## Supplemental material

Supplemental Table 1: Activity types and primary activities with the number of identified impact chains in each aquatic domain as well as the total number of impact chains; FW=fresh water, CW=coastal water, MW=marine water

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Activity Type | Activity | FW | CW | MW | Biota | Total |
| Agriculture & Forestry | Agriculture (crops and livestock) | 401 | 209 | 43 | 280 | 933 |
| Forestry | 171 | 133 | 12 | 134 | 450 |
| Aquaculture | Ex-situ aquaculture | 62 | 58 |   | 61 | 181 |
| In-situ aquaculture | 88 | 279 | 48 | 144 | 559 |
| Environmental Management | Alteration of water levels | 15 |   |   | 10 | 25 |
| Artificial reefs |  | 34 | 9 | 37 | 80 |
| Beach replenishment |  | 106 | 12 | 20 | 138 |
| Culverting lagoons | 8 | 190 |  | 51 | 249 |
| Dredging (including captial and maintenance, and extraction and disposal of substrate) | 125 | 226 | 49 | 143 | 543 |
| Flood and coastal defence - Artificial Structures: including levees, dykes, embankments, sea walls/breakwaters/groynes | 210 | 258 | 6 | 166 | 640 |
| Flood and coastal protection - natural water retention and restoration | 198 |  |  | 118 | 316 |
| Land claim and conversion (including construction and operation) | 328 | 161 | 2 | 211 | 702 |
| Species control | 31 |  |  | 23 | 54 |
| Stocking and moving fish for conservation (including related ex situ aquaculture) | 21 |  |  | 19 | 40 |
| Transversal instream structures - (Weirs, culverts and other transverse structures) | 168 |  |  | 137 | 305 |
| Waterway construction | 65 |   |   | 39 | 104 |
| Fishing | Fishing: Benthic trawling and suction/hydraulic dredges |   | 211 | 110 | 85 | 406 |
| Fishing: Nets, potting/creeling (set up/recovery, operations) | 54 | 213 | 58 | 114 | 439 |
| Fishing: Pelagic trawls and long-line pelagic (including steaming, operations, mooring/anchoring) | 28 | 173 | 92 | 130 | 423 |
| Manufacturing (land-based) - operations | Manufacturing: Industry with discharges - operational | 369 | 282 | 82 | 300 | 1,033 |
| Mining, extraction of materials | Mining, extraction of materials: including inorganic, maerl, rock/minerals, sand/gravel, salt | 463 | 134 | 24 | 303 | 924 |
| Non-Renewable Energy | Non-renewable power stations (land-based, coastal) | 196 | 234 | 28 | 179 | 637 |
| Oil and Gas | 54 | 239 | 78 | 118 | 489 |
| Peat | 19 |   |   | 25 | 44 |
| Renewable Energy | Hydropower including storage, run-off and diversion - construction and operation | 337 |   |   | 245 | 582 |
| Tidal sluices and barrages | 4 | 187 |  | 58 | 249 |
| Wave energy |  | 134 | 4 | 56 | 194 |
| Wind farms |   | 37 | 35 | 61 | 133 |
| Research | Research | 434 | 470 | 111 | 328 | 1,343 |
| Residential & Commercial Development | Marinas and dock/port facilities | 236 | 302 | 25 | 180 | 743 |
| Urban dwellings and commerical developments | 426 | 276 | 10 | 317 | 1,029 |
| Services | Military |   | 235 | 59 | 98 | 392 |
| Shipping | 78 | 314 | 141 | 153 | 686 |
| Telecoms and Electricity | 42 | 206 | 92 | 53 | 393 |
| Transport (roads, vehicles, other) | 239 | 83 | 6 | 200 | 528 |
| Water Supply (including reservoirs, desalination) | 226 | 7 |   | 148 | 381 |
| Tourism/ Recreation and Non-Commercial Harvesting | Angling and sport fishing (including catch and release and stocking) | 288 | 219 | 78 | 256 | 841 |
| Boating/Yachting/Watersports (without engine) | 171 | 139 | 67 | 174 | 551 |
| Boating/Yachting/Watersports, including tourist boats (with engine) | 172 | 314 | 104 | 257 | 847 |
| Collecting (bird eggs, individuals, curios, bait) | 174 | 139 |  | 77 | 390 |
| Commercial Cruise (large) | 65 | 185 | 52 | 132 | 434 |
| Hunting, including wildfowling and spearfishing (shooting, lead shot, boating) | 174 | 137 |  | 110 | 421 |
| Shore recreational activities (including beaches, terrestrial sports, other shore activities) | 155 | 96 | 15 | 133 | 399 |
| Tourist resort | 511 | 209 |   | 347 | 1,067 |
| Waste Management | Waste management - operational disposal of waste or other material and/or sewage treatment and storm overflows | 377 | 265 | 63 | 294 | 999 |
| Total |  | 7,183 | 7,094 | 1,515 | 6,524 | 22,316 |

Supplemental Table 2: List of pressure categories and single pressures with the number of identified impact chains in each aquatic domain as well as the total number of impact chains; FW=fresh water, CW=coastal water, MW=marine water

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Pressure Category | Single Pressure | FW | CW | MW | Biota | Total |  |
| Biological disturbance | Extraction of flora and/or fauna | 266 | 188 | 38 | 120 | 612 |  |
| Introduction of genetically modified species | 12 | 15 | 1 | 14 | 42 |  |
| Introduction of Microbial pathogens | 347 | 469 | 125 | 394 | 1,335 |  |
| Introduction of non-indigenous species | 204 | 232 | 79 | 189 | 704 |  |
| Translocations of species (native or non-native) | 151 | 229 | 69 | 148 | 597 |  |
| Chemical change | Changes in input of organic matter | 554 | 454 | 120 | 330 | 1,458 |  |
| IntroductionNon-synthetic compounds | 626 | 645 | 144 | 546 | 1,961 |  |
| Introduction of Radionuclides | 66 | 113 | 31 | 87 | 297 |  |
| Introduction of Synthetic compounds | 718 | 601 | 142 | 531 | 1,992 |  |
| Litter | 454 | 499 | 137 | 364 | 1,454 |  |
| N&P Enrichment | 453 | 540 | 126 | 265 | 1,384 |  |
| pH changes | 108 | 136 | 27 | 120 | 391 |  |
| Salinity changes | 59 | 94 | 17 | 51 | 221 |  |
| Physical change | Abrasion/Damage | 347 | 368 | 56 | 87 | 858 |  |
| Artificialisation of habitat | 217 | 253 | 41 | 199 | 710 |  |
| Barrier to species movement | 2 |  |  | 116 | 118 |  |
| Change of habitat structure | 530 | 388 | 73 | 239 | 1,230 |  |
| Changes in Siltation | 303 | 592 | 137 | 397 | 1,429 |  |
| Changes in wave exposure | 31 | 74 | 11 | 30 | 146 |  |
| Death or Injury by Collision | 4 |  |  | 146 | 150 |  |
| Disturbance (visual) of species |  |  |  | 531 | 531 |  |
| Emergence Regime Changes | 163 | 79 |  | 127 | 369 |  |
| Extraction of non-living resources | 129 | 95 | 13 | 52 | 289 |  |
| Smothering | 206 | 373 | 69 | 86 | 734 |  |
| Total Habitat Loss | 264 | 195 | 24 | 209 | 692 |  |
| Water abstraction | 209 | 12 | 2 | 129 | 352 |  |
| Water flow rate changes | 542 | 226 | 14 | 394 | 1,176 |  |
| Energy | Electromagnetic changes |   | 3 |   | 15 | 18 |  |
| Input of light | 86 | 156 | 13 | 104 | 359 |  |
| Noise (Underwater and Other) | 10 |  |  | 389 | 399 |  |
| Thermal changes | 122 | 65 | 6 | 115 | 308 |  |
| Total |   | 7,183 | 7,094 | 1,515 | 6,524 | 22,316 |  |

Supplemental Table 3: Overview of single ecosystem components in the aquatic realms and domains

| Domain | Realm | Ecosystem Component | N impact chains |
| --- | --- | --- | --- |
| FW | Lakes | Permanent eutrophic lakes, ponds and pools | 469 |
| Permanent mesotrophic lakes, ponds and pools | 225 |
| Permanent oligotrophic lakes, ponds and pools | 226 |
| Surface standing waters | 137 |
| Riparian | Broadleaved deciduous woodland | 437 |
| Broadleaved evergreen woodland | 80 |
| Coniferous woodland | 428 |
| Dry grasslands | 134 |
| Grassland and land dominated by forbs, mosses and lichens | 19 |
| Inland salt steppes | 20 |
| Lines of trees, small anthropogenic woodlands, recently felled woodland, early-stage woodland and coppice | 178 |
| Mediterranean riparian woodland | 5 |
| Mesic grasslands | 415 |
| Mixed deciduous and coniferous woodland | 286 |
| Mixed riparian floodplain and gallery woodland | 5 |
| Moist or wet tall-herb and fern fringes and meadows | 5 |
| Riparian | 1 |
| Riparian and gallery woodland, with dominant alder, birch, poplar or willow | 5 |
| Seasonally wet and wet grasslands | 176 |
| Sparsely wooded grasslands | 272 |
| Woodland, forest and other wooded land | 314 |
| Rivers | Permanent non-tidal, fast, turbulent watercourses | 414 |
| Permanent non-tidal, smooth-flowing watercourses | 729 |
| Surface running waters | 143 |
| Wetlands | Littoral zone of inland surface waterbodies | 73 |
| Periodically inundated shores with pioneer and ephemeral vegetation | 236 |
| Seasonally wet and wet grasslands | 313 |
| Sedge and reedbeds, normally without free-standing water | 260 |
| Species rich helophyte beds | 220 |
| Species-poor beds of low-growing water-fringing or amphibious vegetation | 236 |
| Unvegetated or sparsely vegetated shores with non-mobile substrates | 236 |
| Unvegetated or sparsely vegetated shores with soft or mobile sediments | 236 |
| Water-fringing reedbeds and tall helophytes other than canes | 250 |
| CW | Coastal | Circalittoral rock and other hard substrata | 497 |
| Deep-sea bed | 267 |
| Infralittoral rock and other hard substrata | 506 |
| Littoral rock and other hard substrata | 601 |
| Littoral sand and muddy sand | 36 |
| Littoral sediment | 514 |
| Pelagic water column | 421 |
| Sublittoral mixed sediments | 31 |
| Sublittoral sand | 39 |
| Sublittoral sediment | 502 |
| CoastalTerr | Coastal dune scrub | 2 |
| Coastal dune woods | 2 |
| Coastal dunes and sandy shores | 314 |
| Coastal habitat (land) | 31 |
| Coastal shingle | 255 |
| Coastal stable dune grassland (grey dunes) | 2 |
| Moist and wet dune slacks | 2 |
| Rock cliffs, ledges and shores, including the supralittoral | 202 |
| Shifting coastal dunes | 5 |
| Inlets Transitional | Circalittoral rock and other hard substrata | 340 |
| Coastal saltmarshes and saline reedbeds | 16 |
| Deep-sea bed | 186 |
| Estuaries | 121 |
| Highly artificial man-made waters and associated structures | 5 |
| Highly artificial saline and brackish standing waters | 3 |
| Infralittoral rock and other hard substrata | 357 |
| Littoral mud | 36 |
| Littoral rock and other hard substrata | 364 |
| Littoral sand and muddy sand | 35 |
| Littoral sediment | 590 |
| Littoral sediments dominated by aquatic angiosperms | 18 |
| Pelagic water column | 299 |
| Sublittoral mixed sediments | 46 |
| Sublittoral mud | 44 |
| Sublittoral sand | 46 |
| Sublittoral sediment | 359 |
| MW | Oceanic | Deep-sea bed | 303 |
| Pelagic water column | 216 |
| Shelf | Circalittoral rock and other hard substrata | 313 |
| Infralittoral rock and other hard substrata | 105 |
| Pelagic water column | 196 |
| Sublittoral sand | 29 |
| Sublittoral sediment | 353 |
| Biota | Amphibian | Amphibian | 793 |
| Birds | Birds | 1105 |
| Fish & Cephalopods | Fish & Cephalopods | 1689 |
| Insects (adults) | Insects (adults) | 739 |
| Mammals | Mammals | 1281 |
| Reptiles | Reptiles | 917 |

**Appendix 1: Pressure Definitions**

The analyses include: inlets and transitional, coastal, shelf, oceanic, coastal/terrestrial, lakes, rivers, wetlands, riparian habitats and biotic groups as part of the ‘aquatic realms’ considered. Pressures acting on any of those are included.

**Biological Disturbance**

1. **Introduction of Microbial Pathogens** Introduction of microbial pathogens into aquatic ecosystems by human activities
2. **Introduction of Non-Indigenous Species** Introduction of non-indigenous species by the activities of a particular sector (e.g. through exchange of ballast waters by shipping, or from release of individuals from the aquaria trade or aquaculture). This specifically refers to the introduction of a *new* species to the area.
3. **Translocations of species (native or non-native)** Movement from one location to another of individuals from a species by the activities of a particular sector (e.g. through exchange of ballast waters by shipping or from release of individuals from aquaculture). Does not include *new* additions of non-native species (see pressure 2). Does not include additions of microbial pathogens which are dealt with separately (see pressure 1)
4. **Extraction of flora and/or fauna** Extraction (and subsequent mortality) of any aquatic fauna (vertebrate or invertebrate) and/or flora (plants and algae) from their natural habitat, including incidental non-target catch (e.g. by commercial fishing, recreational angling and collecting/harvesting). Note that extraction of cultivated fauna is not considered here.
5. **Introduction of genetically modified species** Release of genetically modified species through the activities of a particular sector. A specific example includes through the release of individuals of genetically modified fish or shellfish species from aquaculture.

**Chemical**

1. **pH changes** Change in pH (average, range or variability) e.g. due to run off from land-based industry (localised, not climate change, see 36)
2. **Salinity changes** Change in salinity (average, range or variability), e.g. due to outfalls from industrial plants or alterations in coastal structures affecting mixing (localised, not climate change, see 38)
3. **Introduction of Non-Synthetic compounds** Introduction of heavy metals and hydrocarbons into aquatic ecosystems by human activities; can include new additions and/or release of compounds previously held in sediments following disturbance.
4. **Introduction of Radionuclides** Introduction of radionuclides into aquatic ecosystems by human activities; can include new additions and/or release of compounds previously held in sediments following disturbance
5. **Introduction of Synthetic compounds** Introduction of man-made compounds (e.g. pharmaceuticals, industrial compounds, etc.) into aquatic ecosystems by human activities; can include new additions and/or release of compounds previously held in sediments following disturbance
6. **Litter** Litter originating from numerous sources but entering aquatic ecosystems and consisting of different materials including: plastics, metal, glass, rubber, wood and cloth
7. **N&P Enrichment** Input of fertilisers, and other Nitrogen and Phosphorous rich substances, elevated above the background levels, including any subsequent associated deoxygenation
8. **Change in input of Organic Matter** Organic enrichment and any subsequent deoxygenation, e.g. from industrial and sewage effluent into aquatic ecosystems, or from the waste from aquaculture or from fishing discards. Changes in organic input may also come from changes to riparian vegetation and loss of allochthonous input into rivers and lakes.

**Physical**

1. **Water abstraction** Removal of freshwater or seawater for e.g. drinking water, irrigation, cooling industrial plants or for desalination, directly reducing the availability of habitats and causing hydrological changes.
2. **Water flow rate change** Change in currents (speed, direction or variability) due to barrages or other manmade structures such as coastal defences or hydropower structures (localised, not climate change, see 35)
3. **Death or Injury by Collision** Death or injury of fauna due to impact with moving parts of a human activity, e.g. marine mammals with ships/jet skis, seabirds with wind turbines, fish in hydroelectric turbines, etc.
4. **Emergence Regime changes** Change to natural sea level regime (average, range or variability) of natural shore areas due to barrages or other manmade structures such as coastal defences, or changes to the regime of emergence (e.g. timing, extent) of lakes, rivers or floodplains due to human activities such as alteration of water levels for hydropower (localised, not climate change, see 32)
5. **Abrasion/Damage** Physical interaction of human activities with the seafloor, riverbed or lake bottom, riparian/coastal terrestrial/wetland habitats and with the benthic fauna/flora causing physical damage and/or mortality (e.g. from trawling, dredging, or anchoring).
6. **Barrier to species movement** Preventing the natural movement of motile fauna along a key route of travel (e.g. a migration route) due to dams, barrages, causeways, wind turbines, and other manmade structures. This can take place laterally across a flood plain due to e.g. flood defences.
7. **Changes in wave exposure** Change in the size, number, distribution, and/or periodicity of waves along a coast due to installation of coastal structures (localised, not climate change, see 33); change in wave exposure along a shoreline due to shipping/boating activity
8. **Changes in Siltation** Change in the concentration and/or distribution of suspended sediments in the water column from runoff, dredging etc.
9. **Total habitat loss (physical)** Loss of natural habitat from sealing by permanent manmade construction (e.g. Coastal defences, wind turbines, bridges, river walls) or due to land conversion (e.g. intertidal/littoral habitats lost through land claim). Can include change in habitat type at Eunis Level 3 or above (e.g. Littoral mixed sediments to Littoral sand, or Broadleaf deciduous woodland to Arable land).
10. **Selective Extraction of non-living resources: substrate** Includes sand and gravel (aggregates) extraction, removal of surface substrates for exploration of seabed, river bed, lake bottom, and subsoil. This pressure involves reducing the amount of physical habitat.
11. **Smothering** Cover habitat surface with materials falling to the seafloor, riverbed or lake bottom or other relevant aquatic habitats from activities in the water column (e.g. waste substances from aquaculture cages), on land (e.g. in runoff or effluent), or around activities (e.g. around trawling gear), or from disposal of materials (e.g. disposal of materials from dredging onto the seafloor). Smothering may lead to reduced functioning (e.g. feeding) or mortality of benthic animals living on, or in, the seafloor, river bed or lake bottom.
12. **Disturbance (visual) of species** Physical structures, which may affect the behaviour of fauna, e.g. wind farms and seabirds.
13. **Artificialisation of habitat** The addition of artificial habitat or manmade structures to an aquatic environment e.g. artificial reefs, wind turbines. This could provide stepping stones for invasive species.
14. **Change of habitat structure/morphology** Change of benthic habitat or substrate without total habitat loss (22) e.g. alteration of river channels, loss of habitat complexity such as leaves, dead wood. Broad habitat type remains the same but quality/structure changes.

**Energy**

1. **Electromagnetic changes** Change in the amount and/or distribution and/or periodicity of electromagnetic energy emitted in a marine or freshwater area (e.g. from electrical sources such as underwater cables)
2. **Thermal changes** Change in temperature of the water (average, range or variability) e.g. due to outfalls from industrial plants (localised, not climate change, see 34)
3. **Noise (underwater and other)** Introduction of underwater noise that is outside normal background levels, and originates from activities such as shipping, acoustic surveys, pile driving during construction etc. Other noise can refer to noise elsewhere in the environment that could affect aquatic species such as birds.
4. **Input of light** Addition of light from artificial sources e.g. due to urbanisation around a littoral area

**Appendix 2: Details on the weighting of impact chains**

**Persistence** does not change based on the actual extent and/or frequency of the pressure in the area being assessed. Simply, the assessment describes the likely Persistence of a pressure on an ecological component. This means that:

1. Persistence of a pressure does not often, but can vary between activities exerting the same pressure on an ecological component, if the nature of their specific activities means that the pressure persists for a different length of time. For example, persistence of the pressure ‘Changes in Siltation’ might be Persistent from Coastal Defences, but Low from Agricultural runoff.
2. Persistence of a pressure can vary between ecosystem components within a case study area based on the characteristic features and species.
3. Persistence of a pressure should not vary within the same ecosystem component between case studies unless there is a fundamental difference in the conditions of the area (e.g. very long residence times of water) that would affect Persistence.

**Severity** does not differ based on the actual extent and/or frequency of the pressure in the area being assessed. Simply, the assessment describes the likely sensitivity of an EC to a pressure where there is an interaction. This means that:

1. Severity does not often, but can vary between activities exerting the same pressure on an EC, if the nature of their activities means that the pressure exerts a different Severity. An example here would be that the Severity from the pressure Underwater Noise acting on Marine Mammals, can vary between activities based on the type (frequency and magnitude) of noise associated with their activities.
2. Severity can vary between ECs (e.g. between habitat types and mobile components) for the same activity/pressure combination due to differences in the inherent resistance of the characteristic species and features of the ecosystem components. For example, the Habitat Loss pressure causes Acute effects on habitats because areas of the habitat are lost, but only Chronic effects on Mobile Species groups like Fish because it is only if enough habitat is lost due to this pressure that there may be any noticeable effect on fish species.
3. Severity can also vary within the same EC (e.g. habitat type) between case studies for the same activity/pressure combination if there are (a) locational differences in the characteristic species and features such that those differences affect the inherent resistance of the broad EC, or (b) due to differences in current status of the ecosystem component (e.g. a degraded habitat may have a different sensitivity to a comparatively unimpacted habitat of the same broad type). This will need checking with case study teams.
4. Severity can also vary between case studies for the same activity/pressure combination with the same ecosystem component, if the nature of the activities within the sectors differs between case study areas to the extent that it would affect generic severity of interactions. This will also need checking with case study teams.