Table 2. Most MPAs (n=12,591 and n=15,455) were established before 2009 and 2014 respectively. Overall, the time horizon available for vulnerability assessment and hazard estimation (2012 – 2021; see Table 2) provides an appropriate overview of existing conservation risks. Also, hazard presence was therefore estimated when the vast majority of the MPAs were already designated.

Table 1. Summary table of IUCN protection categories, including definition, management objective and human activities permitted. Extracted from Day et al., 2019².

IUCN Category	Definition	Primary Objective	Permitted Activities	Forbidden Activities
Strict Nature Reserve (Ia)	Strictly protected areas for biodiversity and geodiversity; minimal human impact; reference sites for research.	Conserve outstanding ecosystems and features mostly formed by non-human forces; avoid degradation from human activity.	Minimal-impact scientific research; necessary collection if not possible elsewhere; invasive species control (in some cases).	Extraction or collection of resources (e.g., fishing, dredging); anchoring (unless using mooring buoys); activities degrading conservation values.
Wilderness Area (Ib)	Large, unmodified or slightly modified areas with no permanent human presence; preserve natural condition.	Preserve long-term ecological integrity; allow natural processes to dominate.	Same as Ia; sustainable use by indigenous peoples for traditional/cultural purposes.	Same as Ia; all extractive uses incompatible (e.g., fishing, dredging).
National Park (II)	Large natural or near-natural areas protecting ecosystems and processes; supports compatible recreation and education.	Protect biodiversity and natural processes while promoting education and recreation.	Same as Ib; non-extractive recreation (e.g., diving, boating); research not possible elsewhere.	All extractive use (e.g., fishing), except limited research; incompatible with conservation goals.
Natural Monument (III)	Protect specific natural features (e.g., caves, seamounts); often small with high visitor value.	Conserve unique natural features and associated habitats.	Same as II.	All extractive use (e.g., fishing); any activity impacting the monument (e.g., aquaculture, waste discharge, habitation).
Habitat/Species Management Area (IV)	Protect specific species or habitats; may require active management and interventions.	Maintain, conserve, and restore targeted species and habitats.	Extractive research; renewable energy; restoration projects; sustainable local fishing; small-scale aquaculture; compatible infrastructure (e.g., ports, dredging).	Industrial fishing; industrial aquaculture; untreated waste discharge; mining; habitation.
Protected Landscape/Seascape (V)	Areas shaped by long-term human-nature interaction with high ecological, cultural, scenic value.	Sustain natural and cultural values through traditional human interaction.	Sustainable local use by communities; small-scale fishing/aquaculture; compatible infrastructure if non-damaging.	Industrial fishing/aquaculture; untreated waste discharge; mining.
Sustainable Use Area (VI)	Large natural areas combining ecosystem protection with sustainable resource use and cultural values.	Conserve ecosystems and allow sustainable natural resource use.	Sustainable local fishing; small-scale aquaculture; limited species collection (e.g., food, coral); compatible infrastructure (e.g., ports).	Industrial fishing/aquaculture; untreated waste discharge; mining; habitation.

Vulnerability profile

The level of vulnerability in each MPA was measured based on the number of species present and the total number of threats to which these species are vulnerable. We used AquaMaps³ to determine the probability of occurrence in each MPA of all marine species assessed on the IUCN Red List⁴ (n=21,734). The potential occurrence of each species was obtained by all 0.5 x 0.5 degree grid cells covering their native range, while a single species was considered to be present within a given cell if its probability of occurrence was greater than 0.5³. A total 10709 species had available occurrence data from AquaMaps, with their occurrence in MPAs inferred from the *raquamaps* package in R⁵. For each of those species, we retrieved their identified conservation threats from the IUCN Red List version 2022.1, using threat level 2 categories (n = 45 categories). Hence, we obtained a vulnerability profile for each MPA.

Hazard profile

We estimated the hazard profile in each MPA as the total amount of hazards derived from the present human activities, also called pressures in some disciplines. We focused on key maritime sectors (e.g. fisheries, aquaculture, shipping, tourism) and coastal pressures attributed to habitat modification (e.g. coastal urbanisation, nutrient input) combining unique sets of remotely sensed global variables (Table 2).

We qualified the coastal human environment of MPAs with the Global human settlement data (GHS-SMOD 2015⁶). We added a 1-km buffer to the MPAs to capture their coastline⁷, if existing, and counted the number of 1-km² SMOD grid cell of each type (city, town, semi-dense town, suburbs, village, rural area, uninhabited and water). From those grid cells we derived a variable reflecting the proportion of the MPA covered in urbanised (city + town + semi-dense town + suburbs) and rural landscape (village + rural). We supplemented the SMOD data with satellite imagery estimate of cropland presence in the buffered MPAs⁸ to infer the extent (in km²) of cropland present, based on 2019 estimates, at a resolution of 0.00025 degrees.

Shipping intensity was estimated using global AIS data collated by the International Monetary Fund (IMF) from January 2015 to February 2021 at a resolution of 0.005 degrees⁹. We summed the number of traffic hours within each MPA for the whole period for different vessel categories (commercial, fishing, leisure, oil and gas, and passenger). Then, we estimated fishing effort by gear type in the MPAs using Global Fishing Watch data (version 2.0¹⁰) at 0.01 degrees resolution, obtaining the apparent number of fishing hours per each gear type between 2012 and 2020, as well as for only 2019.

As a measure of tourism intensity, we used the number of photos taken in the MPA and posted on Flickr⁷ during 2010 to 2019, and for 2019 only. For each MPA we estimated the total number of photos, as well as the number of days when unique photographers posted photos (i.e. *user.days*). Nutrient input to MPAs, using nitrogen in 2015 as a proxy, was derived using the global effluent model produced from total sewage effluent in grams of N at a resolution of 0.00833 degrees¹¹.

Finally, we estimated aquaculture production in MPAs using a global estimate of aquaculture production in 2017 (in tonnes produced annually per 0.083 degree cells) for each aquaculture category (bivalve, crustaceans, salmon, other marine fish, shrimp, and tuna)¹².

The different hazards are measured in different units. Hence, we needed to define a suitable approach to compare them within and across MPAs. In this case, our main challenge was that

MPAs cover widely differing areas and are not necessarily representative of the ambient oceanic areas when it comes to human footprint. At the same time, assuming that MPAs are managed, we anticipate that human activities posing threats to the biodiversity will be controlled, and that this will counteract the effect of MPAs extension on hazard intensity. Given these factors, we used the spatial delineations of MPAs as a representative sample of human activities in combination with a rank orders approach¹³, a commonly used method to compare different threats in impact assessment. Then, for each hazard, we defined an empirical cumulative distribution function based on the 17,200 observed values (one per MPA), obtaining the position of that hazard relative to the whole distribution of its values among all MPAs. This rank was used as a hazard level proxy, so we assigned a value of zero to all MPAs where the given hazard was absent. Subsequently, we ranked only non-zero values using percentiles (Eq. 1); ending up with 11 percentiles: from 0 (absent) to 10 (highest level).

$$rk(\mathbf{H}_{t,i}) = \begin{cases} percentile(eCDF(\mathbf{H}_t)), & \text{if } \mathbf{H}_{t,i} \neq 0 \\ 0, & \text{if } \mathbf{H}_{t,i} = 0 \end{cases} \quad [\text{eq. 1}]$$

Here, rank (rk) of a hazard t for a given MPA (i) is estimated from the empirical cumulative distribution (eCDF) of the hazard.

Biodiversity conservation risk

The biodiversity conservation risk (hereafter risk) in each MPA was defined as its degree of exposure to the hazards to which their species are vulnerable. Therefore, once the corresponding vulnerability and hazard profiles were identified for each MPA, we estimated the associated risk as the product between such profiles. As we could not measure all hazards that cause conservation threats, or some emerge from pervasive human activities that cannot be regionally appraised, this impact could only be measured for a subset of conservation threats (14 IUCN Red List threat level 2 categories excluding fisheries and aquaculture related threats). However, the unique human activity dataset we compiled provides coverage for almost all level 1 conservation threats, if not level 2 (Table 2).

Additionally, to consider the presence of relevant fishing activities in the risk assessment, we identified the specific fishing gear (either through intentional or unintentional catches) for all species threatened by fishing (i.e. ‘biological resource use’ category). We performed an automated search of fishing method keywords (see Table 3) in the text of the species-specific IUCN threat assessment narrative. Then, this information complemented the previous human activities/hazard dataset with risk estimates for aquaculture-related threats disaggregated to the production type (six aquaculture variables) and risk estimates for fisheries which accounted for the sensitivity of species to gear type (nine fisheries variables). These additional aquaculture and fisheries hazards were also ranked, treated as described above (see Table 2).

We estimated the risk for a given MPA as the product of its hazard rank and the number of species for which such hazard was identified as a conservation threat. This resulted in a risk matrix containing 29 variables.

$$\mathbf{R}_{t,i} = rk(\mathbf{H}_{t,i}) \times \mathbf{V}_{t,i} \quad [\text{eq. 2}]$$

Dimension reduction of hazard, vulnerability, and risk spaces

We estimated a matrix for each of the dimensionally reduced spaces: **V** (vulnerability matrix, composed of the count of species vulnerable to 45 conservation threats (t) for 17,200 MPAs), **H** (hazard matrix composed of 31 hazard (h) variable estimates for 17,200 MPAs), and **R** (risk matrix, composed of the risk rank of 17,200 MPAs for 29 threats (t) for which we had both species assessment and hazard estimates).

Here we present two measures for each of these spaces: richness and complexity. Richness was estimated as the count of total conservation threats (t) (out of 45) to which any species present in the MPA are vulnerable (vulnerability, Eq. 3), the count of hazards (out of 31) (Eq. 5), and the sum of the species-weighted rank for risk for those three components (risk, Eq. 7). Complexity was estimated as the Shannon entropy (H') of the variable distributions (Eqs. 4,6,8).

These metrics allowed to get a comparable measure of these three socioecological components across different species richness gradients (e.g. latitudinal, coastal...) that may be present between MPAs. Hence, hazard and risk richness were not related to the number of species assessed in each MPA ($\rho_{\text{hazard}} = 0.02$, $\rho_{\text{risk}} = 0.10$), while the relation between vulnerability richness and species count was non-linear and asymptotic as the number of species in the MPA increased above 100 ($\rho_{\text{vulnerability}} = 0.47$).

$$\text{Richness}_{\text{vulnerability},i} = \sum_{t \in [1,45]} B(\mathbf{V}_{t,i} \neq 0) \quad [\text{eq. 3}]$$

$$H'_{\text{vulnerability},i} = - \sum_{t \in [1,45]} \frac{\mathbf{V}_{t,i}}{s_i} \log_2 \frac{\mathbf{V}_{t,i}}{s_i} \quad [\text{eq. 4}]$$

$$\text{Richness}_{\text{hazard},i} = \sum_{h \in [1,31]} B(\mathbf{H}_{h,i} \neq 0) \quad [\text{eq. 5}]$$

$$H'_{\text{hazard},i} = - \sum_{r \in [0,10]} \frac{|\text{rk}(\mathbf{H}_{h,i})_r|}{\sum_r |\text{rk}(\mathbf{H}_{h,i})_r|} \log_2 \frac{|\text{rk}(\mathbf{H}_{h,i})_r|}{\sum_r |\text{rk}(\mathbf{H}_{h,i})_r|} \quad [\text{eq. 6}]$$

$$\text{Richness}_{\text{risk},i} = \sum_{t \in [1,29]} B(\mathbf{R}_{t,i} \neq 0) \quad [\text{eq. 7}]$$

$$H'_{\text{risk},i} = - \sum_{t \in [1,29]} \frac{\mathbf{R}_{t,i}}{s_i} \log_2 \frac{\mathbf{R}_{t,i}}{s_i} \quad [\text{eq. 8}]$$

B represents a Boolean expression ($B \in \{0; 1\}$). Hazard entropy is based on rank (rk) estimated as percentile bins ($rk \in \mathbb{Z} \cap [0,10]$) within a hazard (h) and the count of hazard percentiles, r , for a MPA ($|\text{rk}(\mathbf{H}_{h,i})_r|$). These measures were estimated for each MPA (i) based on the count of species ($\mathbf{V}_{h,i}$) vulnerable to a particular conservation threat (t) in a particular MPA (i) given the total number of species estimated present in the MPA (s_i).

In addition, we estimated the intensity of hazards and risk. Hazard intensity is the mean rank (rk) of each hazard from its eCDF but estimated among all hazards and MPAs. Essentially, higher the value of hazard intensity is, the higher is the exposure of that MPA to all hazards compared to other MPAs. Risk intensity shows the mean rank of MPA's risk value for a certain threat t , compared to its corresponding empirical distribution among all risks and MPAs. Therefore, higher risk intensity values indicate that the MPA ranks high compared to other MPAs' in biodiversity conservation risk, on average for all possible threats.

Provision of Ecosystem services

We estimated fishing target for each fishing target for each fishing gear and location from the global fishing effort data which includes targeted functional groups and fishing gear provided by

IMAS¹⁴ censored for years contemporary to the other datasets (Table 2). We related each MPA to the Fishing Country Code (SAUP) to which it belongs geographically. For each MPA we then determined whether a species functional group was present and if so whether a fishing gear present target that functional group. Functional groups were then related to ISSCAAP groups and the proportion of species from each ISSCAAP group present in the MPA fished by the fishing gear was used to represent the contribution of ecosystem services to the fishing gear.

For tourism the ecosystem service provision is estimated using the mean aesthetic value of the ISSCAAP group (ranging between 0 and 1), with a value of 1 being inferred for all charismatic megafauna and the aesthetic value estimated for fishes (Table 2). For each MPA the contribution to recreational activities is then the mean for each group based on species presence.

Species-Activities network construction

We replicated the process described in the previous section (defining the number of species present in the MPA out of each ISSCAAP group) to define conservation threat exposure. In this case we used our original species x threat matrix, assessed whether the threat was present or not based on activities observed and simply found the proportion of species affected by the activities for each ISSCAAP group for each MPA. This threat matrix (orange edges in the network) was then combined with the ecosystem service provision matrix (blue edges in the networks).

Data

Table 2. Description of all variables used in the analyses, including their sources (all public).

variable	definition
mpa	the unique identifier (WDPA_PID from the UNEP-WCMC database) for the mpa
species.count	the number of species that have been assessed on the IUCN Red List for which we have a native range prediction on Aquamaps. the probabilistic native range is binarised (p_presence>0.5 becomes present). the count represents the number of species for which at least on aquampa cell intersects the mpa
area	the calculated area of the MPA (m2)
entropy	the Shannon entropy of IUCN Red List human threats represented by the assessed species present in the mpa. estimated on the tabulated count of threats based on the threat list for each species present
lat	the latitude of the MPA centroid
mainentropy	as entropy but estimated at the main threat level (1-12)
subentropy	as entropy but estimated at the sub-threat level (1.1 etc)
nthreat	the number of unique threats that assessed species face in this MPA
nmainthreat	the number of unique main threats that assessed species face in this MPA
nsubthreat	the number of unique sub-threats that assessed species face in this MPA
nFisheriesthreat	the number of assessed species which has fisheries described as a threat in their threat narrative (including gear type, and threat type)

pFisheriesthreat	nFisheriesthreat/species.count
PA_DEF	from WDPA
NAME	name of the mpa from WDPA
DESIG	from WDPA, described nature of the designation status
DESIG_ENG	from WDPA, categorised DESIG
DESIG_TYPE	from WDPA, governance scale of the designation institution
IUCN_CAT	from WDPA, IUCN Criteria for MPA
GIS_M_AREA	from WDPA: reported area of the MPA
NO_TAKE	from WDPA: is the MPA a no take zone (not reported, none, all, partial)
NO_TK_AREA	from WDPA, area covered by no take designation
STATUS	from WDPA, current status of the MPA: Designated, Proposed, Adopted, Inscribed, Established, Not Reported
STATUS_YR	from WDPA, when this status was designated
GOV_TYPE	from WDPA, who governs the MPA: Federal or national ministry or agency, Sub-national ministry or agency, Government-delegated management, Not Reported, Collaborative governance, Non-profit organisations, Indigenous peoples, Joint governance, Local communities, Individual landowners, For-profit organisations
OWN_TYPE	from WDPA, who owns the MPA: State, Not Reported, Multiple ownership, Individual landowners, Communal, Joint ownership, Non-profit organisations, For-profit organisations
MANG_AUTH	from WDPA, management authority: detailed, 1155 levels (including country-specific agencies)
MANG_PLAN	from WDPA, is a management plan in place: not reported or the url to the plan
MARINE	from WDPA, marine system included in the MPA: 0 (no marine component), 1 (partial marine component), 2 (fully marine)
PARENT_ISO	from WDPA, ISO code of the country in which the MPA is located
CONS_OBJ	from WDPA, are conservation objectives set: Not Applicable, Not Reported, Primary, Secondary
calc.area	replicate of area
smod.count	number of SMOD grid cells (1km ²) intersecting the MPA - 1-km buffered - , Global human settlement layer from JRC, 1km resolution, Mollweide projection, GHS-SMOD (GHS_SMOD_POP2015_GLOBE_R2019A_54009_1K_V2_0)
smod.city	number of SMOD grid cells intersecting the MPA classified as city
smod.town	number of SMOD grid cells intersecting the MPA classified as town
smod.semiDenseTown	number of SMOD grid cells intersecting the MPA classified as semi dense town
smod.suburbs	number of SMOD grid cells intersecting the MPA classified as suburbs
smod.village	number of SMOD grid cells intersecting the MPA classified as villages
smod.rural	number of SMOD grid cells intersecting the MPA classified as rural area
smod.uninhabited	number of SMOD grid cells intersecting the MPA classified as uninhabited
smod.water	number of SMOD grid cells intersecting the MPA classified as water
AIS.commercial	hours of shipping done by vessels categorised as commercial vessels which has taken place in the MPA from Jan-2015 to Feb-2021. data

	from IMF's World Seaborne Trade Monitoring System (Cerdeiro, Komaromi, Liu and Saeed, 2020), aggregated to 0.005 by 0.005 degrees grid cells
AIS.fishing	hours of shipping done by vessels categorised as fishing vessels which has taken place in the MPA from Jan-2015 to Feb-2021. (note this include vessels fishing and vessels steaming)
AIS.global	hours of shipping done by all vessels carrying AIS and with AIS turned on which has taken place in the MPA from Jan-2015 to Feb-2021.
AIS.leisure	hours of shipping done by vessels categorised as leisure vessels which has taken place in the MPA from Jan-2015 to Feb-2021.
AIS.oilgas	hours of shipping done by vessels associated with OGP and OGE which has taken place in the MPA from Jan-2015 to Feb-2021.
AIS.passenger	hours of shipping done by vessels categorised as passenger ships which has taken place in the MPA from Jan-2015 to Feb-2021.
cropland.2019	the number of grid cells in the cropland data intersecting the MPA - 1-km buffered -, data from https://glad.umd.edu/dataset/croplands 0.00025 x 0.00025 grid cells classified in 2019 as cropland
lon	the longitude of the MPA centroid
cropland.2019.area.km2	the area (km2) of the MPA - 1-km buffered - covered by cropland as defined from satellite imagery
fish.aesthetics.max	the maximum aesthetics value predicted for the fish species present in the MPA (assumed present given native range from aquamaps) for which aesthetics values were estimated by Langlois et al 2022 PLoS Biology (journal.pbio.3001640.s004)
fish.aesthetics.mean	the mean aesthetics value predicted for the fish species present in the MPA (assumed present given native range from aquamaps) for which aesthetics values were estimated by Langlois et al 2022 PLoS Biology (journal.pbio.3001640.s004)
fish.aesthetics.sd	the standard deviation of the aesthetics values predicted for the fish species present in the MPA (assumed present given native range from aquamaps) for which aesthetics values were estimated by Langlois et al 2022 PLoS Biology (journal.pbio.3001640.s004)
fish.aesthetics.count	the number of fish species present in the MPA (assumed present given native range from aquamaps) for which aesthetics value were estimated by Langlois et al 2022 PLoS Biology (journal.pbio.3001640.s004)
trawlers_2012_2020	the apparent number of hours of trawler fishing that took place in the MPA from 2012 to 2020. data disaggregated by year is available in an additional data list (mpa.fish). data from the GlobalFishWatch based on estimated fishing hours for trawling vessels aggregated to 1/100th x 1/100th degree grid cells. the MPA total fishing hours is the sum of the fishing hours in the grid cells intersecting the MPA where partially intersecting grid cells contributions to the sum are weighted by the area of the cell contained in the MPA. data from GlobalFishingWatch version 2
tuna_purse_seines_2012_2020	the apparent number of hours of tuna purse seine fishing that took place in the MPA from 2012 to 2020.
fishing_2012_2020	the apparent number of hours of uncategorised fishing that took place in the MPA from 2012 to 2020. here fishing is not the sum of all gear types.

purse_seines_2012_2020	the apparent number of hours of purse seine fishing that took place in the MPA from 2012 to 2020.
drifting_longlines_2012_2020	the apparent number of hours of drifting longline fishing that took place in the MPA from 2012 to 2020.
set_longlines_2012_2020	the apparent number of hours of set longline fishing that took place in the MPA from 2012 to 2020.
squid_jigger_2012_2020	the apparent number of hours of squid jigging fishing that took place in the MPA from 2012 to 2020.
set_gillnets_2012_2020	the apparent number of hours of set gillnet fishing that took place in the MPA from 2012 to 2020. caution here as the 'fishing effort' estimate is vessel based and not gear based. this provides ore an indication of how often fixed gear was set in the MPA (still a useful piece of information)
pots_and_traps_2012_2020	the apparent number of hours of pot and traps fishing that took place in the MPA from 2012 to 2020. caution here as the 'fishing effort' estimate is vessel based and not gear based. this provides ore an indication of how often fixed gear was set in the MPA (still a useful piece of information)
trollers_2012_2020	the apparent number of hours of troller fishing that took place in the MPA from 2012 to 2020.
dredge_fishing_2012_2020	the apparent number of hours of dredge fishing that took place in the MPA from 2012 to 2020.
pole_and_line_2012_2020	the apparent number of hours of pole and line fishing that took place in the MPA from 2012 to 2020.
other_seines_2012_2020	the apparent number of hours of other seine fishing that took place in the MPA from 2012 to 2020.
seiners_2012_2020	the apparent number of hours of seine fishing that took place in the MPA from 2012 to 2020.
other_purse_seines_2012_2020	the apparent number of hours of other purse seine fishing that took place in the MPA from 2012 to 2020.
trawlers_2019	as above for 2019 alone
tuna_purse_seines_2019	as above for 2019 alone
fishing_2019	as above for 2019 alone
purse_seines_2019	as above for 2019 alone
drifting_longlines_2019	as above for 2019 alone
set_longlines_2019	as above for 2019 alone
squid_jigger_2019	as above for 2019 alone
set_gillnets_2019	as above for 2019 alone
pots_and_traps_2019	as above for 2019 alone
trollers_2019	as above for 2019 alone
dredge_fishing_2019	as above for 2019 alone
pole_and_line_2019	as above for 2019 alone
other_seines_2019	as above for 2019 alone
seiners_2019	as above for 2019 alone
other_purse_seines_2019	as above for 2019 alone
Flickr_userdays_2010_2019	number of days unique users spent posting photographs taken in the MPA from 2010 to 2019 on Flickr. data from Erskine et al. 2020 One Earth ###missing Flickr data for new mpas which are not in Erskine et

	al. were sampled using the same protocol. all mpas informed by Flickr data
Flickr_userdays_2019	number of days unique users spent posting photographs taken in the MPA in 2019 on Flickr. data from Erskine et al. 2020 One Earth. yearly data is available in another data frame.
Flickr_user_2010_2019	number of unique users posting photographs taken in the MPA from 2010 to 2019 on Flickr. data from Erskine et al. 2020 One Earth
Flickr_user_2019	number of unique users posting photographs taken in the MPA in 2019 on Flickr. data from Erskine et al. 2020 One Earth. yearly data is available in another data frame.
Flickr_photo_2010_2019	number of unique photographs posted on Flickr taken in the MPA from 2010 to 2019 . data from Erskine et al. 2020 One Earth
Flickr_photo_2019	number of unique photographs posted on Flickr taken in the MPA in 2019 on Flickr. data from Erskine et al. 2020 One Earth. yearly data is available in another data frame.
total_N_effluent_2015	predicted total sewage effluent in grams of N reported in (from KNB) Tuholske et al. 2021 PLoS ONE (grams of N) resolution 0.00833 x 0.00833 degrees. prediction based on plume model on terrestrial (including coastal) effluents
bivalve_production	predicted bivalve aquaculture production in 2017 in tonnes in the MPA #predicted mariculture Reported at a resolution of 0.083 x 0.083 degrees (5 arc minutes) Clawson et al. (2022) Aquaculture downloaded from KNB #crustaceans_production predicted crustacean aquaculture production in 2017 in tonnes in the MPA #predicted mariculture Reported at a resolution of 0.083 x 0.083 degrees (5 arc minutes) Clawson et al. (2022) Aquaculture downloaded from KNB
marine_fish_general_production	predicted marine fish aquaculture production in 2017 in tonnes in the MPA #predicted mariculture Reported at a resolution of 0.083 x 0.083 degrees (5 arc minutes) Clawson et al. (2022) Aquaculture downloaded from KNB
salmon_production	predicted salmon aquaculture production in 2017 in tonnes in the MPA #predicted mariculture Reported at a resolution of 0.083 x 0.083 degrees (5 arc minutes) Clawson et al. (2022) Aquaculture downloaded from KNB
shrimp_production	predicted shrimp aquaculture production in 2017 in tonnes in the MPA #predicted mariculture Reported at a resolution of 0.083 x 0.083 degrees (5 arc minutes) Clawson et al. (2022) Aquaculture downloaded from KNB
tuna_production	predicted tuna aquaculture production in 2017 in tonnes in the MPA #predicted mariculture Reported at a resolution of 0.083 x 0.083 degrees (5 arc minutes) Clawson et al. (2022) Aquaculture downloaded from KNB
ISO3	reported ISO 3166-1 code for the MPA location (use with caution as key regions have not reported their geographical ISO3166-1)
SUB_LOC	reported ISO 3166-2 code for the MPA location (use with caution as key regions have not reported their geographical ISO3166-2)

Table 3. Additional search keyword for fishing gear-specific threat assessment in the IUCN Red List Conservation assessment narrative for each species threatened by ‘biological resource use’

Threat	Gear keyword
"bycatch" "incidental" "unintentional" "entanglement"	"seine" "trawl" "gillnet" "longline" "pole and line" "jigger" "trap" "pot" "dredge" "line" "net"

References

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