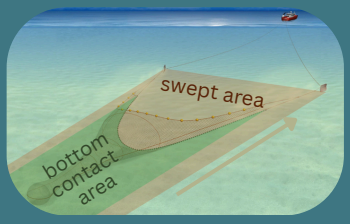
# Fishing Effects Model (FEM)

A decision-support tool to quantify and visualize commercial fishing activity and resulting seafloor habitat disturbance. The Fishing Effects Model workflow has two parts: the **Fishing Module** and the **Habitat Module**.

## The Fishing Module

estimates the amount of **swept area** and **bottom contact area** on the seafloor by integrating track lines of fishing events with corresponding fishing gear parameters.

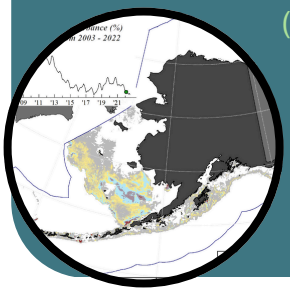



**Gear parameters are the dimensions and combinations of vessel-specific gear components.**

**Fishing tracks are collected via satellite through the Vessel Monitoring System (VMS).**

gear parameters (widths) x fishing track (lengths)
= swept area (total area fished)

swept area x contact adjustment
= bottom contact area
(seafloor contacted)



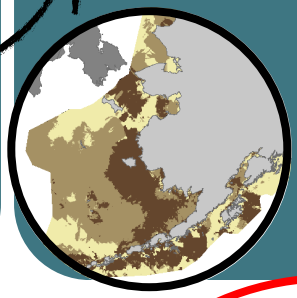
The Fishing Module can be used on its own, separate from the Habitat Module, for fishery management decisions.

## The Habitat Module

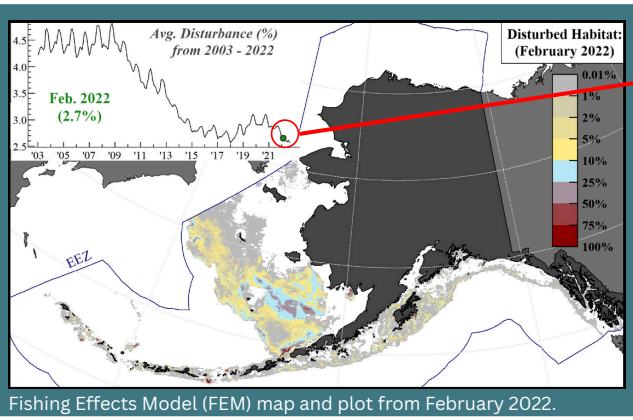
estimates benthic **habitat disturbance** from fishing gear by integrating results from the Fishing Module along with the **susceptibility** (vulnerability to impacts) and **recovery time** (ability to return to original state) of an area.



{prior disturbance - recovery time} + {current fishing + susceptibility}
= habitat disturbance
(% feature reduction)



The Habitat Module incorporates the Fishing Module results and empirical habitat information to estimate seafloor habitat disturbance.



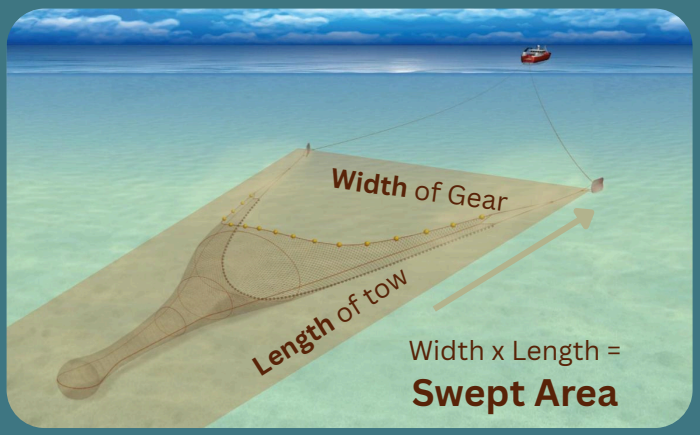

Fishing Effects Model (FEM) map and plot from February 2022.

## Habitat Disturbance

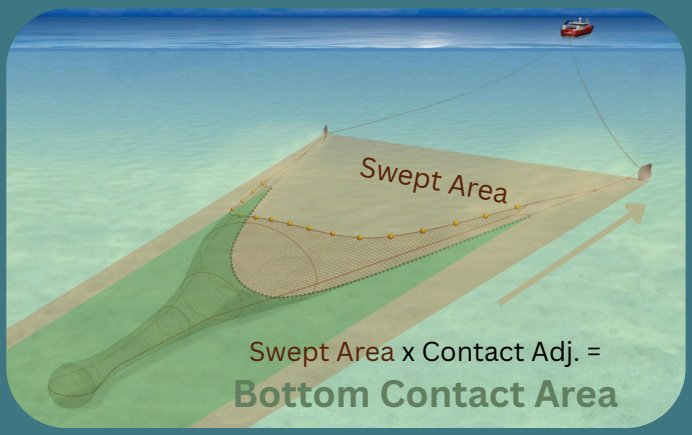
is expressed as a cumulative percentage of habitat feature reduction on a monthly basis for a given area. For example, the average disturbance in the North Pacific in February 2022 was approximately 2.7%.

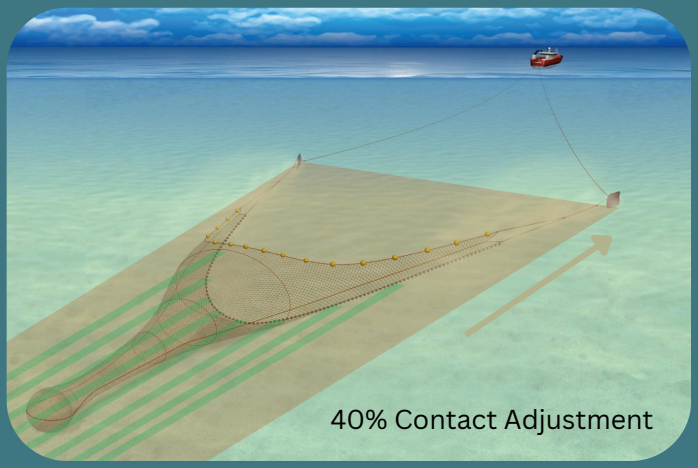
# How are swept area and bottom contact area determined?

**Swept area** is the maximum area over which gear-seafloor interactions may occur. This can be seen as the rectangular area created by the full (nominal) width of the gear as it is being fished.




**Bottom contact area**—a fraction of *swept area*—is the estimated amount of seafloor contacted by fishing gear, and differs by gear type and other fishing factors.




Trawl images provided by Seafish

**Contact adjustment** is the proportional (percentage) value that modifies *swept area* to estimate *bottom contact area*. Fishing gear does not always make contact across its full width, or for the duration of the fishing event. These dynamics are dependent on specific gear-vessel configurations, fishing practices, and hydrodynamic forces.

For Example:

**Contact adj. = 1** full contact
**Contact adj. = 0.4** partial contact
**Contact adj. = 0** no contact

# What gear information does the Fishing Effects Model use?

Contact adjustment proportions are specific to combinations of vessel, gear, and time of year. These values are also dependent on fishing practices (e.g., fishing depth, target species). This information is compiled in the **gear parameter table** of the Fishing Effects Model. The more we know about gear specifications and fishing practices, the better the estimates of bottom contact area.

| Fishery | Vessel Type | Area | Gear | Target Species | Other Sp. | Vessel Length (ft) | Season | Depth Range (fath.) | Nominal Width (m) | Contact Adjustment |
|---|---|---|---|---|---|---|---|---|---|---|
| AI Pcod Bottom Trawl mothership | CV | AI | NPT | Pacific cod | all others | >250 (or Processor M) | | | 75 | 1 |
| AI Pcod Bottom Trawl mothership | CV | AI | NPT | Pacific cod | all others | <99 | | | 55 | 1 |
| AI Pcod Bottom Trawl mothership | CV | AI | NPT | Pacific cod | all others | ≥99 | | | 90 | 1 |
| AI Atka and Rockfish Bottom Trawl | CP | AI | NPT | Atka Mackerel | K, all others | all | | | 100 | 1 |
| AI Pollock | | AI | PTR | Pollock - midwater | all | | | | 100 | 0 - 0.2 |
| GOA Pcod Pot | | GOA | POT | Pacific cod | all others | | | | 5.6 | 0.5 - 1 |
| BSAI Pcod Pot | | BSAI | POT | Pacific cod | all others | | | | 5.6 | 0.5 - 1 |
| BSAI Sablefish Pot | | BSAI | POT | Sablefish | Greenland turbot | | | | 5.6 | 0.5 - 1 |
| GOA Sablefish Pot | | GOA | POT | Sablefish | Greenland turbot | | | | 5.6 | 0.5 - 1 |
| GOA Sablefish Longline | | GOA | HAL | Sablefish | Greenland turbot | | | | 6 | 0 - 1 |
| F Demersal | | | | Rockfish | | | | | 6 | 0 - 1 |

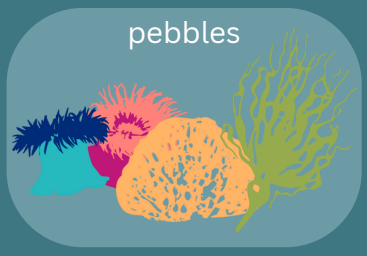
FEM gear parameter table, Zaleski et. al. 2024.

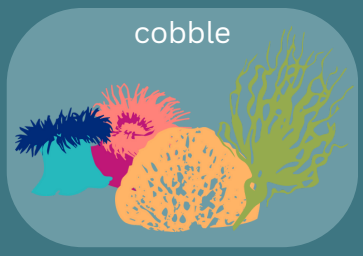

Images provided by Seafish

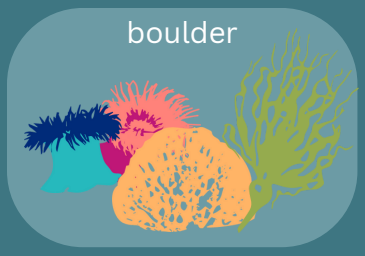
# How are habitat features, such as corals and sponges, included in the model?

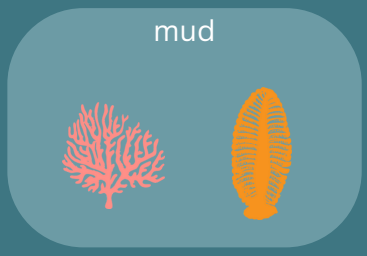
Based on published research, we know that common habitat features correlate to combinations of seafloor sediments and depths. Maps of sediment types are used to estimate where habitat features are found. Associated susceptibility and recovery rates are then applied to those areas. As habitat information improves, we can improve model outputs.

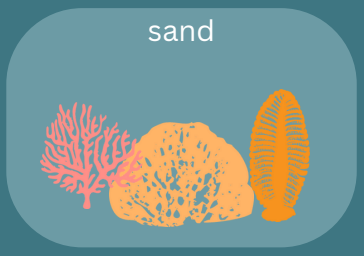


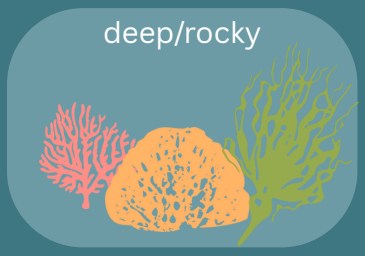


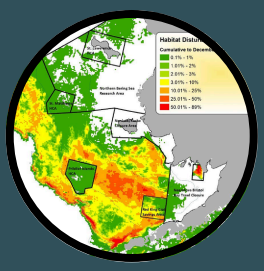




Images: NOAA Fisheries

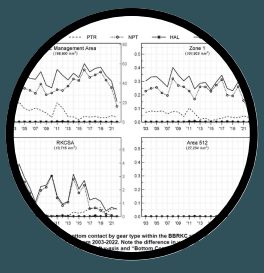
# Fishing Effects Model Applications

The Fishing Effects Model, first used in the North Pacific in 2015, combines and expands features developed in two previous gear impacts models. Since then, it has evolved and is used at various temporal and geographic scales, from small closure areas to seascape-level regions and beyond. Ongoing research aims to improve information support for the Fishing and Habitat modules.



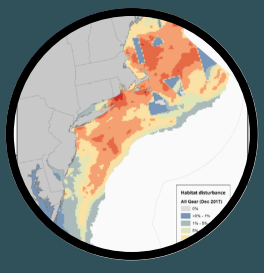
**EFH 5-year Review**

Evaluating potential impacts of commercial fishing to benthic habitat is an important component of the Essential Fish Habitat (EFH) 5-year Review. Stock authors use FEM results overlaid on species core EFH areas, and other life history data to determine whether adverse effects are occurring.



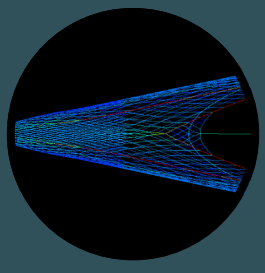
**Council Analyses**

The NPFMC has requested specific analyses to understand impacts to species and associated habitat. For example, in the February 2024 BBRKC closure areas analysis, maps and plots were provided to understand swept area, bottom contact area, and spatial trends without habitat information.



**FE Northeast**

A version of the FEM, known as the *Fishing Effects Northeast* model, is used by the New England Fishery Management Council. This version incorporates region-specific data sources and supports their EFH 5-year Review process.



**Gear Research**

New gear parameter information is being gathered to update the FEM, to inform pelagic trawl gear simulations, and to inform pelagic trawl gear bottom contact field research in the FAST Lab Pollock Gear Project and related Gear Innovation Initiative.

**Broader Uses**

As part of doctoral dissertation work, the FEM was applied on regional and global scales to understand fishing impacts and how they compare to terrestrial sources of protein. The FEM was also integrated with species distribution models to allow for estimations of recovery and susceptibility.

# Frequently Asked Questions

**What does the Fishing Effects Model (FEM) calculate, and what do the results represent?**

The FEM produces several primary outputs: *swept area, bottom contact area,* and *habitat disturbance*. Swept area is a measure of the total area of fishing activity; bottom contact area is a measure of the area of sea floor contacted by fishing gear; and habitat disturbance is a measure of the accumulated reductions in habitat features from impact and recovery processes. The units of habitat disturbance range from 0 – 1 and represent the proportional reduction in structure-forming habitat features.

**What does the term "contact adjustment" mean? What is the difference between a contact adjustment of, say, 0 and 1?**

*Contact adjustment* is a value—ranging between 0 and 1—representing the proportion of the fishing gear's nominal width that is assumed to make contact with the seafloor during a fishing event. A contact adjustment value of 0 implies that the gear makes no contact with the seafloor, while a contact adjustment value of 1 indicates that the entire swath of the gear makes contact with the seafloor. A middle value between 0 and 1 (e.g., 0.5) can indicate partial contact of gear, partial contact during a fishing event, or a combination of the two. Contact adjustment values are unique to each type of gear and can vary based on fishing depth, vessel size, target species, location, and season.

**What is the spatial and temporal scale of the FEM results? What if I only care about a small area for impacts?**

The spatial and temporal scale of the model varies depending on the specific goals of the analysis. Generally, each analysis will have a spatial domain (e.g., the Bering Sea) that is broken into smaller grid cells. The most common output is running the model on 5 km x 5 km grid (i.e., 25 km$^2$) and on monthly time steps for the entirety of the North Pacific (subdivided in the Bering Sea, Aleutian Islands, and Gulf of Alaska). This is the spatiotemporal scale used for the EFH 5-year Review analyses. Higher resolution analyses can be conducted down to 1 km x 1 km (1 km$^2$) grid cells and weekly time scales, which would be useful for analysis of smaller regions, such as closure areas.

**How does the FEM relate to designated Essential Fish Habitat?**

The habitat disturbance output from the FEM is one of the analytical tools that is used during the EFH 5-year Review process to assess whether the impacts of fishing gear are exceeding "more than minimal, and not temporary" adverse effects for the core EFH area of any managed stocks. Stock authors use FEM results overlaid on species core EFH areas, and other life history data to determine whether adverse effects are occurring.

**Does the FEM allow the Council to evaluate the effects of opening closed areas, or reducing fishing vs. prohibiting a type of fishing in an area?**

Yes, the FEM can be used to evaluate potential habitat effects of management actions. To run this type of analysis would require information on how fishing activity would likely change as a result of the action. For example, to evaluate potential habitat effects of closing an area, analysts would need to predict where the displaced fishing effort is likely to go.

**Are fishing events allowed to overlap? Do effects accumulate over time?**

Yes, fishing events frequently overlap and the FEM handles them accordingly. Impacts from overlapping fishing events continue to accumulate until the area (e.g., 5 km x 5 km grid cell) is 100% disturbed. Once all structure-forming habitat features are removed from a location, any subsequent fishing event in that exact location will not add further impacts. Recovery occurs only if sufficient time elapses between fishing events. Habitat disturbance (i.e., effects) does accumulate over time; however, it is not strictly increasing. Habitat disturbance is a continual accumulation of impacts (which increase the effects), and recovery (which results from physical and biological processes, and decreases the effects). Thus, an estimate of habitat disturbance for any given point in time reflects the entire history of impacts and recovery at that location.

# Resources

**FAST Lab:** https://www.alaskapacific.edu/community-research/fast-lab/
**Fishing Gear Effects on Marine Habitats Database:** https://fishmaps.shinyapps.io/FishingEffectsDatabase/
**NOAA Fisheries AK EFH**: https://www.fisheries.noaa.gov/alaska/habitat-conservation/alaska-essential-fish-habitat-reviews
**NPFMC:** https://www.npfmc.org/
**Smeltz, T.S.,** Harris, B.P., Olson, J.V., Sethi, S.A. 2019. A seascape-scale habitat model to support management of fishing impacts on benthic ecosystems. Canadian Journal of Fisheries and Aquatic Sciences. Dx.doi.org/10.1139/cjfas-2018-0243.
**Zaleski, M.,** T. S. Smeltz, S. Gardiner, J. L. Pirtle, and G. A. Harrington. 2024. 2022 Evaluation of Fishing Effects on Essential Fish Habitat. NOAA Technical Memorandum NMFS-F/AKR-29, 212 p. doi: 10.25923/c2gh-0w03, https://repository.library.noaa.gov/view/noaa/66042