# What linkages have been researched between the marine environment and human health? A systematic map protocol

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# Abstract

**Abstract**

**Background:** The health of marine environments (including seas, oceans and coasts) and of people are interlinked. People's exposure to these environments are associated with a broad range of positive and negative impacts on human health and wellbeing. At the same time, anthropogenic activities impact on the 'health' of the marine environments, the consequences of which influence human health. This potentially affects huge numbers of people. In the European Union (EU), for example, 43% of the population live in coastal regions. However, despite the possible consequences for human health, the EU currently has no coherent interdisciplinary research strategy focused on marine environments and human health. The existing evidence base urgently needs to be identified and synthesised to provide a multidisciplinary baseline of evidence to help direct future research priorities, and to inform wider policy developments at national and international levels.

**Methods:** This protocol describes the methodology for examining the research question: *what linkages have been researched between marine environments and the positive and negative impacts to human health and wellbeing?* Using systematic mapping, this study will identify and map the state and distribution of the existing research evidence linking human health and wellbeing with exposure to, and interactions with, marine environments. The types of exposure/intervention to the marine environments and associated health and wellbeing impacts will be categorised and presented in a graphical matrix, illustrating exposure/intervention type and the types of health and wellbeing outcomes. A searchable database containing extracted meta-data from studies included in the map will be developed and presented as a data portal.

# Background

## Background

It is now widely recognised that the health of the marine environment (including seas, oceans and coasts), and of people are closely interlinked [1, 2]. These environments can provide health benefits to humans including, but not limited to, food and nutritional resources (e.g. [3]), new treatments for disease (e.g. [4]), and opportunities for physical activity and mental restoration (e.g. [5]). However, the marine environment is also a source of potential risks to human health, such as drowning [6], diseases (e.g. Gastroenteritis [7]) and infections (e.g. wound infections from *Vibro vulnificus* [8]). Further, it has become apparent that many anthropogenic activities negatively impact the 'health' of the marine environment, which in turn affects human health and activities [2, 9-13]. These impacts may exacerbate, and be exacerbated by, the frequency and scale of natural events, such as coastal flooding and severe storms, and can be seen at both the local scale (such as microbial pollution on specific beaches) and the global scale (such as ocean acidification associated with higher atmospheric carbon dioxide; [13-15]).

Against a background of climate change, continued human population growth and the increasing reliance on the marine environment for human activities, there is a growing recognition of the necessity of understanding the casual relationships behind how people interact with the marine environment and the downstream effects for human health [13, 15-17]. Humans are exposed to the marine environment through a variety of occupational and recreational activities, such as fishing, and through living proximity, or through the consumption of marine products such as seafood (Figure 1). These activities can affect human health both directly and indirectly, negatively and positively, and through more immediate short term effects, like drowning or increased psychological wellbeing, or accumulatively through longer term effects, such as the consumption of heavy metals in seafood or the promotion of a healthy lifestyle (Figure 1). Further, they also often negatively impact the 'health' of the marine environment through processes such as environmental degradation and pollution (e.g. [18]). A loss of marine health can feedback into the scale and type of human activities in the marine environment, and so be detrimental to the blue economy, for example a reduction of fish stocks limiting the fishing industry (Figure 1; e.g. [19]). The evidence is rapidly mounting of the environmental consequences of this loss of health, such as harmful algae blooms, increased frequency of severe weather events and climate change, and these will not only influence human activities in and around the ocean, but will also have direct and indirect health outcomes (Figure 1; e.g. [13, 20]).

The impacts on human health and wellbeing that derive from exposure to the marine environment directly affect large numbers of people and incur significant economic costs. In the European Union (EU), 22 of 28 member states have a coastline on one or more of five major maritime regions (Baltic Sea, North Sea, Mediterranean Sea, Black Sea and Atlantic Ocean). Indeed, two thirds of European frontiers are coasts with 43% of the EU's population (approximately 218 million people) living in coastal regions, including 194 cities (Eurostat,

2012). The EU blue economy represents, in the early 21st century, an estimated 5.4 million jobs and a gross added value of approximately €500 billion per year, with 75% of EU external trade and 37% internal trade within the EU via the seas and oceans [21]. The EU's blue growth strategy is predicting that the negative impact of human activities on the marine environment are likely to increase significantly in the near future [22]. It is likely, therefore, that the health and wellbeing of a large proportion of the European population is, and will increasingly become, connected to the marine environment.

To understand the complex links that exist between marine environmental and human health, there is growing recognition of the necessity for a truly interdisciplinary approach [2, 13, 16, 23]. Marine, social, medical and public health scientists need to come together to address the impacts of the marine environment on human health and wellbeing, and how this affects the stability and sustainability of human populations and their activities. Over the past two decades the importance of the marine environment for human health as an area for research, training and policy has been recognised in the US with the Oceans and Human Health initiative [9]. However, Europe is only just starting to develop its own coherent oceans and human health research agenda on the scale necessary to address the public health implications of the rapidly increasing human activity in European seas and oceans [13]. Although Europe has made significant strides in developing an Integrated Maritime Policy, it has not taken sufficient account of the aspects in maritime policy making for human health.

As a first step towards redressing this, in 2013 the European Marine Board published a position paper highlighting the substantive and complex interactions between the marine environment and its ecological status on one hand, and human health and wellbeing on the other [15]. It concluded that an effective policy framework is required to manage this relationship, linking maritime and public health policies. This was followed in 2014 by a workshop in the U.K. that brought together key scientists, policy makers, funders, businesses, and non-governmental organisations from Europe and the U.S., to discuss the threats and opportunities to human health and wellbeing presented in the European Marine Boards position paper. This team of experts identified knowledge gaps and needs with respect to policy and research, on both the growing impacts of the marine environment on human health and wellbeing, and the effects of humans on the 'health' of marine ecosystems [13]. The workshop delivered a short declaration of intent (*Message from Bedruthan*) to work towards building an 'oceans and human health' research capacity in Europe [24]. Together the European Marine Board position paper and the Message from Bedruthan directly informed the subsequent *Rome Declaration: Setting a vision for seas and ocean science* [25]. Crucially, the Rome Declaration put public health and wellbeing at the centre of the discussion on core EU maritime policies, including EU Blue Growth and the Marine Strategy Framework Directive.

In 2015, the EU Joint Programming Initiative on Healthy and Productive Seas and Oceans (JPI Oceans) launched its Strategic Research and Innovation Agenda 2015-2020 [26]. It identified a

core priority area as *Linking Oceans, Human Health and Wellbeing*, with a key recommendation being the creation of an integrated, international and interdisciplinary training and collaborative research program into oceans and human health. JPI Oceans subsequently funded the €2 million 'Seas, Oceans and Public Health In Europe' (SOPHIE) project (https://sophie2020.eu). The goal of SOPHIE is to advance the coordination of multidisciplinary research and training in Europe, to better manage the risks and opportunities presented by the complex interactions between the marine environment and human health and wellbeing. In doing so, the SOPHIE project brings together researchers and practitioners from across two largely disparate communities: (i) the marine and maritime community; and (ii) the medical and public health community, to work together to better understand both the potential threats to human health from degraded marine environments and the opportunities for human health promotion from sustainable interactions with coastal environments.

SOPHIE aims to contribute towards the EU's Strategic Research Agenda for oceans and human health. However, before a robust research agenda can be created it is critical that the existing knowledge base from across disciplines is synthesised and characterised. This exercise needs to consider the available evidence not only from Europe, which may be relatively limited, but also from studies where the results are applicable to European marine environments and populations. Therefore, a core deliverable of the multidisciplinary SOPHIE project is to map the existing data and information resources around the risks and benefits to human health and wellbeing from interactions with the marine environment. This will be carried out using systematic mapping as a tool for describing current state of the evidence base. This technique allows the identification of knowledge gaps and key areas. Thus, allowing the identification of questions to be explored using a systematic review approach that can synthesis the existing evidence, thereby facilitating the effective direction of resources and guiding policy decisions. The outputs will include structured matrices depicting the distribution and frequency of studies, and coding for study design or mechanism type, across a range of interventions and outcome variables.

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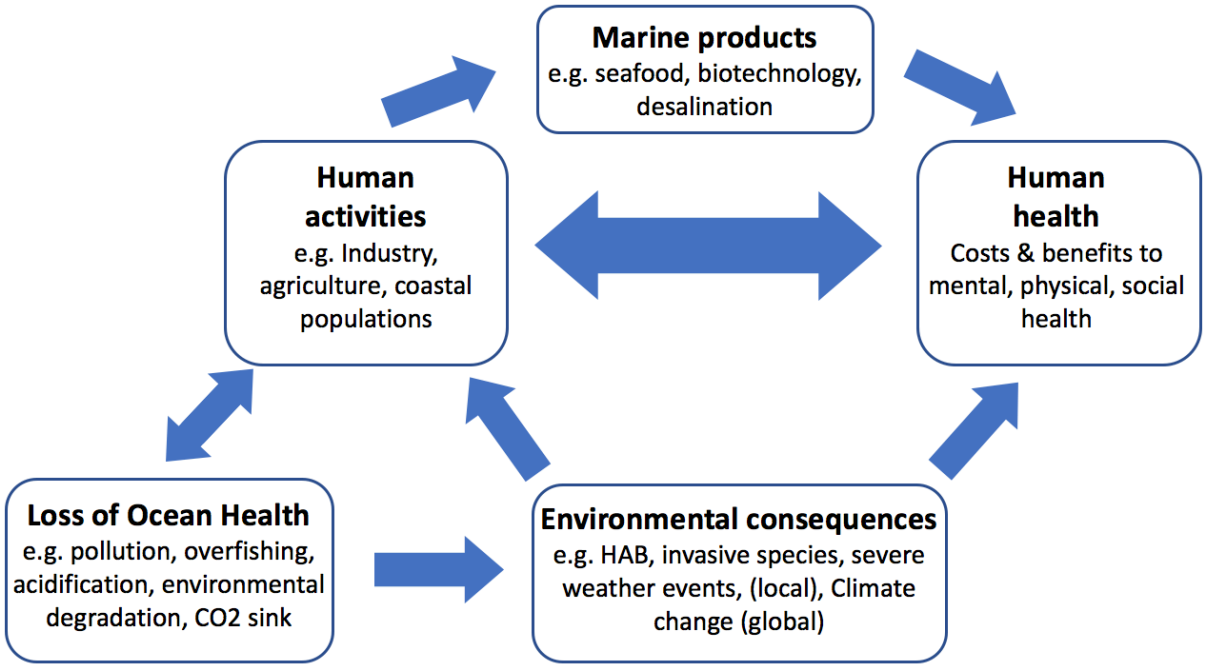


**Figure 1:** Conceptual model of the potential relationships between marine environments and human health and wellbeing outcomes.

# Objectives

The aims and objectives of the systematic map are to:

- Produce a systematic mapping review of the existing research evidence linking the health and wellbeing of coastal communities and the European marine environment.
- Create an online searchable tool to enable researchers, practitioners and policy makers to identify research relevant to their interests.
- Identify evidence gaps for future research, thereby informing the Strategic Research Agenda "Framework Program 9" in Europe.
- Provide the basis of evidence for a future Oceans and Human Health Global Burden of Disease and Health and Wellbeing activity for future economic impact estimation.

We will systematically map the available research evidence to illustrate which linkages between the marine environment and human health and wellbeing have been researched – including both risks and benefits (Table 1).

The research evidence will be identified through systematic searches, and papers meeting the map's inclusion criteria will be characterised using a targeted data extraction strategy.

**Table 1.** Key elements of the study research question

| *Population* | *Exposure/Intervention* | *Comparator* | *Outcome* |
|---|---|---|---|
| Adult, children and communities in the European member states and associated countries | Exposure/intervention to the marine environment | No exposure/intervention with the marine environment | The benefits and/or costs to human health and wellbeing |

**Methods**

The focus of the SOPHIE project is on the marine environment (including seas, ocean and coastal areas) that makes up the five major maritime regions surrounding Europe (Baltic Sea, North Sea, Mediterranean Sea, Black Sea and Atlantic Ocean). This map will also consider studies conducted in those Anglophone countries, namely Canada, U.S.A, Australia and New Zealand, where the populations have similar exposures and activities to marine environments.

The map will first categorise the full range of human activities that link exposures to, or interventions with, the marine environment, with direct and indirect impacts on human health and wellbeing. This will be initially based on the human activity categories identified by ([27], Table 1.1), before being refined during the scoping phase. Health and wellbeing categories will be broadly defined, being adapted from MeSH terms covering a wide range of associated conditions and diseases, the map will then categorise the health and wellbeing outcomes for each type of human activity (i.e. exposure or intervention). The mapping exercise will focus on the health and wellbeing of individuals, households or communities, within the 28 European Union member states, and those other Anglophone countries.

Throughout the process the mapping exercise will be guided by partners in the SOPHIE project, the SOPHIE advisory board and a SOPHIE expert group. The board consists of leading environmental, social and medical scientists, along with members from associated NGO's and government organisations (see additional file 1 for a full list of SOPHIE partners, the advisory board and the expert group members).

The systematic mapping exercise will be conducted in five consecutive stages described below and illustrated in Figure 2:

*Literature cited*

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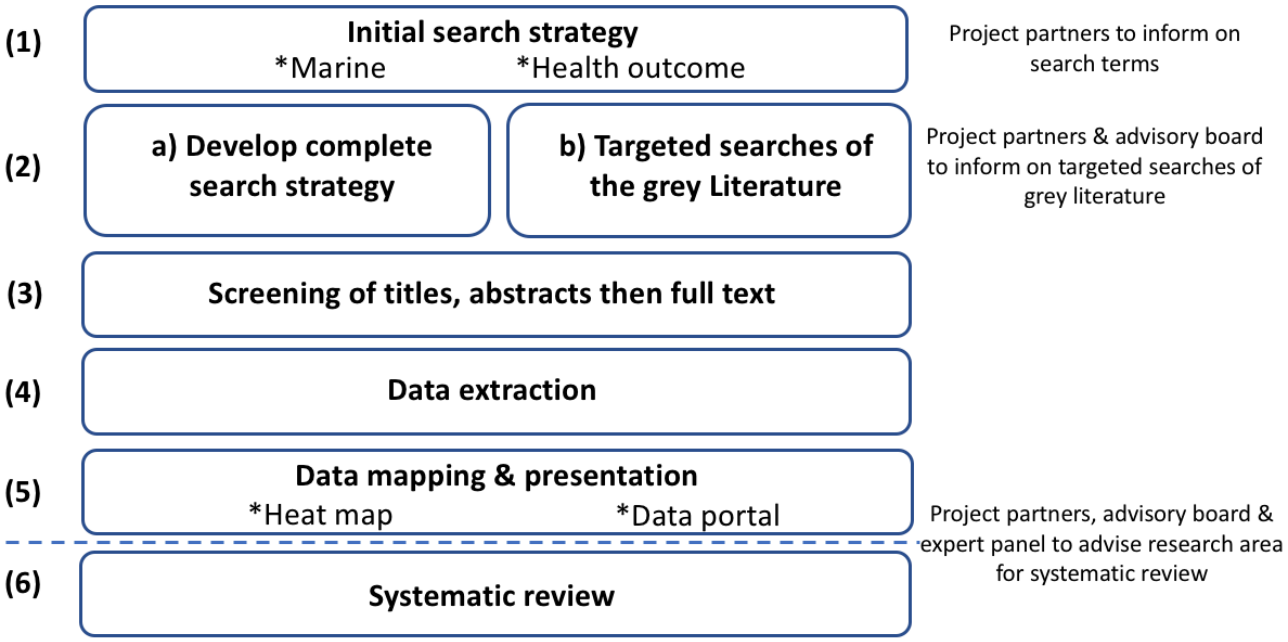


**Figure 2:** Predicted pathway. Stages 1-5 show the pathway for generation of the systematic map. Stage 6 illustrates the expected production of a systematic review.

## Questions

| Primary/secondary | Question type | Question | Definition key elements |
|---|---|---|---|
| primary | P I/E C O | What linkages have been researched between the marine environment and human health and wellbeing impacts, both positive and negative? | Population: Adult, children and communities in the European member states and associated countries Intervention/Exposure: Exposure/intervention to the marine environment Comparator: No exposure/intervention with the marine environment Outcome: The benefits and/or costs to human health and wellbeing |
| secondary | P I/E C O | Which research areas into seas, oceans and human health will benefit from systematic reviews of the current state of evidence? | Population: Adult, children and communities in the European member states and associated countries Intervention/Exposure: Exposure/intervention to the marine environment Comparator: No exposure/intervention with the marine environment Outcome: The benefits and/or costs to human health and wellbeing |
| secondary | P I/E C O | What are the knowledge gaps where funding for research and policy is best focused in the future? | Population: Adult, children and communities in the European member states and associated countries Intervention/Exposure: Exposure/intervention to the marine environment Comparator: No exposure/intervention with the marine environment Outcome: The benefits and/or costs to human health and wellbeing |

# Search Strategy

***Searches***

The search will aim to capture all of the available evidence to answer the question, whether published or unpublished. Different sources of information will be searched to maximise the coverage of the results including:

- Electronic bibliographic databases;
- Website searching, including Government and relevant third sector websites;
- Contact with relevant organisations and networks e.g. World Health Organisation, as determined by the SOPHIE advisory board and expert group (Table 2);
- Backwards and forwards citation searching of included references, and using other relevant systematic maps and reviews;
- Hand searching of relevant journals (focusing on those not indexed in the electronic databases searched;
- Targeted searching using outcomes and activity search terms if we found that we had not covered this adequately.

The published and unpublished references will be collated and sent to experts at the external organisations who are involved in the project to review and identify any additional documents missing. The references will then be screened.

*Publication bibliographic database searches*

The search strategy will be developed in MEDLINE and translated for the following databases: EMBASE; Web of Science; Environment Complete; GreenFILE; BIOSIS; Enviroline and CAB abstracts; PQDT.

1. ***Development of initial electronic search strategy***

First, an initial string of search terms has been developed based on combinations of two groups: the first includes terms relating to the ocean environment, the second includes terms relating to associated human health and wellbeing outcomes. The search terms were developed through scoping relevant titles, abstracts and keywords from a broad range of environmental and health literature. The search included relevant controlled vocabulary (e.g. Medical Subject Headings, MeSH) and free text terms. The preliminary list of terms will then be further refined based on input from the SOPHIE partners and the expert advisory board. A record of the evolution of the electronic search strategy development has been created to track modification and additions based upon the initial scoping exercise and is available from the authors.

# Scoping exercises

### *2. a) Development of a complete electronic search strategy*

Second, the efficacy and relevancy of the initial search strategy will be obtained using a test library of 47 publications (see Additional file 2). This library includes studies related to human health for a broad range of exposures or interventions to the marine environment. The test library will be used to help develop the full search strategy. This will be further refined during implementation of the full search strategy (Additional file 3).

The searches will be conducted in English only due to resource constraints and limited to 1990 onwards since explicit interest in the links between the oceans and human health did not emerge in the literature until the 1990s [2]. Endnote will be used as the reference management software. Non-English references will be kept in a separate reference library of potentially relevant titles and abstracts but won't contribute further to the mapping review. Publications written in other languages that have an English language abstract, will be screened for relevance and relevant publications compiled into a separate database for future assessment in a follow-up phase to this initial systematic mapping exercise. This future assessment would involve the generation of language specific search strings to capture linguistic differences in definitions of key terms associated with the research question.

### **b)** ***Targeted searches including grey literature***

'Grey' literature (i.e., published and unpublished documents that were not submitted to the peer-reviewed system collated in online databases) will be identified in several ways. Only literature published in English will be included. First, SOPHIE partners, advisory board and the expert group will identify potential organisations who have produced grey literature (Table 2). The websites and portals these relevant organisations will be searched as follows: where available the search function in the websites or portals will used to search for "Human health" AND "Ocean". Dependent on the focus of the organisation, other terms such as 'Human wellbeing" or "Seas OR Marine" will also be used. The first 100 returned titles will be scanned, and relevant titles added to the list of articles for further analysis. Second, a call will made to expert contacts in organisations such as the World Health Organisation, European Marine Board, Ocean and Sea Commissions for the Baltic sea, Black sea, North Sea Commission, Third, experts from external organisations who act as an advisory board and expert group on the SOPHIE project will be invited to review the final list of publications and identify any documents missing from the list. Finally, the publications from recent reviews will also be scanned, and relevant publications included in our search.

Limitations to the comprehensiveness of the search include consideration of only English language publications, due to time and resource constraints. Further limitations include access

to grey literature and time required to collate studies from availability of studies by developing countries due to biases associated with peer-reviewed publications and the same aforementioned language constraints.

**Table 2.** Websites of specialist organization and online databases

| *Organisation* | *Website* |
|---|---|
| AquaTT, Ireland | www.aquatt.ie/ |
| Baltic Sea Commission | www.cpmr-baltic.org/who-we-are/ |
| Black Sea Commission | www.blacksea-commission.org/ |
| Ecsite | ww.ecsite.eu |
| Environmental Protection Agency, Ireland | www.epa.ie/irelandsenvironment/environmentandwellbeing/ |
| Eurostat | www.ec.europa.eu/eurostat |
| European Environmental Agency | www.eea.europa.eu |
| European Environmental Agency – Bathing waters | http://ec.europa.eu/environment/water/water-bathing/index_en.html |
| European Centre for Disease Prevention and Control | www.ecdc.europa.eu/en/home |
| European Commission (Science hub) | www.ec.europa.eu/jrc/en |
| European Maritime Affairs & Fisheries | https://ec.europa.eu/info/departments/maritime-affairs-and-fisheries_en |
| European CORDIS –for all relevant projects | https://cordis.europa.eu/home_en.html |
| European Marine Board | www.marineboard.eu |
| European Public Health Association | www.heupha.org/ |
| Foresight Commission | www.gov.uk/government/collections/foresight-projects |
| French Coastal Protection Agency | www.pap-thecoastcentre.org/ |
| Greenpeace | www.greenpeace.org |
| Health and Safety Executive | www.hse.gov.uk/ |
| Intergovernmental Oceanographic Commission | www.ioc-unesco.org |

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|---|---|
| International Union for Conservation of Nature (IUCN) | https://portals.iucn.org/library/ |
| JPI Oceans | www.jpi-oceans.eu |
| Healthy oceans, healthy people | www.healthyoceanshealthypeople.org/ |
| HELCOM | www.helcom.fi/ |
| HM Government | www.gov.uk |
| International Council for Exploration of the Seas (ICES) | http://www.ices.dk |
| International Council for Science | https://www.icsu.org |
| International Maritime Organisation | www.img.org |
| Marine Biological Association | www.mba.ac.uk/tmb-tags/human-health-well-being |
| Marine Institute of Ireland | www.marine.ie/Home/home |
| MacArthur Foundation | www.macfound.org/ |
| NATO | www.nato.int/ |
| National Institute Of Environmental Health Science | www.niehs.nih.gov |
| National Ocean Service | www.oceanservice.noaa.gov |
| Near health project | http://whitakerinstitute.ie/project/near-health/ |
| Ocean Clean Up | www.theoceancleanup.com |
| Oceana | http://oceana.org/publications/reports |
| Oceans Health Index | www.oceanhealthindex.org |
| University of Western Australia, Oceans Institute | www.oceans.uwa.edu.au/ |
| Organisation for Economic Cooperation and Development | www.oecd.org |
| OSPAR Commission | www.ospar.org |
| Netherlands Public Health | www.rivm.nl/en |
| Public health England | www.gov.uk/government/organisations/public-health-england |
| Royal Commission on Environmental Pollution | www.gov.uk/government/organisations/royal-commission-on-environmental-pollution |

| | |
|---|---|
| Royal National Lifeboat Institute | www.rnli.org |
| Royal Society for the Protection of Birds | ww2.rspb.org.uk |
| Sea Change Project | www.seachangeproject.eu |
| Sea for Society | http://seaforsociety.eu/np4/home.html |
| Seas, rivers, islands and coastal areas | http://www.searica.eu/en/ |
| Socio-economic Marine Research Unit (SEMRU), NUI Galway | www.nuigalway.ie/semru/index.html |
| The James Hutton Institute, Scotland | www.crew.ac.uk/publications |
| The Ryan Institute | www.nuigalway.ie/ryaninstitute/ |
| The World Bank | www.openknowledge.worldbank.org |
| The Economics of Ecosystems and Biodiversity | www.teeboceans.org/ |
| United Nations Development Program | www.undp.org.html |
| United Nations Environment Programme | www.unenvironment.org |
| World Wildlife Fund | www.worldwildlife.org/publications |
| World Health Organisation | www.who.int/en/ |

# Study inclusion criteria

### *3. Study selection*

Titles and abstracts for papers identified by the search will be uploaded into ENDNOTE and duplicates removed. They will be screened against the below criteria.

***Inclusion criteria***

*Population*

- Adults, children, households or communities living within the 28 European Union member states or other Anglophone countries (U.S., Canada, Australia or New Zealand).

*Exposure(s) / Intervention(s)*

- Exposures to marine environments due to recreational or occupational activities; or
- Interventions to promote use of marine environments; or
- Interventions to promote consumption of marine products.

This includes:

- Occupational impacts of being involved in fisheries; aquaculture; shipping and oil; marine mining/extraction industries;
- Exposure to any pollutants in coastal / ocean zones;
- Health and wellbeing impacts of recreational and tourist activities in marine environments;
- Health and wellbeing impacts of living by and on marine environments;
- Impacts of exercise in "Blue space".

"Marine environment" includes: oceans, seas, deep sea zones; coastal zones; estuaries, saline lagoons; fjords; intertidal zones.

*Comparison:*

Any reasonable intervention or exposure comparator, depending on the nature of the study, this may be based on spatial, temporal or population comparisons. For exposure studies, correlation and association studies will also be included.

*Outcome(s)*

- Any human health or wellbeing outcome.

*Study types*

- All quantitative study designs will be included;
- Systematic reviews where all studies in the review are associated with health outcomes from exposure to marine environments.

***Exclusion criteria***

*Exposure(s)/ Interventions(s)*

- Studies that do not specifically document or measure the health or wellbeing outcomes that people receive from exposure to,, or interventions with the marine environment;
- Studies that focus solely on the health benefits or costs from fresh water.

*Outcome(s)*

- The study does not empirically observe or measure human health and wellbeing outcomes.

*Study types*

- Theoretical studies or models;
- Commentary, editorials and narrative reviews (reference lists of the latter will be checked to ensure key references are not excluded);
- Qualitative research.

# Study screening mode

***Screening***

Pilot screening will be carried out using up to 1,000 randomly chosen references. This will be conducted independently by two researchers with any disagreements used to discuss and refine the inclusion criteria. If there is any doubt, then the study will be retained for full text screening. Articles will then be obtained for full-text screening based upon the inclusion and exclusion criteria, any disagreement at this stage will be resolved by a third member of the team. Full texted screening will then be carried out by two researchers, along with the data extraction as detailed below. A third reviewer will review any articles that one of the lead systematic reviewers is an author on. A list of references excluded at full text will be provided, along with the reason for their exclusion.

# Critical appraisal of included studies

### Study quality assessment

Given the scope of the mapping process, we do not plan to assess the quality of included studies. By their nature, systematic maps, or evidence gap maps, are broad in scope and limited in depth in order to explore the characteristics of the evidence base rather than specific issues on quality and strength. As part of the data extraction strategy, we will collate data on study design where possible and on what type of comparators are used (see further details in data extraction questionnaire in Additional file 4). Information on study design will be collected, e.g., type of data collected, sample size, duration of study, and used as a proxy to the frequency of study design types, and their relative rigor, among different studies which might indicate quality of the study design. We will however be cautious not to assert that type or frequency of study design as a substitute for confidence in the effects of specific interventions.

## Critical appraisal mode

See study quality assessment statement.

# Data extraction strategy

### *4. Data extraction strategy*

Relevant data from each included article will be extracted using a standard data extraction form developed for the study (Additional file 4). The data extraction form will be developed in Excel to capture key descriptive information about the article and framed according to the research questions relevant to this study. The data extraction form will be reviewed and refined based on discussion with the review team and piloted on 45 articles to check its suitability for capturing all relevant information. The following broad categories of data will be extracted:

1. Unique ID and assessor identification

2. Bibliographic information

3. Type of exposure/intervention and health outcomes

4, Type of marine environment

4. Information on study design

# Data analysis

### 5. Data mapping and presentation

A key output of mapping existing evidence will be a structured matrix, which is a graphical illustration of the distribution and frequencies of studies to document specific relationships between a range of exposures/interventions and outcomes [28]. Evidence on different outcomes (in rows) will be mapped onto different categories of exposures/interventions (in columns). Each cell represents an explored linkage between marine exposure/intervention and a measured human health or wellbeing outcome. Extraction of data from individual studies will be organized based upon the structured matrix. A draft matrix is available in Additional file 5, which illustrates the range of exposures/interventions and outcomes. The structured matrix will be developed using framework synthesis, which applies pre-determined categories to the data and enables structured comparison [29]. Each cell can be colour-coded according to the number of studies in the cell. If resources are available for a quality assessment a circle in each box will give the quality of the evidence (e.g. systematic reviews, meta-analysis), while the number of studies of different evidence strengths (i.e. strong, moderate, weak) will be colour coded. We aim to enable each cell to be linked to a user-friendly summary of the studies that populate it to allow the user to explore the main findings and other information on each study in more detail. The number of systematic reviews on each topic will also be shown in the cell.

In addition to the structured matrix, all articles included in the full text assessment will be characterized using descriptive statistics on key trends, including:

- The number of studies on exposure/intervention types changing through time;
- Map illustrating the number of studies per country;
- Type of study design.

### 6. Systematic review

If resources and time allow we will use the studies that have been extracted and processed for the systematic map to conduct a systematic review. Guided by the systematic map, and through consolation with the SOPHIE partners, advisory board and expert group we will identify a research area where a full systematic review would best be targeted to inform on policy.

*Literature cited*

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## Competing interests and sources of support

### Competing interests

The authors declare no competing interests.

## Timeline

The map will be completed by spring 2019.

# Authors' contributions

### Authors contributions

DTCC and RG conceived of and wrote the protocol. AB advised on developing the search strategy and will carry out the searches.

# Acknowledgements

**Acknowledgements**

We would like to thank the partners on SOPHIE, and the advisory board and the expert group for their input into the development of the protocol. This work complies with the RepOrting Standards for Systematic Evidence Synthesis (ROSES) check list [30].

**Funder details**

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*Literature cited*

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**Additional files**

Additional file 1: a) Partners, b) advisory board and c) expert group, in the Seas, Oceans and Public Health in Europe project;

Additional file 2: Key references used to develop search strategy;

Additional file 3: Search strategy;

Additional file 4: Extraction code;

Additional file 5: Draft of structured matrix.

**Additional file 1:** Partners, advisory board and expert group on the Seas, Oceans and Public Health in Europe project. Partners discussed and revised all relevant terms relating to 'marine' and 'human health'. The partners and advisory board informed on websites and data portals to search for grey literature.

The partners and advisory board met at the official opening of the SOPHIE project in Dublin, Ireland on 21st-23rd April 2018. At the opening DTCC and RG ran a workshop with the partners and advisory board to develop the structure of the exposures/interventions and health outcomes for the heat map (see additional file 5). Discussions also centred around the theoretical framework for the health outcomes from interactions with marine environments. The expert group subsequently met with SOPHIE project leads on 24-25th April, discussions from the meeting also feed into the structure of the map.

**1a:** Partners in the Seas, Oceans and Public Health in Europe project.

*Names of participants and their affiliations:*

| Name | Institution |
|---|---|
| Professor Lora Fleming | University of Exeter |
| Dr Ruth Garside | University of Exeter |
| Dr Timothy Taylor | University of Exeter |
| Dr Matthew White | University of Exeter |
| Dr Daniel Cox | University of Exeter |
| Dr Claire Eatock | University of Exeter |

| | |
|---|---|
| Sophie Davidson | University of Exeter |
| Dr Christine Domegan | National University of Ireland, Galloway |
| Dr Patricia McHugh | National University of Ireland, Galloway |
| Dr Sabine Pahl | University of Plymouth |
| Joke Coopman | European Marine Board |
| Dr Shelley Heymans | European Marine Board |
| Dr Paula Kellett | European Marine Board |
| Dr Kate Larkin | European Marine Board |
| Dr Jan-Bart Calewaert | EMODnet |
| Dr Oonagh McMeel | EMODnet |
| Dr Anouk Blauw | Marine and Coastal Information Service |
| Julia Vera Prieto | Travel Ecology |
| Dr Mariluz Parga | Sea Change Project |
| Dr Nathalie Tonne | Seascape consultants |
| Dr Susanne Wuijts | National Institute for Public Health and the Environment, UK |

**Additional file 1b: SOPHIE** advisory board.

| Name | Position/Institution |
|---|---|
| Professor Michael Depledge (Chair) | Chair Environment and Human Health, European Centre for Environment and Human Health, University of Exeter Medical School UK |
| Prof Sam Dupont | Associate Professor in marine ecophysiology at the University of Gothenburg (Sweden) and an Honorary Assistant Professor at the School of Biological Sciences, Hong Kong University. |
| Ms Esther Garrido Gamarro | Food Safety and Quality Officer working for the Products, Trade and Marketing Branch of the Fisheries and Aquaculture Department of the Food and Agriculture Organisation (FAO) of the United Nations. |
| Prof Bruce Maycock | Director Health Promotion, School of Public Health, Curtin University (Australia) and Secretary General of Asian Pacific Academic Consortium for Public Health. |
| Prof Katja Phillipart | Senior Scientist Royal Netherlands Institute for Sea Research and Associate Professor (University of Utrecht). |
| Mr Torsten Thiele | Founder of the Global Ocean Trust, focusing on marine conservation, technology and governance. |

**Additional file 1c:** SOPHIE expert group.

| Name | Position/Institution |
|---|---|
| Dr Ariana Zeka | Brunel Collete, University of London |
| Dr Alisa Berdalet | Consejo Superior de Investigaciones Científicas (CSIC) |
| Dr Micheál Ó Cinnéide | Environmental Protection Agency, Ireland |
| Dr Caroline Costongs | EuroHealthNet |
| Dr Hans Pirlet | Flanders Marine Institute (VLIZ) |
| Dr Anja Diekmann | Free University of Brussels |
| Professor Frank Sullivan | National University of Ireland, Galway (NUIG) |
| Professor Marcel Jaspers | University of Aberdeen |
| Dr Josep Lloret | University of Girona |
| Dr Tom Appleby | University of West of England |

| | |
|---|---|
| Dr Willem De Moor | JPI Oceans |

**Additional file 2** Key studies used to develop the search string.


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Resilience on Women's Health Study. Psychological Trauma:Theory, Research, Practice and Policy **04**: 04.
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**Additional file 2: Search strategy:**

Database: Ovid MEDLINE(R) Epub Ahead of Print, In-Process & Other Non-Indexed Citations, Ovid MEDLINE(R) Daily, Ovid MEDLINE and Versions(R) <1946 to May 16, 2018>

Search Strategy:

---

1 red tide*.ti. (293)

2 coast$1.ti. (6556)

3 coastal.ti. (8054)

4 seawater.ti. (3568)

5 sea$1.ti. (37212)

6 human*.ti. (988862)

7 surfer*.ti. (160)

8 fishing.ti. (1770)

9 fisheries.ti. (963)

10 communit*.ti. (141950)

11 toxin*.ti. (43024)

12 toxic*.ti. (130508)

13 neurotoxin*.ti. (4541)

14 Exposure*.ti. (141703)

15 Hazard*.ti. (21567)

16 Mortality.ti. (108214)

17 Fatalit*.ti. (3780)

18 Health$1.ti. (627396)

19 wellbeing.ti. (2060)

20 well being.ti. (10505)

21 illness*.ti. (41643)

22 infection*.ti. (401998)

23 intoxicat*.ti. (16555)

24 poison*.ti. (50160)

25 marine*.ti. (30615)

26 intoxicat*.ti. (16555)

27 poison*.ti. (50160)

28 disease*.ti. (1026566)

29 1 or 2 or 3 or 4 or 5 or 6 or 7 or 8 or 9 or 10 or 11 or 12 or 13 or 14 or 15 or 16 or 17 or 18 or 19 or 20 or 21 or 22 or 23 or 24 or 25 or 26 or 27 or 28 (3625470)

30 red tide*.tw. (621)

31 coast$1.tw. (23958)

32 coastal.tw. (26587)

33 seawater*.tw. (14961)

34 marine water*.tw. (1348)

35 bathing water*.tw. (371)

36 recreational water*.tw. (855)

37 seafood.tw. (4965)

38 beach*.tw. (6353)

39 30 or 31 or 32 or 33 or 34 or 35 or 36 or 37 or 38 (70586)

40 exp "Oceans and Seas"/ (30261)

41 39 or 40 (92686)

42 29 and 41 (42439)

43 (human adj2 health*).tw. (52351)

44 (public adj2 health*).tw. (199647)

45 (health adj2 risk*).tw. (35863)

46 (health adj2 outcome*).tw. (45089)

47 (mental adj2 health).tw. (116574)

48 wellbeing.tw. (11182)

49 well being.tw. (61008)

50 toxin*.tw. (124575)

51 neurotoxin*.tw. (16102)

52 exposure*.tw. (760596)

53 hazard*.tw. (202065)

54 illness*.tw. (231821)

55 intoxic*.tw. (43252)

56 poison*.tw. (77352)

57 43 or 44 or 45 or 46 or 47 or 48 or 49 or 50 or 51 or 52 or 53 or 54 or 55 or 56 (1779736)

58 42 and 57 (7751)

59 exp animals/ not humans.sh. (4463161)

60 58 not 59 (5148)

61 tetrodotoxin.ti. (1680)

62 (oil adj spil*).ti. (1221)

63 health*.tw. (2301593)

64 poison*.tw. (77352)

65 62 and 63 (176)

66 61 and 63 and 64 (11)

67 60 or 65 or 66 (5284)

68 limit 67 to yr="1990 -Current" (5028)

**********

**Additional file 4:** Data extraction form.

**CODE BOOK**

| **General** | | **Format type** |
|---|---|---|
| 0.1 | Article ID | Number |

| | | |
|---|---|---|
| 0.2 | Endnote ID | Number |
| 0.3 | Name of Assessor | Text |
| 0.4 | Date of assessment | Date |

**Bibliographic information**

| | | |
|---|---|---|
| 1.1 | Title | List |
| 1.2 | Authors citation | Text |
| 1.3 | Year of publication | Text |
| 1.4 | Journal name | List |
| 1.5 | Publication type | List |

**Exposure/intervention and health outcome**

| | | |
|---|---|---|
| 2.1 | Exposure or intervention | List |
| 2.2 | Type of exposure/intervention (Category) | List |
| 2.3 | Type of industry | List |
| 2.4 | Human activity | |
| 2.5 | Exposure route | List |
| 2.6 | Description of exposure/intervention | Text |
| 2.7 | Health outcome | List |
| 2.8 | Description of health outcome | Text |

**Study location**

| | | |
|---|---|---|
| 3.1 | Ocean or sea of exposure/intervention | List |
| 3.2 | Region of study | Text |
| 3.3 | Sub-region of study | List |
| 3.4 | Longitude | Text |
| 3.5 | Latitude | Text |

| | | |
|---|---|---|
| 3.6 | Notes | Text |

**Study design**

| | | |
|---|---|---|
| 4.1 | Population | |
| 4.2 | Sample size (treatment) | |
| 4.3 | Sample size (control) | Text |
| 4.4 | Population age | List |
| 4.5 | Study design | Text |
| 4.6 | Type of data | Text |
| 4.7 | Duration of study | Text |
| 4.8 | Duration of exposure / intervention | Text |
| 4.9 | Comparator used | Text |

**Other**

| | | |
|---|---|---|
| 5.1 | Any concerns over applicability | Text |

---

**Additional file 5:** Draft of structured matrix illustrating the existing literature on exposures to, and interventions with, the marine environment in Europe and associated countries.

| | OCEAN HEALTH | | | | | | | | | HUMAN ACTIVTIES | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | OCEAN HEALTH | | | | | | | | | INDUSTRY | | | | | | | | LIFESTYLES | | MARINE PRODUCTS | |
| | **Climate change, ocean acidification, carbon sink** | **Severe weather events** (hurricanes, storms, flooding) | **Overfishing** | **Plastic pollution** | **Microbial pollution (including HAB)** | **Air pollution** | **Agricultural pollution** | **Chemical pollution** (including oil spills, heavy metals, radiation, radionuclides, munitions) | **Pharmaceutical pollution** | **Fisheries and shellfish** | **Aquaculture** | **Shipping** | **Oil industry** | **Mining industry** | **Marine renewables** | **Other marine occupations** (e.g. coastguard, military) | **Tourism** (Coastal & water-based, cruises) | **Physical activity** (Blue Gym: coastal or water-based recreation) | **Non-physical activity / Coastal proximity** | **Desalination** | **Consumption of marine products** (including: fish, shellfish, seaweed) | **Marine biotechnology** (medical compounds, natural products, bio-prospecting, genomics, cosmetics) | |
| | | | | | | | | | | | | | | | | | | | | | | **Mortality** |
| | | | | | | | | | | | | | | | | | | | | | | **General health** (not covered by diseases below) |
| | | | | | | | | | | | | | | | | | | | | | | **Cardiovascular** |
| | | | | | | | | | | | | | | | | | | | | | | **Mental health** |
| | | | | | | | | | | | | | | | | | | | | | | **Wellbeing** (Quality of life, Social, Economic) |
| | | | | | | | | | | | | | | | | | | | | | | **Wounds and injuries** |
| | | | | | | | | | | | | | | | | | | | | | | **Infections** |
| | | | | | | | | | | | | | | | | | | | | | | **Toxins, poisoning, bites and stings** |
| | | | | | | | | | | | | | | | | | | | | | | **Gastrointestinal diseases** |
| | | | | | | | | | | | | | | | | | | | | | | **Muscoskeletal disease** |
| | | | | | | | | | | | | | | | | | | | | | | **Respiratory disease** |
| | | | | | | | | | | | | | | | | | | | | | | **Nervous system disease** (including HIV) |
| | | | | | | | | | | | | | | | | | | | | | | **Endocrine** |