Template for Social and Economic Data Collection

OES-Environmental has developed [Good Management Practices](https://tethys.pnnl.gov/publications/good-management-practices-social-economic-data-collection-marine-renewable-energy) for the collection of social and economic data for marine energy in order to provide greater standardization in baseline and development/operational data requested to support permitting/consenting marine energy projects and to increase understanding of the social and economic effects of marine energy. To achieve this, increasing consistency in data collection will be necessarily, particularly as it can allow for comparisons of data across projects, communities, and technologies (for more information, see the [2020 State of the Science Report chapter on Social and Economic Data Collection for Marine Energy](https://tethys.pnnl.gov/publications/state-of-the-science-2020-chapter-9-social-economic)).

*Table 1. Good management practices for collecting social and economic data for marine energy. Adapted from Freeman 2020, 2024 in press.*

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| Practice 1 | Strategic level data collection, analysis, and assessments should be carried out by the appropriate level of local, regional, or national government (or relevant agencies) to understand benefits and effects of marine energy projects.  |
| Practice 2 | Specific questions should be developed that elucidate changes in social or economic conditions (either benefits or effects) for the communities and regions in which marine energy development is planned. These questions should drive the specific data collection efforts and analyses. |
| Practice 3 | Baseline social and economic data should be collected that address the current social and economic attributes, at the appropriate scale, prior to development.  |
| **Practice 3a:** Baseline data for strategic assessments should be gathered by appropriate level of local, regional, or national government, scaled to the closest possible geographic scale to the area of the project before development occurs.  | **Practice 3b:** Project level baseline data should be gathered by the project developer, assisted by existing supply chain companies and other local stakeholders as part of permitting/consenting processes before development occurs. If multiple projects are occurring on similar timescales, the project developers should be encouraged to collaborate to help gather data to inform strategic assessments.  |
| Practice 4 | Social and economic data should be collected once marine energy development has occurred and the devices are operational. To the greatest extent possible, data should be collected using similar variables/methods as baseline data to allow for direct before/after comparison.  |
| **Practice 4a:** Social and economic data should be collected at the same scales, using the same methodologies for strategic level assessments, by the appropriate level of local, regional, or national governments.  | **Practice 4b:** Social and economic data should be collected at the same scales, using the same methodologies for project level assessment, by the project developer, with assistance from supply chain personnel and other local stakeholders, including local governments.  |
| Practice 5 | Results from both social and economic assessments should be clearly communicated to the communities affected by marine energy developments, with a focus on transparency of methods, analyses, and purpose of the studies. Strategic level assessment communication is the responsibility of the appropriate level of government, while project level social and economic assessments should be jointly presented by the project developer and the appropriate level of government.  |

The OES-Environmental [2020 State of the Science Report chapter on Social and Economic Data Collection for Marine Energy](https://tethys.pnnl.gov/publications/state-of-the-science-2020-chapter-9-social-economic) identifies the need for a framework and tools to support the consistent collection of social and economic data. The following template has been developed to aid this effort, as well as to support users in the process of baseline data collection (Practice 3), and for measuring social and economic effects after development/operation (Practice 4). For more information on the metrics described in this template, refer to the Social and Economic Data [Toolkit](https://tethys.pnnl.gov/marine-energy-social-economic-data-collection-toolkit)or the [Definitions](https://tethys.pnnl.gov/sites/default/files/attachments/Definitions.pdf).



# Baseline Social and Economic Data to Collect

Baseline data needs to be collected in order to appropriately plan and site a marine energy project, as well as to have an information basis to assess any changes resulting from the project implementation and operation. This data can be collected at a strategic level, for example, to inform a marine spatial planning process for marine energy ([Marine Scotland Science 2015](https://consult.gov.scot/marine-scotland/pfowmarinespatialplan/supporting_documents/PFOW%20MSP%20%20SocioEconomic%20Baseline%20Review.pdf)) or at the project level (e.g., Iguigig Hydrokinetic Project, [FERC 2019](https://tethys.pnnl.gov/publications/environmental-assessment-hydropower-license-igiugig-hydrokinetic-project)) in siting or developing a particular marine energy project. In either case, the earlier this template is used to synthesize data and identify future efforts for data collection, the more helpful it will be to inform the planning process and any future assessments.



# Monitoring Social and Economic Effects

Once marine energy projects are operational, comparisons to baseline data are needed to assess whether there are unforeseen benefits or effects of the developments and to assess whether the predictions set forward by the developer in permitting/consenting applications are realized, and to inform adaptive management. Ideally, this monitoring data is collected at the same scales and using the same methods as baseline assessments. Monitoring can be done at a strategic-level ([Government of Canada 2018](https://tethys.pnnl.gov/publications/proposed-impact-assessment-system)) or a project-level (e.g., [European Marine Energy Center 2019](https://tethys.pnnl.gov/publications/emec-socio-economic-report)) and is common across renewable energy developments ([Karytsas et al. 2020](https://tethys.pnnl.gov/publications/measurement-methods-socioeconomic-impacts-renewable-energy-projects), [Vanclay et al. 2015](https://tethys.pnnl.gov/publications/social-impact-assessment-guidance-assessing-managing-social-impacts-projects)) to ensure successful deployments that ultimately benefit communities in an equitable way. The requirements for monitoring social and economic effects vary by country and other jurisdictions, so it will be important especially at the project-level to consult with regulators to determine the highest priority metrics in the template below.

# Template for Data Collection

The tables below organize the social (light blue) or economic (light orange) data that can be collected for baseline assessments and monitoring by themes with 54 key metrics, provides resources and methods for how to collect that data and the typical units that are used in reporting that data. Additional information on each metric and examples of data collection are available in the [Toolkit](https://tethys.pnnl.gov/marine-energy-social-economic-data-collection-toolkit).

The last two columns are left blank for a user to fill in notes or data collected on the metrics selected. There is no requirement to complete the full table, rather this is provided as an example approach to identify factors for consideration as part of a baseline assessment and continued monitoring of effects that can be tailored to communities and project goals.

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|  | **Type of Data/Information** | **Methods + Resources** | **Typical Units and Scale of Collection** | **Findings for Project** |
| **Baseline Data** | **Monitoring Data** |
| Social | *Social/Cultural Context and Communities* |
| * Adaptation
 | Adaptation is an aspect of a community’s capacity and can be assessed using community based scenario planning ([Bennett et al., 2016](https://doi.org/10.1007/s10668-015-9707-1)) and participatory action research ([Sumardjo et al. 2019](https://doi.org/10.1088/1755-1315/399/1/012028)). It is often assessed in the context of climate change resilience.  | Unitless, described based on the ability of a person or people to change; how easy or difficult different paths are. Adaptation attributes could be available at a strategic level, though additional information and conversations with communities will need to be had to determine adaptation at a project level. | Click or tap here to enter text. | Click or tap here to enter text. |
| * Behaviors
 | Community behaviors can be assessed using surveys ([Community Toolbox Section 7](https://ctb.ku.edu/en/table-of-contents/evaluate/evaluate-community-initiatives/behavioral-surveys/main)) at regular intervals to collect data relevant to project acceptance, renewable energy technology adoption, or participation ([Klein and Coffey 2016](https://doi.org/10.1016/j.rser.2016.01.129)). | Behaviors can be measured through the decisions that a person makes. Individual or community behavior data is typically collected at the project level. | Click or tap here to enter text. | Click or tap here to enter text. |
| * Climate Concerns
 | Information on climate impacts is often available for particular regions (e.g., [NASA SEDAC](https://sedac.ciesin.columbia.edu/data/collections/browse)), though local concerns and perceptions of climate impacts are measured using interviews or surveys for a particular community ([Dreyer et al. 2017](https://tethys.pnnl.gov/publications/changing-tides-acceptability-support-perceptions-tidal-energy-united-states)). Scales and indices exist for measuring climate awareness and risk perceptions ([Libarkin et al. 2018](https://doi.org/10.1007/s10584-018-2279-y), [van Valkengoed et al. 2021](https://doi.org/10.1016/j.jenvp.2021.101652), [Climate Perceptions Index 2022](https://www.socialprogress.org/static/c418b8270a98d47a10372b1025015aa0/Climate%20Perceptions%20Index%20%289%29.pdf)). | In interviews or surveys climate concerns may be measured in terms of a set ranking system of concern level. This system might be specific to the study and not widely applicable.Information on spatial climate impacts may be available at a strategic level (e.g., [NASA SEDAC](https://sedac.ciesin.columbia.edu/data/collections/browse)), though additional information and conversations with communities will need to be had to determine specific local concerns and perceptions at the project level. | Click or tap here to enter text. | Click or tap here to enter text. |
| * Community Structure
 | Community structure is observed and described through conversations, focus groups, ethnographic fieldwork or other social science approaches (e.g., [Gjorgievski et al. 2021](https://doi.org/10.1016/j.renene.2021.01.078), [Girvan and Newman 2002](https://doi.org/10.1073/pnas.122653799)). | Community structure can be measured in terms of the roles of community members; looking at who is involved in which aspects of the community. Information on community structure is collected at the project level. | Click or tap here to enter text. | Click or tap here to enter text. |
| * Conflict
 | Conflicts around a project (spatial or ideological) can be identified using marine spatial planning tools ([Harte et al. 2010](http://hdl.handle.net/1834/21568), [Kyriazi 2018](https://doi.org/10.1016/j.ocecoaman.2018.03.018), [Michalak 2018](https://doi.org/10.1007/978-3-319-74576-3_31)), participatory mapping ([Moore et al. 2017](https://doi.org/10.1016/j.jenvman.2016.12.026)), surveys or interviews ([Alexander 2012](https://pure.uhi.ac.uk/en/studentTheses/offshore-power-production-and-marine-stakeholders)), or Environmental and Social Impact Assessments ([Omenge et al. 2020](https://doi.org/10.2495/EQ-V5-N2-157-174)).  | Conflicts can be measured by how likely they are to occur, how big of an impact they would have, and the specific consequences that would result. Potential conflicts may be identified at the strategic level but are assessed and mitigated at the project level. | Click or tap here to enter text. | Click or tap here to enter text. |
| * Cultural Values
 | Cultural values may include perceptions of the physical landscape, historical connections, social structures or moral principles. These can be measured using ethnographic fieldwork ([Howell 2019](http://hdl.handle.net/1842/35911)), participatory methodologies such as value mapping ([Janssen et al. 2014](http://dx.doi.org/10.1080/09640568.2014.887561)), social media analysis ([Ginzarly et al. 2019](https://doi.org/10.1016/j.culher.2018.10.002)), or Q methodology ([Loring and Hinzman 2018](https://doi.org/10.1016/j.ecolecon.2018.06.020)). | Described in text format or as themes or goals, that may be formalized or informally agreed upon within a community.Information on cultural values may be available at a strategic level, though additional information and conversations with communities will need to be had to determine specifics at the project level. | Click or tap here to enter text. | Click or tap here to enter text. |
| * Demographics
 | Demographic information includes data on age, sex, income level, race/ethnicity, employment, homeownership, and level of education, and is typically collected through self-reporting in surveys at the census or household level. | Demographics overall are not measured in units, more in descriptions, such as gender, age, and education. Within these categories there can be units (i.e., education years) or reported as percentages for defined categories. Demographic information is often collected at a strategic level but may need to be downscaled or ground-truthed at the project level.  | Click or tap here to enter text. | Click or tap here to enter text. |
| * Energy Justice and Equity
 | Energy justice and equity can be difficult to measure but are important to consider and monitor. Environmental justice frameworks (such as [JUST-R](https://doi.org/10.1016/j.joule.2023.01.007), [EJ Screen](https://www.epa.gov/ejscreen), [EPA 2016](https://www.epa.gov/environmentaljustice/technical-guidance-assessing-environmental-justice-regulatory-analysis)), can provide a structure for this. The Meaningful Marine Renewable Energy Development Framework provides an example case study and a list of questions to consider for marine energy specifically ([Caballero et al., 2023](https://tethys.pnnl.gov/publications/energy-justice-coastal-communities-case-meaningful-marine-renewable-energy-development)).  | It can be difficult to attach units to energy justice and equity as there are many dimensions of justice to consider. Several metrics related to equity with baseline data are included in the US DOE’s [Energy Justice Dashboard](https://www.energy.gov/justice/energy-justice-dashboard-beta) as well as described by [Dutta et al. 2023](https://doi.org/10.1016/j.joule.2023.01.007).Energy justice and equity are often assessed at a strategic level, though additional planning and monitoring is needed at the project level to ensure fair outcomes. | Click or tap here to enter text. | Click or tap here to enter text. |
| * Fisheries
 | Less data exist around the social aspects of fisheries than the economic aspects, but some social indicators can be measured that help describe current fisheries as stakeholders to be engaged in planning processes ([FAO Stakeholder Analysis](https://www.fao.org/fishery/en/eaftool/eaf_tool_16/en)), to understand perceptions and concerns of fishers related to marine energy ([Kazimierczuk et al. 2023](https://tethys.pnnl.gov/publications/socio-technical-assessment-marine-renewable-energy-potential-coastal-communities)), and to assess vulnerabilities ([NOAA Social Indicators](https://www.st.nmfs.noaa.gov/data-and-tools/social-indicators/)).  | Social fisheries information can be measured in terms of commercial or recreational fishing engagement and reliance, from Low to High ([NOAA Social Indicators](https://www.st.nmfs.noaa.gov/data-and-tools/social-indicators/)).Some fisheries data is collected at a strategic level for fishery management purposes, though additional information gathering may be needed at the project level to assess social effects. | Click or tap here to enter text. | Click or tap here to enter text. |
| * Gender
 | Gender distribution and effects within a community can be assessed with surveys and gender analysis tools (e.g., [WHO Gender Assessment Tool](https://www.ndi.org/sites/default/files/WHO%20Gender%20Assessment%20Tool.pdf)). Gender is increasingly important to consider in the renewable energy development space ([Bagdi et al. 2023](https://doi.org/10.1016/j.jclepro.2023.138654)). | Gender distribution in a community is reported in terms of percentages per defined category along a spectrum. Gender analysis may be conducted at a strategic level, though additional information gathering may be needed at the project level to assess effects or identify opportunities for a project to contribute to gender equality. | Click or tap here to enter text. | Click or tap here to enter text. |
| * Participation
 | Public participation in a marine energy project is driven by regulatory requirements and developer planning processes. Participation opportunities fall on a spectrum of inform, consult, involve, collaborate, and empower ([International Association for Public Participation](https://organizingengagement.org/models/spectrum-of-public-participation/)).  | Unitless.Participation is designed and implemented at the project level, though may be evaluated or regulated at a strategic level. | Click or tap here to enter text. | Click or tap here to enter text. |
| * Perceptions
 | Public perceptions of a marine energy project are measured using surveys, interviews, or focus groups ([Stelmach et al. 2023](https://doi.org/10.1016/j.ocecoaman.2023.106666), [Hooper et al. 2020](https://tethys.pnnl.gov/publications/public-perceptions-tidal-energy-can-you-predict-social-acceptability-across-coastal)). Perceptions can be incorporated into frameworks for decision-making ([Richardson et al. 2022](https://doi.org/10.1016/j.rser.2021.112032)). | Unitless, typically described in terms of level of support or positive vs. negative attitudes. Perception studies on marine energy in general are often conducted at a strategic or research level, but additional information is needed to understand perceptions of a particular project or development. | Click or tap here to enter text. | Click or tap here to enter text. |
| * Resilience
 | Social resilience is measured using various indicators, as described by [Saja et al. 2021](https://doi.org/10.1016/j.ijdrr.2020.101957) for disaster management and by [Sterling et al. 2017](https://doi.org/10.3167/ares.2017.080104) more generally for social-ecological systems, though there are no agreed upon standards across disciplines ([Copeland et al. 2020](https://doi.org/10.1016/j.ijdrr.2020.101799)). It is often linked with vulnerability. | Unitless, described based on selection of various indicators.Social resilience data can be collected at a strategic level or project level. | Click or tap here to enter text. | Click or tap here to enter text. |
| * Vision
 | Vision can be elucidated through conversations or strategic planning efforts with communities. A [tip sheet for structured community visioning](https://ctb.ku.edu/en/table-of-contents/overview/models-for-community-health-and-development/mapp/tools) has been developed in the Community Tool Box by the University of Kansas for community health that can be adapted for marine energy. Q methodology can also be used to assess the tradeoffs that people consider in developing a vision and set of shared values (e.g., [Loring and Hinzman 2018](https://doi.org/10.1016/j.ecolecon.2018.06.020)). | Vision is usually described in a text document with goals that is agreed upon by a community.A community vision or set of goals may exist prior to a marine energy project, but additional planning is typically needed at the project level to incorporate marine energy or clarify the community’s vision for a marine energy project. | Click or tap here to enter text. | Click or tap here to enter text. |
| * Vulnerability
 | Social vulnerability indicators have been developed for coastal communities and fisheries by the [National Oceanic and Atmospheric Administration (NOAA 2021)](https://www.fisheries.noaa.gov/national/socioeconomics/social-indicators-coastal-communities) and for natural disasters by the [Center for Disease Control (CDC 2023)](https://www.atsdr.cdc.gov/placeandhealth/svi/index.html), and can be applied for marine energy. | The CDC tool uses a unitless summary score and the NOAA tool allows for exploration of various indicators without presenting an overall score.Vulnerability data is typically collected at a strategic level. | Click or tap here to enter text. | Click or tap here to enter text. |
| *Leisure, Recreation, and Enjoyment of Place* |
| * Accessibility
 | Accessibility of a site is typically assessed using spatial tools (e.g., [Alwah et al. 2021](https://doi.org/10.1016/j.ufug.2021.127152), [UrbanAccess](https://github.com/UDST/urbanaccess)) to determine usability, while accessibility of a process is assessed using more social science tools (see Participation). | Various units.Accessibility data is typically collected at a strategic level, but may be influenced by development of a new project, requiring further assessment. | Click or tap here to enter text. | Click or tap here to enter text. |
| * Aesthetics
 | Aesthetic impacts of a project are typically simulated using visualization software (e.g., [Sullivan et al. 2013](https://tethys.pnnl.gov/publications/offshore-wind-turbine-visibility-visual-impact-threshold-distances)) and shared with communities or the public for feedback using surveys or choice experiments (e.g., [Caporale et al. 2024](https://doi.org/10.1016/j.jenvman.2023.119454)). | Various units, based on the design and questions used.Aesthetic impacts are assessed at a project level. | Click or tap here to enter text. | Click or tap here to enter text. |
| * Place Attachment
 | Place attachment can be measured using a standard, 5 point scale (Strongly Agree to Strongly Disagree) responding to the question “I feel at home in (location)”; “This (location) is part of my identity”; and more questions available from [Hernández et al. 2007](https://doi.org/10.1016/j.jenvp.2007.06.003). Responses to questions can be summed to generate strength of place attachment. These questions can be asked in a survey or discussed in more detail in interviews or focus groups to identify themes related to place attachment (e.g., [Devine-Wright and Howes 2010](https://doi.org/10.1016/j.jenvp.2010.01.008)). | Unitless, based on rankings and relative to other respondents.Place attachment data can be collected at a strategic level or project level. | Click or tap here to enter text. | Click or tap here to enter text. |
| *Local Governance, Services, Infrastructure, and Facilities* |
| * Education
 | Education can be measured using a variety of methods ([Smith 1995](https://doi.org/10.1006/ssre.1995.1008)). Available data can be collected such as census or education system data (e.g., [USDA Educational Attainment](https://www.ers.usda.gov/data-products/county-level-data-sets/county-level-data-sets-download-data/)). Education data can also be collected more directly via surveys, polls, interviews, expert elicitation, or workshops.  | Units of education to be measured include the quantity or amount of education (number of years attended/completed or highest degree obtained), the content of education (courses, content of courses, majors/minors), and the type of education (high school, 4-year, university, community college, vocational, etc.) ([Smith 1995](https://doi.org/10.1006/ssre.1995.1008)).  | Click or tap here to enter text. | Click or tap here to enter text. |
| * Policies and Governance
 | Local and national policies play a major role in facilitating or limiting the development of marine energy, as well as stipulating requirements for social data collection. Some tools exist to provide or evaluate these policies, including the [Marine Energy Toolkit](https://marineenergy.app/) in the United States. | No units.Data and guidance on policies and governance are typically collected at strategic levels, though will need to be applied at the project level. | Click or tap here to enter text. | Click or tap here to enter text. |
| * Spatial Aspects and Displacement
 | Spatial aspects are a category of data that can include ocean use (recreation areas, fishing grounds, navigation channels, etc.), distribution of marine resources, and others. Data are often available via open access data portals hosted by government agencies, or they can be collected through participatory mapping exercises. Spatial data are typically shown or assessed via geospatial tools such as GIS, which map and help analyze data. One common approach to analyze data includes multi-criteria decision making, which can be used to identify potential overlap in use, possibly displaced activities, or opportunities for new uses. | Units will depend on the type of each data collected but may be shown as presence or absence of a use or resource. Spatial data can be collected at a strategic level or project level. | Click or tap here to enter text. | Click or tap here to enter text. |
| *Health and Well-Being* |
| * Health
 | Health effects of a marine energy project are measured using various tools depending on the effect proposed (e.g., [AirToxScreen](https://www.epa.gov/AirToxScreen/airtoxscreen-mapping-tool), [Climate and Economic Justice Screening Tool](https://screeningtool.geoplatform.gov/en/#3/33.47/-97.5)). | Various units related to toxicity, emissions, noise, etc.Research on health effects is done at the strategic level, but will likely be monitored at the project level. | Click or tap here to enter text. | Click or tap here to enter text. |
| * Risk
 | Risks are identified and assessed using tools such as Ready.gov’s [Risk Assessment Tool](https://www.ready.gov/business/planning/risk-assessment), though many others exist. Risks can also be identified through participatory methodologies and conversations with communities. In the context of health and well-being of a community, risks from marine energy projects could include mechanical failures, impacts to the ecosystem, pollution, and insufficient regulatory / policy systems to ensure equitable outcomes. | Often determined on a scale of low, medium, or high – units may vary based on assessment tool or components considered.Risk is assessed at the project level. | Click or tap here to enter text. | Click or tap here to enter text. |
| * Safety
 | Safety can be assessed before a project begins by developing and evaluating prevention plans, specifically in the context of workers for installation or operations and maintenance. Developing and improving on safety culture within a community or organization can be key to preventing accidents ([Vogus et al. 2007](https://doi.org/10.1097/01.mlr.0000244635.61178.7a), [Moriarty 2015](https://doi.org/10.1016/B978-0-12-420244-3.00004-2)). | Unitless – typically improvement areas are identified from an assessment.Safety is assessed at the project level, though mechanisms for regulation or enforcement are developed at the strategic level. | Click or tap here to enter text. | Click or tap here to enter text. |
| * Well-Being
 | Measuring economic well-being is a complex task as it involves assessing various aspects of individuals' lives. It can be measured using subjective well-being, where individuals rate their overall life satisfaction or happiness on a scale (e.g., [Oxford Happiness Questionnaire](https://doi.org/10.1016/S0191-8869%2801%2900213-6), [Kusier and Folker 2021](https://doi.org/10.1007/s10728-020-00420-y)); or by combining indicators such as quality and quantity of social relationships, available support networks, environmental quality, level of autonomy, sense of purpose, personal values, and other social indicators (e.g., [Larson 1993](https://doi.org/10.1007/BF01079022), [Burke et al. 2010](https://doi.org/10.1145/1753326.1753613)). | Various units, depending on indicators used and if summarized into an overall metric.Data on social well-being may be collected at a strategic level, though effects may need to be assessed at a project level. | Click or tap here to enter text. | Click or tap here to enter text. |
| *Success Stories and Lessons Learned* |
| * Barriers / Enablers
 | Social barriers and enablers, while possible to identify and infer based on information from other locations, are most likely to be recognized after a project has been initiated or completed. This information is often collected informally by those involved in the project reflecting on difficult phases compared to smooth phases or comparing experiences with projects in other locations to identify unique social factors. | Unitless.Social barriers or enablers can vary by project or location/country. Data can be collected at all levels for strategic planning and for project development. | Click or tap here to enter text. | Click or tap here to enter text. |
| * Social License and Acceptance
 | Social license (or social license to operate or engage) is considered in terms of the level of acceptance, social approval or support for a project, going beyond what is required for regulatory consent ([Soukissian et al. 2023](https://doi.org/10.5281/zenodo.7561906)). It can be measured through providing opportunities for public participation and feedback on project planning processes ([Uffman-Kirsch et al. 2020](https://doi.org/10.3389/fmars.2020.571373), [Kelly et al. 2017](https://doi.org/10.1016/j.marpol.2017.03.005)).  | Typically considered an earned achievement or level agreed upon with community.Social license and acceptance are obtained at the project level. | Click or tap here to enter text. | Click or tap here to enter text. |
| * Trust
 | Credible consultation processes are needed to build trust and acceptance of marine energy ([Simas et al. 2012](https://tethys.pnnl.gov/publications/understanding-role-stakeholders-wave-energy-consenting-process-engagement)). Trust in organizations can be measured using tools such as the [Leadership Trust Index](https://www.forbes.com/sites/forbescoachescouncil/2023/02/14/measuring-trust-using-the-leadership-trust-index/), while trust in governments can be measured using information like the [OECD Guidelines on Measuring Trust (2017)](https://doi.org/10.1787/9789264278219-en). | Unitless – can be reported as low, medium, high or in an index.Trust is measured at both the project level and strategic level. | Click or tap here to enter text. | Click or tap here to enter text. |

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|  | **Type of Data/Information** | **Methods + Resources** | **Typical Units and Scale of Collection** | **Findings for Project** |
| **Baseline Data** | **Monitoring Data** |
| Economic | *Business Sectors, Existing Industries, and Infrastructure* |
| * Barriers / Enablers
 | Economic barriers or enablers – aspects that either facilitate or present success – information may be collecting using GIS, interviews, surveys, workshops, literature (e.g., [Brummer 2018](https://doi.org/10.1016/j.rser.2018.06.013)), or PESTEL or SWOT analyses (e.g., [Posterari and Waseda, 2022](https://doi.org/10.3390/en15072606)).  | Unitless – may include legal requirements and frameworks, financial (cost, funding/grants, financing, etc.), market structure, and political or institutional/government support ([Brummer 2018](https://doi.org/10.1016/j.rser.2018.06.013)). Economic barriers or enablers can vary by project or location/country. Data can be collected at all levels for strategic planning and for project development.  | Click or tap here to enter text. | Click or tap here to enter text. |
| * Capacity
 | Capacity can be understood with a variety of methods including case studies, economic analysis, industry research, interviews, surveys, comprehensive vulnerability framework, resource assessment, and more. Capacity is not static and will need to be reassessed overtime to understand changes in capacity.  | Unitless. Data can include generating/marine energy resource, human resource, supply chain/industry capacity (e.g., [AEDG Metric Explorer](https://akenergygateway.alaska.edu/community_metric_explorer/)). Data is often collected at the project level to understand capacity at a location for development but could be collected at the strategic level for strategic planning and management.  | Click or tap here to enter text. | Click or tap here to enter text. |
| * Emissions
 | Emissions from marine energy and other businesses and industries can be calculated using life cycle assessments, dynamic computable equilibrium model of the whole economy of marine energy to identify associated emissions, input-output model.  | Units may vary, but typical units are metric tons or kiloton (kt). Other greenhouse gases may be converted to equivalents (such as carbon dioxide equivalents) to allow for comparison and individual/total contributions to climate change (e.g., [EPA Greenhouse Gases Equivalencies Calculator](https://www.epa.gov/energy/greenhouse-gases-equivalencies-calculator-calculations-and-references)). Data is likely to be collected at a strategic level for the marine energy sector, though it may also be assessed for a specific project.  | Click or tap here to enter text. | Click or tap here to enter text. |
| * Fisheries
 | Fisheries data is often available at a high level by governments or jurisdictions responsible for sustainable management and may exist as stock assessments (e.g., [NOAA Fisheries Fish Stock Assessment Report](https://www.fisheries.noaa.gov/national/population-assessments/fish-stock-assessment-report)), maps (e.g., [Global Fishing Watch](https://globalfishingwatch.org/our-map/)), or landing reports. Interviews or participatory meetings can be conducted to get a more detailed assessment of fished species, gear types, critical locations, and fisher values – often as part of larger marine spatial planning activities (e.g., [ScotMap](https://marine.gov.scot/information/scotmap-inshore-fisheries-mapping-project-scotland), [Kafas et al. 2017](https://doi.org/10.1016/j.marpol.2017.01.009), [Bakker et al. 2019](https://tethys.pnnl.gov/publications/resilience-social-capital-engagement-fisheries-communities-marine-spatial-planning)). | Annual fishing effort and catch by gear type, location, and season. Often measured in catch per unit effort (kg/hour fished or similar), or through [Fishery Performance Indicators](https://fisherysolutionscenter.edf.org/tools/fishery-performance-indicators).Fisheries data is often collected at a strategic level for management purposes, though additional information gathering may be needed at the project level to assess displacement or plan sites appropriately. | Click or tap here to enter text. | Click or tap here to enter text. |
| * Grid
 | Grid data is typically acquired from local utility information or maps. In some cases, this is publicly available, but for site-specifics it will likely need to be requested from the utility. Analysis to incorporate additional renewable energy sources into existing grid can be done using tools like NREL’s [REopt](https://reopt.nrel.gov/). | Typically available in map formats or vessel tracks. Grid data is available from the utility, though planning is also done at a strategic level for regions (e.g., [Amaro et al. 2022](https://doi.org/10.3390/jmse10040463)). | Click or tap here to enter text. | Click or tap here to enter text. |
| * Navigation
 | Existing navigation routes that present spatial conflicts for marine energy (deployment or operations) can be identified using a variety of resources based on the location, such as [Kpler’s Marine Traffic](https://www.marinetraffic.com/en/ais/home/centerx%3A-151.3/centery%3A39.8/zoom%3A4). A GIS or other spatial tools are used to identify areas of overlap or navigation risk (e.g., [Rawson and Brito 2022](https://doi.org/10.1016/j.ocecoaman.2022.106078)). | Typically, available in map formats. Navigation data is often collected and provided at a strategic level, though additional information gathering may be needed at the project level to predict effects and plan appropriately. | Click or tap here to enter text. | Click or tap here to enter text. |
| * Tourism
 | Tourism impacts can be assessed using Tourism and Recreation Impact Assessments ([Canteiro et al. 2018](https://doi.org/10.1016/j.tmp.2018.09.007), [Machado et al. 2023](https://doi.org/10.1016/j.eiar.2022.106999)) that typically leverage participatory mapping and interviews with key stakeholders to understand and model anticipated impacts. Indicators are often used to assess sustainability ([Lozano-Oyola et al. 2012](https://doi.org/10.1016/j.ecolind.2012.01.014), [Rasoolimanesh et al. 2020](https://doi.org/10.1080/09669582.2020.1775621)). Additional sources of tourism data can include crowd sourced photographs (Sessions et al. 2016), big data ([Kalvet et al. 2020](https://doi.org/10.3390/su12187470)), or on-site surveys ([Riddington 2009](https://doi.org/10.1002/jtr.750)). | Typically reported in terms of additional revenue generated.Tourism data is often collected at a strategic level, though additional information gathering may be needed at the project level to predict effects and plan appropriately. |  |  |
| *Employment and Wages* |
| * Employment
 | Existing employment information is often available in public census data. Employment effects can be measured using a coupled Techno-economic Input-Output Model that considers project design, operation, and costs, location of the project, and device information to project the total gross added value and number of created jobs ([Draycott et al. 2018](https://doi.org/10.3390/en11102824)). | Total job years per project phase.Employment data is often collected at a strategic level, though planning and monitoring may be done at the project level. | Click or tap here to enter text. | Click or tap here to enter text. |
| * Income
 | Information on income can be found through public census data or within interviews and surveys to a community. A stated preference approach can be used to understand how income level may impact perceptions of the effects of renewable energy projects ([Dalton et al. 2020](https://doi.org/10.1016/j.marpol.2020.104216)). | Annual pre- or post-tax household income, annual salary ranges.Income data for specific jobs or communities is often collected at a strategic level, though planning and monitoring may be done at the project level. | Click or tap here to enter text. | Click or tap here to enter text. |
| * Livelihood
 | Livelihood status can be measured using indicators for income, vulnerability, risk, health, nutrition, and education. Several approaches can be used, including the [Livelihoods Programme Indicators](https://www.livelihoodscentre.org/key-indicators), the Livelihood Asset-Status Tracking Method ([Bond and Mukherjee 2002](https://doi.org/10.1002/jid.926)), the Sustainable Livelihood Approach (e.g., [Chen et al. 2013](https://doi.org/10.1016/j.landusepol.2012.06.009)). Livelihood security and resilience can also be measured ([Quandt, 2018](https://doi.org/10.1016/j.worlddev.2018.02.024), [Pal et al. 2023](https://doi.org/10.1016/j.mex.2023.102301), [Singh and Hiremath 2010](https://doi.org/10.1016/j.ecolind.2009.07.015)). | Typically unitless, depending on the index may be reported as a value or a percentile.Data on livelihood may be collected at a strategic level, though effects may need to be assessed at a project level. | Click or tap here to enter text. | Click or tap here to enter text. |
| * Well-Being
 | Measuring economic well-being is a complex task as it involves assessing various aspects of individuals' lives. It can be measured using subjective well-being, where individuals rate their overall life satisfaction or happiness on a scale (e.g., [Oxford Happiness Questionnaire](https://doi.org/10.1016/S0191-8869%2801%2900213-6), [Kusier and Folker 2021](https://doi.org/10.1007/s10728-020-00420-y)); or objectively using physical health, education, income and other economic indicators. The United Nations combines several of these indicators in the [Human Development Index](https://hdr.undp.org/data-center/human-development-index#/indicies/HDI) to assess overall well-being.  | Various units, depending on indicators used and if summarized into an overall metric.Data on economic well-being may be collected at a strategic level, though effects may need to be assessed at a project level.  | Click or tap here to enter text. | Click or tap here to enter text. |
| *Marine Energy Industry* |
| * Aesthetics
 | The aesthetic or visual impacts of a marine energy project vary based on device design, siting, and features or perceptions of the local environment. A detailed methodology for Seascape, Landscape and Visual Assessment (SLVIA) has been applied for offshore wind in the US ([BOEM 2021](https://tethys.pnnl.gov/publications/assessment-seascape-landscape-visual-impacts-offshore-wind-energy-developments-outer)), and similar methodologies have been used at the EMEC Billia Croo test site ([EMEC 2019](https://tethys.pnnl.gov/publications/billia-croo-test-site-environmental-statement)) and in coastal Oregon’s Territorial Sea Planning ([Lanier et al. 2013](https://www.oregonocean.info/index.php/ocean-documents/planning/territorial-sea-plan2/part-5-marine-renewable-energy-facility-siting-2009-2013-2019/2070-vrm-methods-presentation/file)). An SLVIA includes provision of a clear description of the proposed project options, often with visual simulations, and engagement with stakeholders through surveys, focus groups, or public meetings to gauge preferences. Site visits and photographs may be needed to assess baseline aesthetics or viewsheds. | Spatial data (including viewsheds) is typically generated as an output of aesthetic impact assessments and may be linked to site suitability maps. In the design phase, data may include ranked lists of designs, layouts, or sites that are preferred by community members.Aesthetic impact data is typically collected at the project level, though some strategic level assessments may exist as part of larger marine spatial planning activities. | Click or tap here to enter text. | Click or tap here to enter text. |
| * Affordability
 | Affordability is assessed by comparing the expected cost of marine energy to current cost of electricity and the capacity of the end user to pay (which can vary across households or specific applications). A technoeconomic assessment (e.g., [Pyke et al. 2018](https://tethys-engineering.pnnl.gov/publications/robustness-testing-techno-economic-assessment-tool-tidal-energy-converters)) or other cost modeling is typically needed.  | Energy expenditure share (percentage), though additional metrics around energy poverty may be needed to reflect community nuance ([Deller 2018](https://doi.org/10.1016/j.enpol.2018.03.033)).Affordability is assessed at the project level, though strategic level data may be used to calculate baseline energy costs. | Click or tap here to enter text. | Click or tap here to enter text. |
| * CAPEX
 | Capital expenditure (CAPEX) for a project includes cost of construction, associated infrastructure development, installation, and grid connections. Operational costs (OPEX) are often also calculated. Online calculators are available (e.g., [WallStreetPrep](https://www.wallstreetprep.com/knowledge/capital-expenditure-capex/)).  | Units are in local currency (e.g., USD or EUR).CAPEX is calculated for a particular marine energy project. | Click or tap here to enter text. | Click or tap here to enter text. |
| * Economic Feasibility
 | An economic feasibility assessment involves considering initial and recurring costs of a marine energy project and its benefits over the project lifetime to determine payout. Factors besides costs can influence feasibility, including how additional environmental aspects are valued in more holistic assessments ([Richardson et al. 2021](https://tethys.pnnl.gov/publications/developing-holistic-framework-investigate-environmental-social-economic-suitability)). Example guidance exists for wave energy converters [Têtu and Chozas 2021](https://tethys.pnnl.gov/publications/proposed-guidance-economic-assessment-wave-energy-converters-early-development-stages)) and marine current devices ([Segura et al. 2018](https://tethys-engineering.pnnl.gov/publications/economic-financial-modeling-marine-current-harnessing-projects)) and numerous hypothetical assessments have been conducted (often as techno-economic analyses) for a variety of other marine energy device types. | Typically reported as feasible or not, or as Low, Medium, or High.Economic feasibility is calculated for a particular marine energy project. | Click or tap here to enter text. | Click or tap here to enter text. |
| * Funding
 | Identifying available funding sources and aligning with project timelines is a key step in project planning. Current opportunities vary by jurisdiction but many are listed on [EERE Exchange](https://eere-exchange.energy.gov/) (United States) or on the European Commission’s [SEDIA](https://ec.europa.eu/info/funding-tenders/opportunities/portal/screen/opportunities). | Units are in local currency (e.g., USD or EUR).Funding is often provided at the strategic level but available support is calculated at the project level. | Click or tap here to enter text. | Click or tap here to enter text. |
| * GVA
 | Calculating GVA provides insights into the economic value generated by a marine energy project to the overall economy, excluding the impact of taxes and subsidies. The [US Bureau of Economic Analysis](https://www.bea.gov/) and the [UK Office of National Statistics](https://www.ons.gov.uk/) both provide guidelines for calculating. | Units are in local currency (e.g., USD, EUR, etc.).GVA is calculated for a particular marine energy project, though strategic level data will be needed for comparisons to other industries or calculating contributions to gross domestic product. | Click or tap here to enter text. | Click or tap here to enter text. |
| * LCOE
 | Levelized Cost of Energy (LCOE) can be calculated by dividing the cost of a project over its lifetime by the total quantity of electricity generated (each over the lifetime of the project or a defined period of performance. Simple and complex tools exist to calculate LCOE (e.g., [NREL’s LCOE](https://www.nrel.gov/analysis/tech-lcoe-documentation.html), [SLOPE Data Viewer](https://maps.nrel.gov/slope), [DTOcean](https://energy.sandia.gov/programs/renewable-energy/water-power/projects/dtocean/)). | Units are in local currency (e.g., USD or EUR) /kWh.LCOE is calculated for a particular marine energy project. | Click or tap here to enter text. | Click or tap here to enter text. |
| * NPV
 | Net present value (NPV) for marine energy projects is calculated using standardized methods that take into account initial investment, discount rates, and cash flow. Several online calculators exist (e.g., [Economics of Energy Efficiency](https://www.energytools.com/calc/EnerEcon.html), [NPV Calculator](https://npvcalculator.info/)) as well as more complex models (e.g., [INVEST Wave Energy Model](https://naturalcapitalproject.stanford.edu/invest/wave-energy), [Kim et al. 2012](https://doi.org/10.1371/journal.pone.0047598)).  | Units are in local currency (e.g., USD or EUR).NPV is calculated for a particular marine energy project. | Click or tap here to enter text. | Click or tap here to enter text. |
| * Payback Period
 | Payback period provides a straightforward estimate of the time it takes for a marine energy project to recover its initial investment and is calculated using standardized methods that take into account upfront costs, cash inflows, and discounting. Online calculators exist (e.g., [OMNI Calculator](https://www.omnicalculator.com/finance/payback-period)). | Time period (typically years).Payback period is calculated for a particular marine energy project. | Click or tap here to enter text. | Click or tap here to enter text. |
| *Coastal Development* |
| * Community Benefits
 | Community benefits can be documented in a legally binding community benefits agreement (CBA) between a developer and a particular community (for examples see the [CBA Database](https://climate.law.columbia.edu/content/community-benefits-agreements-database)), but can also be more generally assessed. Examples of social and economic benefits are reviewed in [Brummer et al. 2018](https://doi.org/10.1016/j.rser.2018.06.013). Planned or assumed benefits need to be identified at the outset of a project in order to be accurately measured. Decision support tools or dashboards (e.g., [Thomas et al. 2022](https://doi.org/10.1016/j.jglr.2022.07.005)) can be used to track and display social or economic benefits generated throughout a project. | Likely multiple units that are variable, depending on the benefits generated by the project or provided by the developer.Community benefits are typically assessed at the project level, though may need to consider external factors or cumulative effects in determining total benefits. | Click or tap here to enter text. | Click or tap here to enter text. |
| * Compensation
 | Plans for compensation of affected parties due to a project are typically negotiated in the planning phase, though can evolve through project development due to unforeseen effects or variability in profitability. Ensuring delivery of agreed-upon compensation can be accomplished through documentation of financial transactions as well as post-compensation interviews to determine satisfaction or alignment with customer expectations ([Kerr et al. 2017](https://doi.org/10.1016/j.enpol.2017.02.034)). | Multiple, as types of compensation schemes vary (e.g., [van Wijk et al. 2021](https://doi.org/10.1016/j.erss.2021.102260)).Compensation plans are typically developed and effects are assessed at the project level. | Click or tap here to enter text. | Click or tap here to enter text. |
| * Energy Security
 | Measures of energy security include information on the energy supply, vulnerability to natural disasters or human threats, frequency of standard interruptions, and susceptibility to cost fluctuation. Modeling is typically used to assess and identify measures for improvements that can be provided by marine energy (e.g., [Kazimierczuk et al. 2023](https://tethys.pnnl.gov/publications/socio-technical-assessment-marine-renewable-energy-potential-coastal-communities)). | Various units are used and are typically combined through existing evaluation tools (e.g., [Assessment of Capabilities in Energy Security](https://aces.anl.gov/)) or grid modeling that requires multiple inputs.Energy security data is typically collected at a strategic level, though planning and monitoring may be done at the project level. | Click or tap here to enter text. | Click or tap here to enter text. |
| * Policies and Governance
 | Local and national policies play a major role in facilitating or limiting the development of marine energy, as well as stipulating requirements for economic data collection or access. Some tools exist to provide or evaluate these policies, including the [Marine Energy Toolkit](https://marineenergy.app/) in the United States. | No units.Data and guidance on policies and governance are typically collected at strategic levels, though will need to be applied at the project level. | Click or tap here to enter text. | Click or tap here to enter text. |
| * Resilience
 | Numerous indicators exist for economic aspects of resilience, including frequency of natural disasters, climate adaptations, redundancies in power grid, available financing, human capacity and more – all of which are culturally embedded ([Sterling et al. 2017](https://doi.org/10.3167/ares.2017.080104)). Resilience is often assessed holistically through existing planning tools (e.g., [Resilience Analysis and Planning Tool](https://www.fema.gov/about/reports-and-data/resilience-analysis-planning-tool), [Energy Resilience in the Public Sector Resources](https://www.energy.gov/scep/slsc/energy-resilience-public-sector)). Determining a location or communities’ current level of resilience and vulnerability (see below) to climate and natural disasters and assessing changes caused by presence of marine energy devices and associated installations is the recommended approach. | Various units, including some unitless scores depending on the tools selected. Typically, resilience can be considered High, Medium, or Low – though provision of specific information is necessary to determine effects of marine energy on economic resilience. Economic resilience data can be collected at a strategic level or project level. | Click or tap here to enter text. | Click or tap here to enter text. |
| * Vulnerability
 | Economic vulnerability can be measured at the community or country scale using an index (e.g., [EVI](http://byind.ferdi.fr/en/evi)) or structured equations ([Altimari et al. 2019](https://doi.org/10.1007/978-3-030-21140-0_10)). The important aspects to consider in assessing vulnerability are exposure (including population size, remoteness, exports, reliance on agriculture or fisheries) and risk of shocks (including natural disasters or climate change) ([Cariolle 2010](https://ferdi.fr/dl/df-cT7xN1CvmPnbwrmfA6gYL7hf/ferdi-i9-the-economic-vulnerability-index.pdf), [Briguglio 2009](https://doi.org/10.1080/13600810903089893)). | Various units, including some unitless scores depending on the tools selected. Typically, vulnerability can be considered High, Medium, or Low – though provision of specific information is necessary to determine effects of marine energy on economic vulnerability.Economic vulnerability data is typically collected at a strategic level, though planning and monitoring may be done at the project level. | Click or tap here to enter text. | Click or tap here to enter text. |
| *Local/Regional Economy* |
| * Ecosystem Services
 | Ecosystem services can be measured through value mapping ([SolVES](https://www.usgs.gov/centers/geosciences-and-environmental-change-science-center/science/social-values-ecosystem), [ValuES](http://aboutvalues.net/method_database/)), ecosystem service assessments ([Reyers et al. 2013](https://doi.org/10.1890/120144)), and GIS ([Sherrouse et al. 2011](https://doi.org/10.1016/j.apgeog.2010.08.002), [Winn et al. 2018](https://www.nature.scot/sites/default/files/2018-06/Publication%202018%20-%20SNH%20Research%20Report%20954%20-%20EcoServ-GIS%20v.3.3%20A%20toolkit%20for%20mapping%20ecosystem%20services%20%28GB%20scale%29.pdf)). An ecosystem-based natural capital evaluation framework has been used to evaluate how offshore renewable energy developments impact ecosystem services [(Trifonova et al. 2022)](https://iopscience.iop.org/article/10.1088/2516-1083/ac702a), and ecosystem services based management has been recommended for offshore energy development ([Bravo et al. 2023](https://doi.org/10.3389/fmars.2022.994632)). Recommendations for accurate accounting of marine ecosystem services are available ([Johnston et al. 2017](https://abdn.elsevierpure.com/en/publications/contemporary-guidance-for-stated-preference-studies)) and recent literature for the United States has been reviewed by NOAA Fisheries ([Lew et al. 2023](https://doi.org/10.15351/2373-8456.1159)). | Changes in outputs from ecosystem services (i.e., primary productivity levels).Ecosystem service assessments are typically conducted at the project level, though may be conducted more strategically for key regions. | Click or tap here to enter text. | Click or tap here to enter text. |
| * Exports
 | Exports include all the goods or services that are sent or sold outside the community. Global databases exist for major exports (e.g., [WITS TradeStat Database](https://wits.worldbank.org/countrystats.aspx?lang=en)) though more detailed information relevant for a marine energy project may need to be collected from community economic leadership or from surveys. Input-output analysis is used to determine how major expenditures (such as renewable energy projects) impact economies, including exports [(Allan et al. 2008](https://www.sciencedirect.com/science/article/pii/S030142150800075X)). Renewable energy can also be exported ([Ralph and Hancock 2019](https://doi.org/10.1016/j.erss.2018.10.023)). | List of common export goods or materials, changes in gross domestic production values. Baseline export data is often available at a strategic level, though project level impacts will need to be estimated and monitored. | Click or tap here to enter text. | Click or tap here to enter text. |
| * Supply Chain
 | Effects are typically quantified based on economic indicators and are often indirect, or due to a marine energy project.Deployment scenarios, value chain analysis, and case studies can all be used to measure supply chain. Deployment scenarios have been used to calculate potential impact of deployments on supply chain activity ([ETIPOCEAN Deliverable 3.3](https://tethys.pnnl.gov/sites/default/files/publications/D3.3-GVA-Study.pdf)). | Total gross value added effects. Indirect job creation. Investments in supply chain companies or purchases or expenditures in businesses/industry that occur due to a marine energy project.Supply chain data can be collected at the project level to assess impacts of a particular marine energy project or a test center, or they can be assessed at a strategic level, particularly for countries where supply chains are built out for all aspects within marine energy development.  | Click or tap here to enter text. | Click or tap here to enter text. |