THE FISHING EFFECTS MODEL DESCRIPTION FOR THE 2015 EFH REVIEW

Introduction

The 2005 Essential Fish Habitat (EFH) cycle used the Long-term Effect Index (LEI) model (Fujioka 2006) to assess fishing impacts on essential fish habitat in the Gulf of Alaska, Aleutian Islands and Bering Sea (USDC 2005). The LEI model was developed originally by Dr. J. Fujioka (National Marine Fisheries, retired), and later implemented by Dr. C. Rose (National Marine Fisheries Service, retired). The LEI model produces an estimate of the long-term proportion of habitat disturbance that would result from a constant rate of fishing impacts counteracted by a constant rate of habitat recovery. Habitat disturbance is estimated within 5 km grid cells and split among four habitat features (epifaunal prey, infaunal prey, biological structures, and physical structures). The amount of fishing impacts in any given cell depend on the total amount of bottom contact by fishing gear, the types of gear used, the substrate within the grid cell, and the sensitivity of the habitat feature to the gear used. Recovery rates depend on the habitat feature and the type of substrate. Importantly, since the model was derived from differential equations, both impact and recovery are defined as instantaneous rates (Fujioka 2006). However, during model implementation it was not clear how best to convert a fishing event that occurs over a discrete time period into an instantaneous rate (FAST, 2014).

During the 2015 EFH cycle, the NPFMC requested several updates to the LEI model to make the input parameters more intuitive and to draw on the best available data. In response to their requests, the Fishing Effects (FE) model was developed. Like the LEI model, it is run on 5 km grid cells throughout the North Pacific and is based on interaction between habitat impact and recovery, which depend on the amount of fishing effort, the types of gear used, habitat sensitivity, and substrate. The FE model updates the LEI model in the following ways:

1. The FE model is cast in a discrete time framework. This means rates such as impact or recovery are defined over a specific time interval, compared to the LEI model which used continuous time. Using discrete time makes fishing impacts and habitat recovery more intuitive to interpret compared to continuous time. For example, an impact rate can be defined as 25% habitat disturbed per month.
2. The FE model implements sub annual (monthly) tracking of fishing impacts and habitat disturbance. While this was theoretically possible in the LEI model, the LEI model was developed primarily to estimate long term habitat disturbance given a constant rate of fishing and recovery. The FE model allows for queries of habitat disturbance for any month from the start of the model run (January 2003). This aids in the implications of variable fishing effort within season and among years.
3. The FE model draws on the spatially explicit Catch-in-Areas (CIA) database with VMS-Obs-UnObs-Lines (provided by Analytical Team, NOAA Fisheries Alaska Region) to use the best available spatial data of fishing locations. The CIA database provides line segments representing locations of individual tows or other bottom contact fishing activities. The LEI model in

comparison, used endpoint only representations of fishing activity. The use of the CIA database provides more accurate allocation of fishing effort among grid cells.

4. The FE model incorporates the extensive literature review conducted by the New England Fisheries Management Council (NEFMC 2011) to estimate susceptibility and recovery dynamics. A consequence of this change is that the FE model splits habitat into 26 unique features rather than the four of the LEI model. Typical outputs of the FE model will average over all 26 features, or aggregate them into Biological or Geological features. However, the FE model is designed to be flexible to produce output based on any single habitat feature or unique combination of features.

Fishing Effects model description

The Fishing Effects (FE) model is conceptualized as an iterative model tracking habitat transitions between disturbed and undisturbed states. We let H represent the proportion of habitat disturbed by fishing activities, and h represent the proportion of habitat undisturbed by fishing activities. Terminology may vary slightly according to context, but in general, we will treat "undisturbed", "showing no effect of fishing" or other similar terms as equivalent. In this model, habitat that has had no historic fishing is equivalent to disturbed habitat that has fully recovered. Likewise, we will treat terms such as "disturbed", "affected by fishing", or "impacted" as equivalent.

The two habitat states, H and h are mutually exclusive and complete,

$$H + h = 1 \tag{1}$$

The FE model considers transition between H and h in monthly discrete time steps, t. Thus, H_t is undisturbed habitat and h_t is disturbed habitat at time t. In implementation of the model, $t = 1$ represents January 2003 when using the complete CIA dataset. H transitions into h from one month to the next through fishing impacts and h transitions into H through recovery. We let I'_t represent the proportion of H that transitions to h by fishing impacts from month t to month $t + 1$, and ρ'_t as the proportion of h that recovers to H over the same time step. As a time-varying model, both I'_t and ρ'_t can vary from month to month. Thus, H_{t+1} is the is the sum of non-impacted H_t and recovered h_t. Conversely, h_{t+1} is the sum of impacted H_t and non-recovered h_t,

$$\begin{aligned} H_{t+1} &= H_t(1 - I'_t) + h_t\rho'_t \\ h_{t+1} &= H_tI'_t + h_t(1 - \rho'_t) \end{aligned} \tag{2}$$

These state transitions are run independently within 5 km x 5 km grid cells across the complete domain of the model in a spatially explicit tracking of H and h through time. In implementation of the model, we only track H since h can easily be back calculated through Eq. 1. Each grid cell is characterized by the proportion of five sediment types within it: mud, sand, granule/pebble, cobble, and boulder. For example, a grid cell may be 50% sand and 50% mud, or 10% mud, 80% sand, and 10% cobble, or any other combination of sediment types that sums to 100%. Sediment types are assumed to be uniformly spread throughout each grid cell based on their proportion, thus this model does not consider spatial structure of sediment within a grid cell. H and h, then are tracked not only within grid cells, but also within sediment classes. Let the subscripts t, i, s represent time (month), grid cell, and sediment class respectively. Let a $\bullet$ represent summations across a given index. Thus, the total undisturbed habitat in a given cell is the sum of undisturbed habitat for each sediment times the proportion of sediment with the grid cell, $\phi_{i,s}$, across all five sediment types (note the sediment proportion remains constant across all time periods),

$$H_{t,i,\bullet} = \sum_{s=1}^{5} H_{t,i,s}\, \phi_{i,s} \tag{3}$$

For example, if a grid cell was composed of 10% mud, 80% sand, and 10% cobble, with H of 90%, 60%, and 100% for mud, sand and cobble respectively, the total undisturbed percent of the grid cell would be 67%. If the total undisturbed area within each grid cell is the quantity of interest, we simply need to multiply $H_{t,i,\bullet}$ times the the total area of the grid cell, A_i. The area for most grid cells will be 25 km^2 (5 km X 5 km), however, some grid cells will have smaller areas when they are located at the edge of the domain or along coastlines.

Fishing Impacts

The proportion of undisturbed habitat that transitions to disturbed habitat as a result of fishing impact, I', is calculated as the exponentiation of the impact rate, I (for a discussion on this conversion, see Section *Expectation of impact rate*),

$$I' = 1 - \mathrm{e}^{-I} \tag{4}$$

In the FE model implementation, the parameter I is indexed across grid cells, i, time periods, t, sediment classes, s, and gear types, g. We sum across n gear types to calculate an impact rate for each grid, time period, and sediment combination. For the remainder of the model discussion, we will omit the i and t indexing as all parameters are unique to grid cell and time period unless otherwise stated.

$$I_{s,\bullet} = \sum_{g=1}^{n} I_{s,g} \tag{5}$$

The impact rate for each gear-sediment combination, $I_{s,g}$, is calculated as the product of the gear specific fishing effort, f_g and the gear-sediment susceptibility $q_{s,g}$,

$$I_{s,g} = f_g q_{s,g} \quad (6)$$

f_g is a measure of the total bottom contact by each gear type as a proportion of the total grid cell area. It can range from zero, indicating no bottom contact by a gear type, to proportions greater than or equal one, indicating that the total bottom contact area was greater than or equal the area of the grid cell. Proportions exceeding one may occur because f_g is summed across all individual tows of the same gear type within a cell regardless of possible overlap. When $f_g \geq 1$, it does not necessarily mean that the entire grid cell has been contacted by fishing gear, but only that the sum of bottom contact by individual tows is greater than or equal to the grid area. For example, we can consider the two following hypothetical (and unlikely) scenarios both resulting in $f_g = 1$. In the first scenario, one tow may contact the entire grid cell, resulting in 100% contact by one vessel. In the second scenario, 10 vessels may contact the same 10% area of the grid cell, in which case $f_g = 10 \times 0.1 = 1$. Although, $f_g = 1$ in both scenarios, the actual percent of ground contact differs. f_g is calculated for each gear as the nominal area swept by fishing gear, A_g, multiplied by contact adjustment, c_g. Nominal area swept is the door-to-door area of a tow not accounting for the degree to which the components of a tow actually touch the sea floor. The contact adjustment, then, is the proportion of the nominal area swept in contact with the sea floor. Because we assume a uniform distribution of sediment within a grid cell, f_g is not indexed over sediment, and is assumed to be spread proportionally among all sediments within a grid cell. Nominal areas are calculated for each tow, x, within a grid cell and are summed over n tows within gear types. Since f_g is measured as a proportion and A_g is an area, we need to divide by the total area of a grid cell, A_i,

$$f_g = \frac{c_g \sum_{x=1}^{n} A_{g,x}}{A_i} \quad (7)$$

Estimate of susceptibility

Susceptibility, $q_{s,g}$, is the proportion of habitat affected by bottom contact with fishing gear. We index it over s and g because we assume differing susceptibilities for gear-sediment combinations (). Within each sediment class is a defined set of geological and biological habitat features that are associated with that type of sediment. The susceptibility for a gear-sediment combination is the average of the susceptibility of all habitat features within a gear-sediment combination. Habitat features definitions and their susceptibility were based on a literature review conducted for the SASI model. In a few cases, the SASI model split habitat feature susceptibility between high and low energy systems. In these cases, we selected the low energy susceptibility. Habitat feature susceptibilities were not estimated as absolute values, but were classified into four ranges: 0: 0--10%; 1: 10--25%; 2: 25--50%; 3: >50%.

To calculate an average susceptibility for each gear-sediment combination, we first randomly selected a susceptibility for each habitat feature within its range of susceptibilities for a given gear-sediment combination. We then computed the mean of these randomly selected habitat feature susceptibilities to get an average susceptibility for each gear-sediment combination. In the initial implementation of the FE model, random susceptibility values were generated once then used throughout the model. In future version of the model, random susceptibilities may be generated for each time step and/or grid cell.

Recovery

Recovery, ρ'_s, is the proportion of disturbed habitat, h, that transitions to undisturbed habitat, H, from one time step to the next. It is indexed over sediment, s, assuming differing recovery dynamics for different sediment classes. ρ' is calculated as the exponentiation of the negative recovery rate, ρ_s subtracted from one,

$$\rho'_s = 1 - \mathrm{e}^{-\rho_s} \tag{8}$$

ρ_s is defined as the inverse of recovery time,

$$\rho_s = \frac{1}{\tau_s} \tag{9}$$

where τ_s is the average number of years it takes for habitat in a sediment class to recover from a disturbed to an undisturbed state. In the implementation of the model, we divide ρ_s by twelve to convert years to months (equivalent to multiplying τ_s by twelve) to align with the monthly time step of the present FE model implementation. Similar to susceptibility, ρ_s is calculated by averaging across all habitat features within a sediment class. However, we first average recovery times, τ, using he recovery times published for the SASI model. We then convert average recovery times to recovery rate, ρ_s using Eq. 9. Unlike the SASI model, which estimates a recovery time for each gear-sediment-habitat feature combination, the FE model does not account for differing recovery times when habitat is impacted by different gear types (i.e., recovery dynamics are independent of impact source). Thus, when using the SASI values, we used their sediment-habitat features values for only, regardless of what gear caused the disturbance. In a few cases, the SASI recovery values differed for high and low energy systems. In these cases, low energy values were used. Also, like susceptibility, recovery times were classified into four ranges: 0: $<$ 1 year; 1: 1 – 2 years; 2: 2 – 5 years; 3: >5 years.

To calculate an average recovery time for each sediment class, we first randomly selected a recovery time for each habitat feature within its range of recoveries for a given sediment. We then computed the mean of these randomly selected habitat feature recoveries to get an average recovery time for each sediment class. We bounded class 3 to a maximum of ten years for recovery. In the initial implementation of the FE model, we generated random recoveries once, then subsequently used these values throughout the model. In future versions of the model, we may generate random recoveries for each time step and/or each grid cell. Additionally, it is worth noting, that in the current method of converting from yearly recovery rates to monthly recovery rates, we are assuming the recovery rate to be spread uniformly throughout the year. It is possible in future versions of the model to consider recovery rates that are seasonal or differ among months.

Expectation of impact rate

We used Eq. 4 to convert impact rate, I to a proportion I' representing the proportion of undisturbed habitat that converts to disturbed habitat each time step. While I itself is measured as a proportion, it is calculated within each grid cell for each gear type by summing across the impacted area for each tow and dividing by the grid area. Because we sum across tows, regardless of whether or not they overlap, the value I can exceed of one. Using an untransformed I in the model would be problematic, as this could lead to estimations of disturbed area that exceed the total area of the grid cell. Eq. 4 solves this problem as the transformed I' is bounded between zero and one.

We can motive this particular transformation by imagining a grid cell to be composed of N discrete habitat units. We will consider an example with only one gear and sediment type in the grid cell. We will let n be the number of impacted habitat units impacted by fishing as summed across individual tows. Thus n is the product of I and N,

$$n = IN \qquad (10)$$

Note that n can exceed N if $I > 1$. Given only I as a measure of fishing activity, we don't know how much of the habitat was actually impacted. For example, if we imagine $N = 100$ discrete habitat units in a grid cell and $I = 1$, then $n = 100$. We don't know if all 100 units were impacted in the grid cell or if the same 10 units were impacted by 10 different tows ($I = 0.1$, for 10 tows). We can model this scenario by treating the impact of each unique tow a sampling from N discrete habitat features. For a habitat feature to be "sampled" means that it gets disturbed by fishing. We sample with replacement because each tow can disturb a habitat feature that has already been disturbed by another tow. We can think of n as the number of times we take a sample with replacement of one from N. This assumes that there are n independent tows each with $I = 1/N$. Thus, each habitat feature has a $1/N$ probability of disturbance for each tow. Because a habitat feature can be repeatedly impacted, the probability of disturbance for each unit remains constant over all n tows. So, for any habitat feature, X_i, the probability of being impacted k times follows a Binomial distribution, $\mathbf{Bin}(n, 1/N)$, with the probability mass function,

$$f(k; n, \frac{1}{N}) = \Pr(X_i = k) = \binom{n}{k} \frac{1}{N}^k (1 - \frac{1}{N})^{n-k} \qquad (11)$$

Using Eq. 11, we can calculate the probability of a habitat feature not impacted over n tows,

$$\Pr(X_i = 0) = (1 - \frac{1}{N})^n \qquad (12)$$

Thus, the probability of a habitat feature being impacted is,

$$\Pr(X_i > 0) = 1 - \Pr(X_i = 0) = 1 - (1 - \frac{1}{N})^n \tag{13}$$

We can treat each X_i as a Bernoulli trail with the expectation of being impacted,

$$\mathbb{E}[X_i] = 1 - (1 - \frac{1}{N})^n \tag{14}$$

The expected proportion of impact I' across the entire grid cell will then be the sum of expected impacts for each habitat feature divided by N,

$$\frac{1}{N}\sum_{i=1}^{N} \mathbb{E}\,[X_i] = \frac{1}{N} N\mathbb{E}[X_i] = 1 - (1 - \frac{1}{N})^n \tag{15}$$

While Eq. 15 models the grid cell and impact in discrete units, this processes can be modeled across a continuous surface by letting $N \to \infty$ and substituting IN for n using Eq. 10,

$$I' = \lim_{N\to\infty} 1 - \left(1 - \frac{1}{N}\right)^{IN} = 1 - e^{-I} \tag{16}$$

We can interpret I' as the expected habitat disturbance, given an impact rate of I. Certainly, true measures of actual non-overlapping ground contact disturbance will vary about the expected value depending on how much overlap there is among tows. Likewise, we can anticipate higher variance as I increases, as greater impact will allow for greater variance in overlap patterns. We also note that the assumption of n independent tows each with $I = 1/N$, is almost certainly not met. Within a tow, impacts are not independent, and cannot be modeled as a sample with replacement since we know that individual tows do not overlap themselves (even where individual tows do intersect themselves, the area of the overlap is not counted twice). If a grid cell contained just one tow with an impact rate of $I = 0.25$, we know that the true proportion impacted is 25%. Using Eq. 16, however, we would estimate $I' = 1 - \exp(-0.25) = 0.22$, a difference of ~0.03. This difference is small, and in general, $I' \approx I$ for low values of I (Fig. 1). For grid cell containing only a single tow, I will generally be small, as the width of a tow (max $<$ 300 m) is small compared to the area of a typical grid cell (25 million sq. ~m). At greater values where we would expect multiple tows within a grid cell, I and I' do diverge considerably.

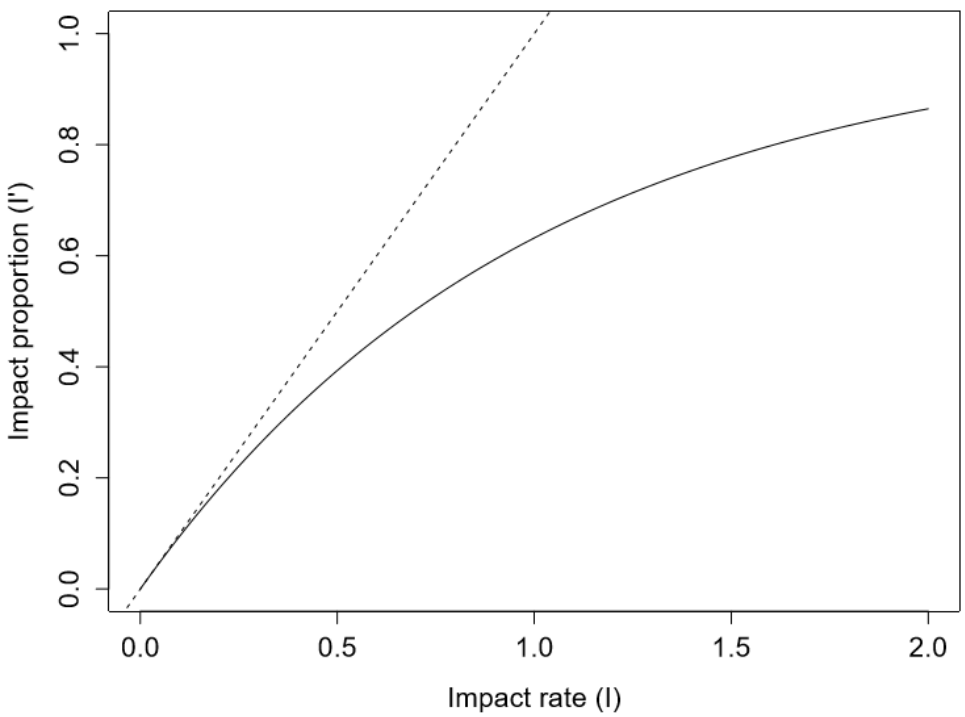

Figure 1. Comparison of I′ to I. The 1:1 relationship is represented by the dashed line. I' and I values remain relatively similar to about 0.2 before they begin to diverge. This represents the fact that as more total fishing occurs in a region, there is a higher probability that the fishing activities will overlap thus decreasing the proportion of area impacted relative to fishing effort.

Calculation of fishing effort

Fishing effort, f_g is calculated for each cell, month, and gear type using the CIA data set. The CIA data set was provided as a polyline feature class representing individual tows from January 2003 through June 2015. Nominal widths were joined to each fishing event in the CIA dataset based on the following attributes (Table 5): vessel type, subarea, gear, target species, vessel length, season (date), and grid cell depth. Buffers were created around the polylines based on the nominal gear with (ArcMap v 10.2.1). Square buffer ends were used to ensure the area swept did not exceed the extent of the polyline as well as to increase the efficiency of subsequent spatial operations by reduced the number of vertices compared to a rounded buffer. The buffered tows were then intersected with the 5 km grid creating a nominal area swept for individual tows within each cell. Each of these nominal areas were multiplied by a contact adjustment to calculate total ground contact. Ground contacts for each FE model gear type were summed over each grid cell and month and divided by the grid cell area to calculate f_g.

Table 1. Hook and line (HAL) susceptibility codes

Feature Class	Feature	Mud	Sand	Gran-Peb	Cobble	Boulder
G	Bedforms		0			
G	Biogenic burrows	1	1			
G	Biogenic depressions	0	1			
G	Boulder, piled					0
G	Boulder, scattered, in sand					0
G	Cobble, pavement				0	
G	Cobble, piled				1	
G	Cobble, scattered in sand				0	
G	Granule-pebble, pavement			0		
G	Granule-pebble, scattered, in sand			0		
G	Sediments, suface/subsurface	0	0			
G	Shell deposits		0	0		
B	Amphipods, tube-dwelling	1	1			
B	Anemones, actinarian			1	1	1
B	Anemones, cerianthid burrowing	1	1	1		
B	Ascidians		1	1	1	1
B	Brachiopods			1	1	1
B	Bryozoans			1	1	1
B	Corals, sea pens	1	1			
B	Hydroids	1	1	1	1	1
B	Macroalgae			1	1	1
B	Mollusks, epifaunal bivalve, Modiolus modiolus	0	0	0	0	0
B	Mollusks, epifaunal bivalve, Placopecten magellanicus	0	0	0	0	0
B	Polychaetes, Filograna implexa		1	1	1	1
B	Polychaetes, other tube-dwelling			1	1	1
B	Sponges		0	1	1	1

Adapted from longline susceptibility table (NEFMC 2011)

Susceptibility codes: 0: 0-10%; 1: 10-25%; 2: 25-50%; 3: >50%

Blank spaces are habitat features not associated with the given sediment class

G = Geological features; B = Biological features

Table 2. Pot (POT) susceptibility codes

Feature Class	Feature	Mud	Sand	Gran-Peb	Cobble	Boulder
G	Bedforms		0			
G	Biogenic burrows	1	1			
G	Biogenic depressions	1	1			
G	Boulder, piled					0
G	Boulder, scattered, in sand					0
G	Cobble, pavement				0	
G	Cobble, piled				1	
G	Cobble, scattered in sand				0	
G	Granule-pebble, pavement			0		
G	Granule-pebble, scattered, in sand			0		
G	Sediments, suface/subsurface	1	1			
G	Shell deposits		0	0		
B	Amphipods, tube-dwelling	1	1			
B	Anemones, actinarian			1	1	1
B	Anemones, cerianthid burrowing	1	1	1		
B	Ascidians		1	1	1	1
B	Brachiopods			1	1	1
B	Bryozoans			1	1	1
B	Corals, sea pens	1	1			
B	Hydroids		1	1	1	1
B	Macroalgae			1	1	1
B	Mollusks, epifaunal bivalve, Modiolus modiolus	0	0	1	1	1
B	Mollusks, epifaunal bivalve, Placopecten magellanicus		0	0	0	
B	Polychaetes, Filograna implexa		1	1	1	1
B	Polychaetes, other tube-dwelling			1	1	1
B	Sponges		0	1	1	1

Adapted from trap susceptibility table (NEFMC 2011)

Susceptibility codes: 0: 0-10%; 1: 10-25%; 2: 25-50%; 3: >50%

Blank spaces are habitat features not associated with the given sediment class

G = Geological features; B = Biological features

Table 3. Nonpelagic (NPT) and pelagic (PTR) trawl susceptibility codes

Feature Class	Feature	Mud	Sand	Gran-Peb	Cobble	Boulder
G	Bedforms		2			
G	Biogenic burrows	2	2			
G	Biogenic depressions	2	2			
G	Boulder, piled					2
G	Boulder, scattered, in sand					0
G	Cobble, pavement				1	
G	Cobble, piled				3	
G	Cobble, scattered in sand				1	
G	Granule-pebble, pavement			1		
G	Granule-pebble, scattered, in sand			1		
G	Sediments, suface/subsurface	2	2			
G	Shell deposits		1	1		
B	Amphipods, tube-dwelling	1	1			
B	Anemones, actinarian			2	2	2
B	Anemones, cerianthid burrowing	2	2	2		
B	Ascidians		2	2	2	2
B	Brachiopods			2	2	2
B	Bryozoans			1	1	1
B	Corals, sea pens	2	2			
B	Hydroids	1	1	1	1	1
B	Macroalgae			1	1	1
B	Mollusks, epifaunal bivalve, Modiolus modiolus	1	1	2	2	2
B	Mollusks, epifaunal bivalve, Placopecten magellanicus		2	1	1	
B	Polychaetes, Filograna implexa		2	2	2	2
B	Polychaetes, other tube-dwelling			2	2	2
B	Sponges		2	2	2	2

Adapted from trap susceptibility table (NEFMC 2011)
Susceptibility codes: 0: 0-10%; 1: 10-25%; 2: 25-50%; 3: >50%
Blank spaces are habitat features not associated with the given sediment class
G = Geological features; B = Biological features

Table 4. Recovery codes

Feature Class	Features	Mud	Sand	Gran-Peb	Cobble	Boulder
G	Bedforms		0			
G	Biogenic burrows	0	0			
G	Biogenic depressions	0	0			
G	Boulder, piled					3
G	Boulder, scattered, in sand					0
G	Cobble, pavement				0	
G	Cobble, piled				3	
G	Cobble, scattered in sand				0	
G	Granule-pebble, pavement			0		
G	Granule-pebble, scattered, in sand			2		
G	Sediments, suface/subsurface	0	0			
G	Shell deposits		2	2		
B	Amphipods, tube-dwelling	0	0			
B	Anemones, actinarian			2	2	2
B	Anemones, cerianthid burrowing	2	2	2		
B	Ascidians		1	1	1	1
B	Brachiopods			2	2	2
B	Bryozoans			1	1	1
B	Corals, sea pens	2	2			
B	Hydroids	1	1	1	1	1
B	Macroalgae			1	1	1
B	Mollusks, epifaunal bivalve, Modiolus modiolus	3	3	3	3	3
B	Mollusks, epifaunal bivalve, Placopecten magellanicus		2	2	2	
B	Polychaetes, Filograna implexa		2	2	2	2
B	Polychaetes, other tube-dwelling			1	1	1
B	Sponges		2	2	2	2

Adapted from trawl recovery table (NEFMC 2011)

Recovery codes: 0: < 1 year; 1: 1 – 2 years; 2: 2 – 5 years; 3: >5 years

Blank spaces are habitat features not associated with the given sediment class

G = Geological features; B = Biological features

Table 5. Gear widths and contact adjustment based on attributes from the CIA database

Fishery	Vessel type	Area	Gear	Target1	Target2	Vessel Length (ft)	Season	Depth Range (fath.)	Gear mod[1]	Nom Width (m)	Min Width (m)[2]	Max Width (m)[2]
GOA Pollock Pelagic Trawl Sand Point	CV	GOA	PTR	P	all others	<75				50	50	50
GOA Pollock Pelagic Trawl	CV	GOA	PTR	P	all (but K, S)	≥75				75	0	30
GOA Slope Rockfish Pelagic Trawl	CV	GOA	PTR	K	S	≥75				75	0	0
GOA Slope Rockfish Pelagic Trawl	CP	GOA	PTR	K	W	all				100	0	0
GOA PCod Bottom Trawl Inshore	CV	GOA	NPT	C	B, P	≥75				90	90	90
GOA Deepwater Flatfish Bottom Trawl	CV	GOA	NPT	D	W, X	≥75			2014	90	23	68
GOA Shallowwater Flatfish Bottom Trawl	CV	GOA	NPT	H	all others	≥75			2014	90	23	68
GOA PCod Bottom Trawl Sand Point	CV	GOA	NPT	C	all others	<75				55	55	55
GOA Deepwater Flatfish Bottom Trawl CP	CP	GOA	NPT	D, W	X	all			2014	193	39	143
GOA Shallowwater Flatfish/Cod Bottom Trawl CP	CP	GOA	NPT	H, C	L, all others	all			2014	193	39	143
GOA Slope Rockfish Bottom Trawl CP	CP	GOA	NPT	K	S	all				75	75	75
BS Pollock Pelagic Trawl (incl Mothership)	CV	BS	PTR	P	B, all others	<125 ≥300	A	≥90		62	12	37
BS Pollock Pelagic Trawl (incl Mothership)	CV	BS	PTR	P	B, all others	<125 ≥300	A	60-90		58	12	35
BS Pollock Pelagic Trawl (incl Mothership)	CV	BS	PTR	P	B, all others	<125 ≥300	A	<60		50	10	30

Fishery	Vessel type	Area	Gear	Target1	Target2	Vessel Length (ft)	Season	Depth Range (fath.)	Gear mod[1]	Nom Width (m)	Min Width (m)[2]	Max Width (m)[2]
BS Pollock Pelagic Trawl (incl Mothership)	CV	BS	PTR	P	B, all others	<125 ≥300	B	≥90		77	15	46
BS Pollock Pelagic Trawl (incl Mothership)	CV	BS	PTR	P	B, all others	<125 ≥300	B	60-90		73	15	44
BS Pollock Pelagic Trawl (incl Mothership)	CV	BS	PTR	P	B, all others	<125 ≥300	B	<60		64	13	38
BS Pollock Pelagic Trawl	CV	BS	PTR	P	B, all others	125-151	A	≥90		93	19	56
BS Pollock Pelagic Trawl	CV	BS	PTR	P	B, all others	125-151	A	60-90		87	17	52
BS Pollock Pelagic Trawl	CV	BS	PTR	P	B, all others	125-151	A	<60		75	15	45
BS Pollock Pelagic Trawl	CV	BS	PTR	P	B, all others	125-151	B	≥90		115	23	69
BS Pollock Pelagic Trawl	CV	BS	PTR	P	B, all others	125-151	B	60-90		109	22	65
BS Pollock Pelagic Trawl	CV	BS	PTR	P	B, all others	125-151	B	<60		96	19	58
BS Pollock Pelagic Trawl	CV	BS	PTR	P	B, all others	151-300	A	≥90		132	26	79
BS Pollock Pelagic Trawl	CV	BS	PTR	P	B, all others	151-300	A	60-90		124	25	74
BS Pollock Pelagic Trawl	CV	BS	PTR	P	B, all others	151-300	A	<60		106	21	64
BS Pollock Pelagic Trawl	CV	BS	PTR	P	B, all others	151-300	B	≥90		163	33	98
BS Pollock Pelagic Trawl	CV	BS	PTR	P	B, all others	151-300	B	60-90		154	31	92
BS Pollock Pelagic Trawl	CV	BS	PTR	P	B, all others	151-300	B	<60		137	27	82
BS Pollock Pelagic Trawl	CP	BS	PTR	P	B, all others	all	A	≥90		142	99	128
BS Pollock Pelagic	CP	BS	PTR	P	B, all	all	A	60-90		133	93	120

Fishery	Vessel type	Area	Gear	Target1	Target2	Vessel Length (ft)	Season	Depth Range (fath.)	Gear mod[1]	Nom Width (m)	Min Width (m)[2]	Max Width (m)[2]
Trawl					others							
BS Pollock Pelagic Trawl	CP	BS	PTR	P	B, all others	all	A	<60		114	80	103
BS Pollock Pelagic Trawl	CP	BS	PTR	P	B, all others	all	B	≥90		175	140	175
BS Pollock Pelagic Trawl	CP	BS	PTR	P	B, all others	all	B	60-90		166	133	166
BS Pollock Pelagic Trawl	CP	BS	PTR	P	B, all others	all	B	<60		147	118	147
BS Pcod Bottom Trawl	CV	BS	NPT	C	all others	≤100				90	90	90
BS Pcod Bottom Trawl	CV	BS	NPT	C	all others	>100 ≤250				110	110	110
BS Pcod YFS Bottom Trawl mothership	CV	BS	NPT	Y	C, all others	>250 (or Processor M)				90	90	90
BS Pcod Bottom Trawl	CP	BS	NPT	C	B, P	<150			2011	193	42	145
BS Rock Sole Bottom Trawl	CP	BS	NPT	R		<150			2011	193	42	145
BS Yellowfin Sole Bottom Trawl a80	CP	BS	NPT	Y		<150			2011	193	42	145
BS Flathead Sole/ Other Flat Bottom Trawl	CP	BS	NPT	L	F, W, all others	<150			2011	193	42	145
BS Pcod Bottom Trawl	CP	BS	NPT	C	B, P	≥150 <225			2011	259	47	189
BS Rock Sole Bottom Trawl	CP	BS	NPT	R		≥150 <225			2011	259	47	189
BS Yellowfin Sole Bottom Trawl a80	CP	BS	NPT	Y		≥150 <225			2011	259	47	189
BS Flathead Sole/ Other Flat Bottom Trawl	CP	BS	NPT	L	F, W, all others	≥150 <225			2011	259	47	189

Fishery	Vessel type	Area	Gear	Target1	Target2	Vessel Length (ft)	Season	Depth Range (fath.)	Gear mod[1]	Nom Width (m)	Min Width (m)[2]	Max Width (m)[2]
BS Bottom Trawl - non a80	CP	BS	NPT	Y	all others	225+			2011	259	47	189
BS POP Bottom Trawl	CP	BS	NPT	K	S, T	<250				100	100	100
AI Pcod Bottom Trawl mothership	CV	AI	NPT	C	all others	>250 (or Processor M)				75	75	75
AI Pcod Bottom Trawl	CV	AI	NPT	C	all others	<99				55	55	55
AI Pcod Bottom Trawl	CV	AI	NPT	C	all others	≥99				90	90	90
AI Atka and Rockfish Bottom Trawl	CP	AI	NPT	A	K, all others	all				100	100	100
AI Pollock		AI	PTR	P	all					100	0	20
GOA PCod Pot		GOA	POT	C	all others					5.6	2.8	5.6
BSAI Pcod Pot		BSAI	POT	C	all others					5.6	2.8	5.6
BSAI Sablefish Pot		BSAI	POT	S	T					5.6	2.8	5.6
GOA Sablefish Pot (few, but future) can combine BS for now		GOA	POT	S	T					5.6	2.8	5.6
GOA Sablefish Longline		GOA	HAL	S	T					2	0	2
GOA SE Demersal Shelf Rock Longline		GOA	HAL	K						2	0	2
GOA Halibut longline		GOA	HAL	I						2	0	2
GOA Pcod Longline		GOA	HAL	C	all others					2	0	2
BSAI Pcod Longline		BSAI	HAL	C	all others					2	0	2
BSAI Sabelfish/ Greenland Turbot Longline		BSAI	HAL	S	T					2	0	2
BSAI Halibut longline		BSAI	HAL	I						2	0	2

Fishery	Vessel type	Area	Gear	Target1	Target2	Vessel Length (ft)	Season	Depth Range (fath.)	Gear mod[1]	Nom Width (m)	Min Width (m)[2]	Max Width (m)[2]
PCod Jig (also rockfish and halibut)		GOA	JIG	C	all others					0.2	0	0.2
BS Pcod Jig		BS	JIG	C	all others					0.2	0	0.2
AI Jig		AI	JIG	C	all others					0.2	0	0.2

[1] Indicates year in which a gear modification regulation went into effect.
[2]Min and max widths are same as nominal width prior to gear modification

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