# Dependency of commercial fisheries on kelp forests for valuation of ecosystem services

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**Abstract:**

The world's kelp forests cover over a third of the world's coastlines and provide numerous benefits to humans. Understanding the values associated with kelp forests is essential for meeting international initiatives concerning ocean accounting and ecosystem assessments. The GEAK network is an international group of expert kelp forest ecologists and environmental economists working to synthesize the values and functions of kelp forests globally. The network has developed a common data collection approach and protocol to quantify the different ecosystem services (e.g., provisioning, regulating, biodiversity, and cultural) provided by kelp forests. This manuscript presents the guidelines for attributing proportional value of kelp dependent commercial and subsistence fisheries to different target species.

**Key words:** Ecosystem services, kelp forest, economic valuation, value attribution, habitat dependency

**JEL classifications:** Q57, Q51

**Introduction**

The GEAK network is an international group of expert kelp forest ecologists and environmental economists working to synthesize the values and functions of kelp forests globally. The world's kelp forests are extensive vegetated marine ecosystems that cover over a third of the world's coastlines and provide numerous benefits to humans, including 14 of the 18 contributions of nature to people identified by the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services. Current economic valuations of kelp are state-specific and heavily dominated by direct-use services such as fisheries and kelp harvest, yet these are most likely a considerable underestimation because they do not include the numerous cultural values, as well as their role in carbon storage, nutrient filtration, and biodiversity provision. These data on kelp forests are also essential for meeting international initiatives concerning ocean accounting and ecosystem assessments.

The network includes 32 kelp and seaweed experts, restoration practitioners and environmental economists. GEAK uses a 4-step process where we: 1) use expert assessment to identify the presence/absence of different ecosystem services based on a modified IPBES framework on nature's contributions to peoples, 2) quantify the effect size of different ecosystem services based on literature values, 3) quantify the economic benefits of these ecosystem services based on a review of valuation studies, and 4) estimate the economic value of these services using a total economic valuation framework.

The network has developed a common data collection approach and protocol to quantify the different ecosystem services (e.g., provisioning, regulating, biodiversity, and cultural) provided by kelp forests. Using relevant categories from the IPBES framework we developed indicators tailored specifically to kelp forests. The data collection is conducted at the ecoregion scale and synthesized globally.

The following pages outline the GEAK protocol for attributing proportional value of kelp dependent commercial and subsistence fisheries to different target species as set out in the "GEAK guidelines for data collection v2.doc" as of 16 June 2022.

**Value of relevant proportion of fisheries catches**

Not all fisheries resources are equally dependent on kelp forests. Therefore, the value of the fisheries attributed to the kelp forests should be adjusted accordingly. To help identify the level of dependency, we ask what the counterfactual case would be if there was no kelp forest: What would be the value of the fishery if the kelp was not there?

This judgment can be made based on the biology and habitat use of the predominant target species per fishery using literature, online platforms (e.g. Fishbase) and expert opinion. We suggest adding the following information into the "additional data for valuation" columns:

Category of the fisheries dependency on kelp as 'low', 'medium', or 'high'.

Description of the information that helped making this judgment (if possible, with the level of dependency as percentage).

We then can convert from percentage to dependency category and vice versa, depending on what information is available:

low dependency = 1 – 30%

medium dependency = 31 – 70%

high dependency = 71 – 100%

Below are 10 example scenarios with rationales as to how to categorize dependencies of fisheries on kelp forests:

**Example Scenarios**

1.  The commercial fishery is operating directly inside a kelp forest because the fished species is abundant there but there is no research/evidence that the fished species depends on kelp (e.g., crab, octopus).

    Given that they live in this habitat it is appropriate to assume that there is a dependency on the kelp forest ecosystem (although there might not be a direct dependency on kelp species themselves). Then the question is: Do we assess the value of the kelp ecosystem or only kelp species within that ecosystem? It would be very difficult to tease that apart and that might not be meaningful because without kelp species that ecosystem with all those species would not exist in this way. Hence, this would fall into the medium to high dependency category, but we could not specify a percentage. We might want to use information on how much of those landings were caught inside kelp forests (might get a rough estimate from fisheries associations or other sources).

2.  The fish species spends 2 years of its juvenile period in kelp forest before moving offshore, average age is 20 years. Kelp is identified as critical habitat.

The question we have to ask is: What percentage of those juvenile fish would have died without the kelp forest and could therefore not recruit into catchable sizes? This depends on with what the kelp forest would be replaced when it disappears and whether that is a suitable habitat for those species (see 3). Given that it is a critical habitat, we would classify the dependency as high (again without specifying the percentage unless there is data that answer the questions above).

3.    The fish species spends 2 years of its juvenile period in kelp forest before moving offshore, average age is 20 years. It is found in both kelp and seagrass meadows.

We have to ask the same question as in 2. Given that in this scenario there is a substitute habitat for juvenile fish, we would classify the dependency as low to medium depending on whether
- The juveniles of the target species can travel between kelp and seagrass habitats and/or
-The kelp that disappears is being replaced by seagrass meadows.

Answers to the two points being yes, we would classify dependency as rather low. Answers being no, it would be medium.

4a.The fishery is a subsistence fishery, the species is not fished commercially and there is no data on landed value, only on number of fishers / licenses.

We need to know at least the target species and whether (and to what extent) subsistence fishers fish in kelp forests to estimate the dependency on kelp. We could assume that the landing values are similar to those from other subsistence fisheries in kelp forests that are geographically close. But whether that is an appropriate assumption needs to be decided on a case by case basis.

4b.The fishery is a subsistence fishery, and there is data on landed tonnes.

We would classify the dependency on kelp based on the landed species just as if it was a commercial fishery. If there is no information of landings on species level, there might be information on percentage of fish caught within kelp forests?
In terms of how to put a value on this: we need the landed unit value of the target species just like in a commercial fishery because we use that as a proxy. It probably doesn't reflect the true value to subsistence fishers, (especially when they fish species with a low price or even species that are not commonly sold commercially), but it is the best we can do.

5.    The fishery is a recreational fishery and there is no data on landed value, only on amount caught.

Again, it would be necessary to know which species are caught to understand the kelp dependency of the species. If that is not available, some information about what percentage of the landings was caught inside kelp forests, and ideally both.

6.  The commercial fishery is operating in the larger coastal shelf with no data on whether landings come from the kelp. There is evidence that the fished species is abundant in kelp forests and consumes kelp.

We would classify the kelp dependency as medium to high because we have evidence that the target species uses kelp as habitat and feeds on it. Depending on whether kelp is a critical habitat and/or food source, I would distinguish between medium and high. Unless we have information about how much percent of the catch would be lost if kelp was not there we could not answer this with a percentage.

7.  The fished species preys on smaller fish that are only found in kelp forests. These prey make up 10-20% of the fished species diet, but only when it is adult.

We would classify the dependency as low because the target species would have to substitute part of their prey if kelp was not there, but would otherwise not be hugely affected.

8.  The lobster fishery is operating within coastal zone, there are anecdotal reports that lots of kelp are good for lobsters and are where the fishers put their pots, however there is no relationship between lobster abundance and kelp abundance from time series data in the system.

The evidence of the level of dependency is based on local ecological knowledge which is an accepted measure. We would classify the dependency as medium to high depending on the fraction that fishers harvest their lobster within kelp forests.

9.  The fished species is found across the continental shelf and its total range is unknown. 10% of the tissue of the fish can be traced to originate in kelp using stable isotope analyses.

Similar to 7, we would classify the dependency as low because the target species would have to substitute part of their food source if kelp was not there, but would otherwise not be hugely affected. If we had more information about its use of kelp as a habitat we maybe would have to adjust this up or down.

10.  The fishery landings for a kelp-associated species were reduced by 50% following a heat wave and complete loss of kelp, this was due to a combination of warming and habitat loss.

We had to answer the question: How much of reduction in fisheries landings was associated with the habitat loss? We know that the combined effect was 50%, so we would say that depending on the level of influence of habitat loss alone (which might be roughly estimated by an expert), the dependency is either low or medium.