Crab Plan Team
1/10/24

Unobserved Fishing Mortality Working Group Report

Working group members:

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Background

- Crab Conservation Workplan (December 2022)
- SSC report (October 2022) and Council motion (December 2022)
- Initial CPT discussion (May 2023)
- SSC report, AP motion, Council motion (June 2023)
- Working group met for four two-hour meetings (Nov / Dec 2023)
  - Composed of CPT / SSC members and NMFS employees

Council motion (June 2023)

The Council approves the objectives of working group as follows:

- Identify data sources, major data gaps, and assumptions to estimate unobserved mortality for stock assessments and to better understand temporal/spatial extent across fisheries and gear types.
- Provide research priority recommendations and/or needed research projects.

The anticipated products include:

- Framework for estimating unobserved fishing mortality and explicitly incorporating into stock assessments.
- Report on specific research priorities and data needs.
- Recommendations for approaches to investigate spatial/temporal extent of unobserved mortality over fisheries and gear types to the extent practicable.

The Council will consider a public workshop on the working group progress and/or products in the future.

Working Group Terms of Reference / Caveats

- Only considered “big three” stocks: BBRKC, EBS Tanner and snow
- Did not consider any uncertainty around data on *observed* mortality
- Did not consider any habitat effects from gear (direct mortality only)
- Gear considered: pots, ghost pots, hook and line, non-pelagic trawl, pelagic trawl
- WG cautions that conclusions and perspectives in this report reflect the perspective and expertise of the membership

Outline

1. Assumptions and uncertainties for estimating unobserved mortality
2. Tools for estimating unobserved mortality
3. Framework for incorporating unobserved mortality in stock assessment models
4. Framework for comparing potential magnitude among gears and research priorities (Tables 1 & 2)
5. Working group recommendations

Information required for assessing UFM

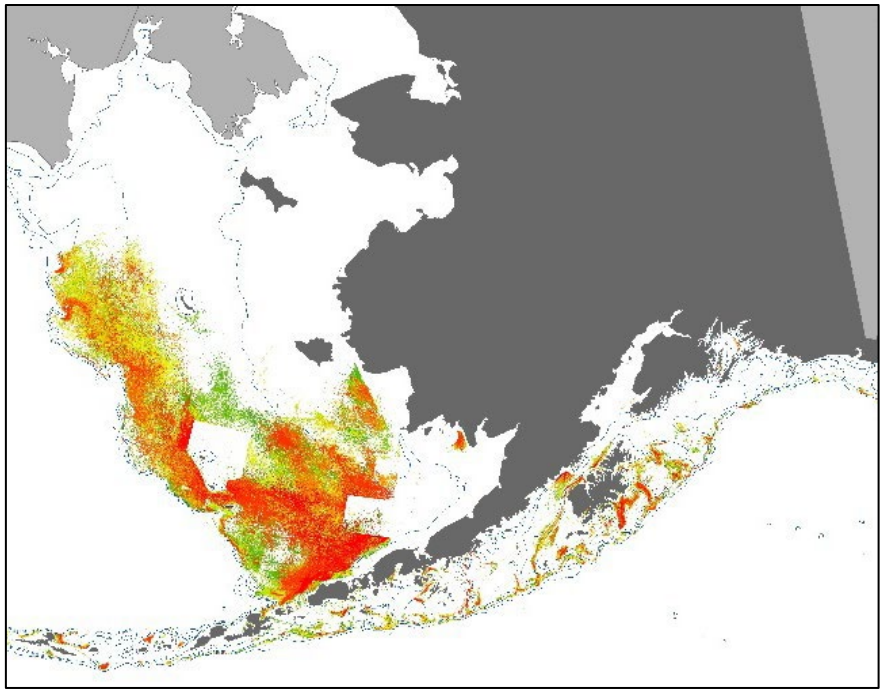
1. Estimated gear bottom contact in space and time
2. Distribution of crab in space and time
3. Probability of gear-crab encounter based on (1) and (2)
4. Mortality rate if encounter occurs

Other considerations

- Variability in gear materials & design likely critical to unobserved mortality

Most important existing and in-development tools

- Fishing Effects (FE) model (FAST Lab, APU)
  - Bottom contact estimates for 50 gear configurations
  - Currently available
  - Doesn't estimate contact with crab or "lethality" of gear



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NRC Research Press

ARTICLE

A seascape-scale habitat model to support management of fishing impacts on benthic ecosystems

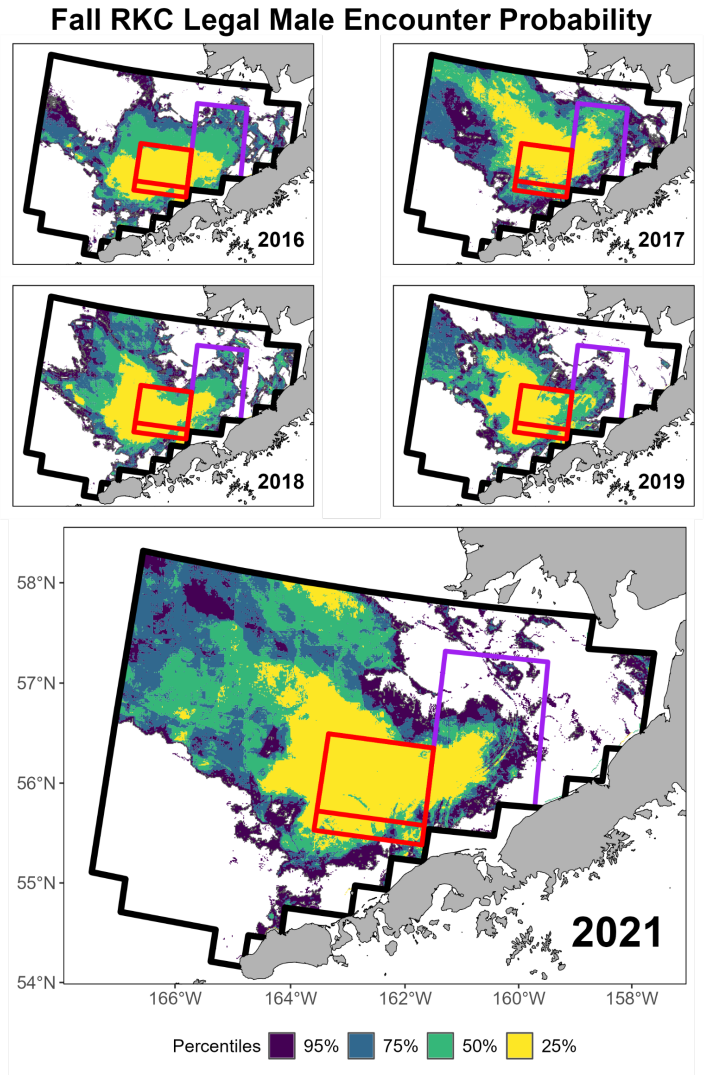
T. Scott Smeltz, Bradley P. Harris, John V. Olson, and Suresh A. Sethi

Abstract: Minimizing fishing impacts on seafloor ecosystems is a growing focus of ocean management; however, few quantitative tools exist to guide seascape-scale habitat management. To meet these needs, we developed a model to assess benthic ecosystem impacts from fishing gear contact. The habitat impacts model is cast in discrete time and can accommodate overlapping fisheries as well as incorporate gear-specific contact dynamics. We implemented the model in the North Pacific using fishing data from 2003 to 2017, estimating that habitat in 3.1% of the 1.2 million km² study area was disturbed at the end of the simulation period. A marked decline in habitat disturbance was evident since 2010, attributable to a single regulatory gear change that lifted trawl gear components off the seafloor. Running scenarios without these gear modifications showed these policies might have contributed to a 24% reduction in habitat disturbance since their implementation. Ultimately, model outputs provide direct estimates of the spatial and temporal trends of habitat effects from fishing — a key component of regulatory policies for many of the world's fisheries.

Résumé : Si la minimisation des impacts de la pêche sur les écosystèmes du fond marin est un domaine d'intérêt croissant en gestion des océans, il existe toutefois peu d'outils quantitatifs pour guider la gestion des habitats à l'échelle du paysage marin. Pour répondre à ces besoins, nous avons développé un modèle pour évaluer les impacts sur les écosystèmes benthiques des contacts d'engins de pêche. Le modèle d'impacts sur l'habitat est configuré en temps discret et peut intégrer des pêches se chevauchant, ainsi que la dynamique de contact d'engins précis. Nous avons appliqué le modèle dans l'océan Pacifique Nord en

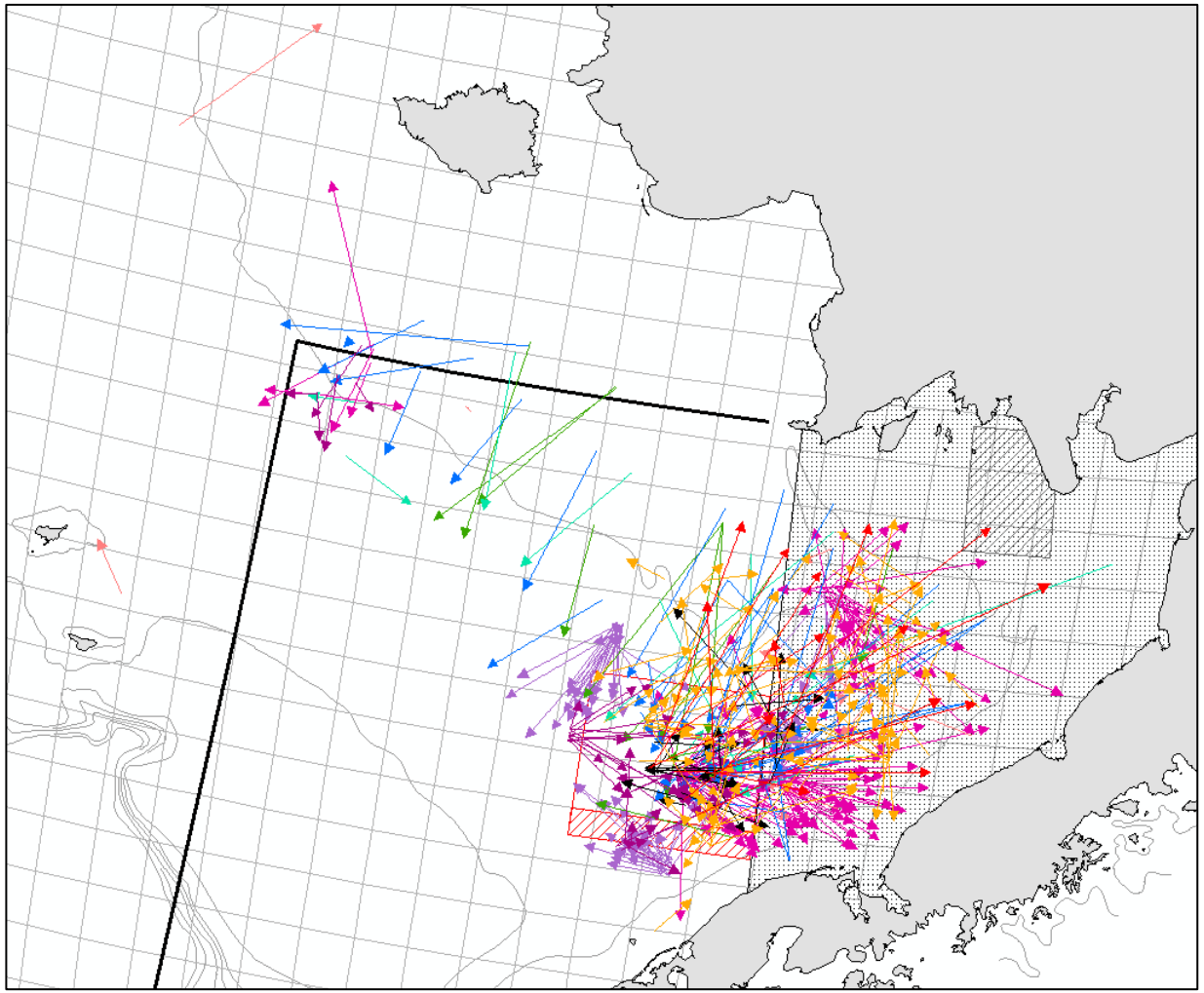
Most important existing and in-development tools

- Species Distribution Models (NMFS / OSU)
  - Snow crab and BBRKC
  - Models completed, papers in review
  - Topics of research updates this meeting (Thursday afternoon)
- Gear / crab overlap (NMFS / UAF)
  - Combined FE and SDM output
  - Just starting



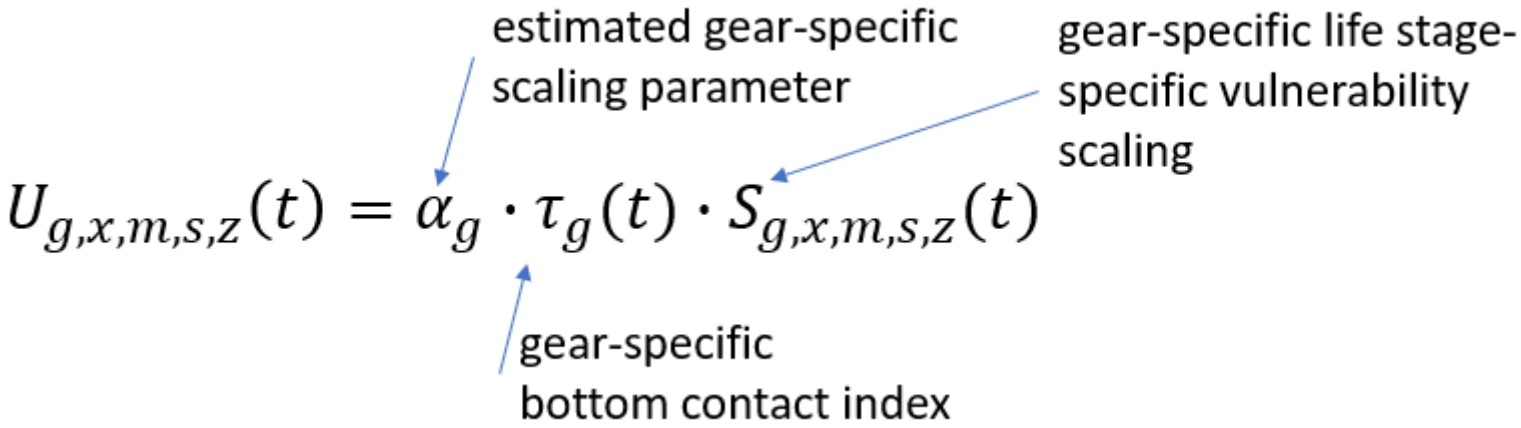
Most important existing and in-development tools

- BBRKC satellite tagging
  - (ADF&G / BSFRF / NMFS)
  - Extensive data collection
  - Analysis under way



First approach for incorporating *U* (unobs. mortality)

- Parameterized for each gear as:



- Incorporated as additional mortality term (*U*; specified or estimated) or additional "fleet" (fit to data)
- Required data do not exist
- Most valuable as a research model framework

Second approach for incorporating UFM in models

- Incorporate independent estimates of UFM in models
- Similar to approach for incorporating observed bycatch mortality
- Could be similar to previous approach of inflating observed bycatch mortality to evaluate sensitivity of snow crab population to UFM
- Could be informed by additional field experiments estimating unobserved:observed mortality ratios for different gear types

Incorporating UFM in models: caveats

- Most necessary data do not exists
- Model structure varies for different stocks, requiring specific approaches for each
- Any approach for incorporating unobserved mortality would undergo normal CPT / SSC / AP / Council review process before implementation for management purposes

Table 1: Information for estimating magnitude, data availability and gaps, and research priorities

- Individual fishing event level
  - Area contacted
  - Time on bottom
  - “Lethality” of gear
- Population level
  - Total # of events
  - Overlap with crab
- Information types for each level
  - Magnitude
  - Data available
  - Research priority
  - Research timeline

4. Framework for estimating magnitude of UFM and research priorities

Table 1 (fixed gear). Note shading for medium / high priority research items.

Gear Type (# of configs)	Information Type	Individual Event (e.g., pot/trawl) Level			Population Level	
		Bottom Contact Area	*Time on Bottom*	*"Lethality" of gear*	*Total # of Events (pot lifts/trawls)*	*Overlap with Crab*
Pots (2)	*Magnitude*	10^1 m^2	Hours to Days	High	10^5	High
	Data Available	Yes	Yes	No	Yes	Yes
	Research Needed	Data mining	Data mining	Field exp'ts	Data mining	Data mining
	Priority	Low	Low	Low	Low	Low
	Timeline (years)	0.5-1	0.5-1	3-5	0.5-1	0.5-1
Lost Pots (2)	*Magnitude*	10^1 m^2	Months to Years	Medium	Unknown	High
	Data Available	Yes	Some	Some	Some	Some
	Research Needed	Data mining	Field expt's	Field expt's	Data mining/Field expt's	Data mining
	Priority	Low	Medium	Medium	Medium	Low
	Timeline (years)	1-2	3-5+	1-3	3-5	0.5-1
Hook-and-Line (3)	*Magnitude*	10^4 m^2	Hours to Days	Low	10^4	Medium
	Data Available	Yes	Yes	No	Yes	Some
	Research Needed	Data mining	Data mining	Field expt's	Data mining	Crab Dist.
	Priority	Low	Low	Low	Low	Low
	Timeline (years)	0.5-1	0.5-1	3-5	0.5-1	0.5-1

4. Framework for estimating magnitude of UFM and research priorities

Table 1 (trawl gear). Note shading for medium / high priority research items.

Gear Type (# of configs)	Information Type	Individual Event (e.g., pot/trawl) Level			Population Level	
		Bottom Contact Area	*Time on Bottom*	*"Lethality" of gear*	*Total # of Events (pot lifts/trawls)*	*Overlap with Crab*
Non-Pelagic Trawl (13)	*Magnitude*	10^6 m^2	Minutes	High	10^4	Medium
	Data Available	Yes	Yes	Some	Yes	Some
	Research Needed	Data mining	Data mining	Field Exp'ts	Data mining	Crab Dist.
	Priority	Medium	Medium	Medium	Low	Medium
	Timeline (years)	0.5-1	0.5-1	3-5	0.5-1	1-5
Pelagic Trawl (30)	*Magnitude*	10^5 m^2	Minutes	High	10^4	Medium
	Data Available	Yes	Yes	No	Yes	Some
	Research Needed	Data mining	Data mining	Field Exp'ts	Data mining	Crab Dist.
	Priority	Medium	Medium	High	Low	Medium
	Timeline (years)	0.5-1	0.5-1	3-5	0.5-1	1-5

Table 2: Information required for estimating UFM: approaches, availability, limitations, and research needs

- Information required
  - Gear bottom contact
  - Crab spatial distribution
  - Crab movement
  - Size / life stage vulnerabilities
  - Encounter rate
  - Mortality rate if encountered
- Each needed piece of information evaluated based on:
  - Possible approaches for providing information
  - Available data
  - Key limitations to available data or models
  - Research needs

4. Framework for estimating magnitude of UFM and research priorities

Table 2 (1 of 3). Information status and research needs. Note shading for medium / high priority research items (darker grey is higher priority).

Information Need	Approach	Available data/inputs	Key limitations (data & models)	Research needs
Bottom contact (footprint of fishing gears)	Fishing Effects model (all fisheries/gear types)	Catch-In-Areas database, based on VMS & observer data	uncertain estimates of 'effective' bottom contact, switch to EM may affect accuracy	Improved contact ratio estimates; sensitivity to model assumptions
	SDM approach to model distribution of ghost pots	Some empirical data for ghost pots (log book data)	'Effective area' unknown & dependent on crab movement	Direct observations (video)
Crab spatial distribution by size or life stage and season	Species Distribution Models (SDMs) such as GAMs, VAST, etc.	Summer bottom trawl surveys (EFH analyses & maps)	Summer distribution only	Surveys in other seasons
		BSFRF small mesh trawl surveys	Few years of data, summer only	Integrate with SDMs of summer distribution
		Winter Cooperative Pot Survey (CPS) for Red King Crab	Spatially restricted	SDMs of winter distribution; additional winter surveys
		Fishery-dependent CPUE (incl. bycatch 'CPUE' in groundfish fisheries)	Sampling effort not independent of crab distribution, limited footprint of fishery	Models appropriate to fishery-dependent CPUE & combining data from multiple fisheries

4. Framework for estimating magnitude of UFM and research priorities

Table 2 (2 of 3). Information status and research needs. Note shading for medium / high priority research items (darker grey is higher priority).

Information Need	Approach	Available data/inputs	Key limitations (data & models)	Research needs
Movement (relative to stationary gear, ghost pots)	Movement models	Tagging data (e.g. RKC)	Sparse data, large cab only	Integrating movement into SDMs when possible
	Infer movement from SDMs	combine fishery-dependent & independent data	limited seasonal & spatial coverage to infer movement	Improved models for combining multiple, disparate data sources
Size / life stage dependent vulnerabilities	Vulnerability assessment	Literature review, assumed high during molting	limited information on relative vulnerability at different life stages	Timing and location of molting
	Use size as proxy for vulnerability	Spatial distribution by size class over the observed size range	Distribution & habitat requirements for recently settled juveniles	Vulnerability of small crab to fishing impacts

4. Framework for estimating magnitude of UFM and research priorities

Table 2 (3 of 3). Information status and research needs. Note shading for medium / high priority research items (darker grey is higher priority).

Information Need	Approach	Available data/inputs	Key limitations (data & models)	Research needs
Encounter rate	Mechanistic: FE impacts model	Fishery footprint + SDM results on distribution of crab	Uncertainty associated with inputs	Distribution of crab during fishing seasons
	Empirical: Ratio of unobserved / observed encounters	Rose et al under-bag experiments	few experiments, likely high variability across gear configurations	Experiments / direct observations (all gear types & configurations)
Mortality rate (when encountered)	Under-bag experiments	Rose et al (some NPT gear)	Mortality difficult to assess	Experiments / direct observations (all gear types & configurations)
	High volume tagging experiments	None	Study design - feasibility of estimating M and disentangling mortality sources	Simulations to assess effectiveness and sampling effort needed
	Video observations	Limited observations from experimental fishing	Visibility, assessing injury & long-term mortality risk visually	Forward-looking cameras on trawls + independent video observations in trawl pass
	Assess escape mechanism effectiveness	ADF&G reports (AI GKC) Literature	Variety of pot types & escape mechanisms	lab experiments on degradation rates & force needed to escape
	Pop Dy model with M linked to modeled encounters	Modeled encounter rates by stock (FE model)	Model complexity is expensive; model does not account for small crab	Develop research models for Tanner and snow crab; begin exploring modeling approaches and information needs
	Pop Dy model with R linked to modeled encounters	Modeled encounter rates by stock (FE model)	Unlikely to provide estimates of mortality of small crab	Research models to explore potential impacts on recruitment

Working Group conclusions & recommendations

- Report is the first step to achieving Council's requested products
- Substantial data deficiencies preclude estimation of UFM
- Additional WG meetings would likely not be fruitful until further data have been collected
- If additional meetings are held, input from a broader group of experts would be helpful
- WG encourages stakeholders and members of the public to provide feedback to CPT and SSC/AP/Council (June 2024)