Spasming Sablefish: Biology, Population Dynamics, and Ideas for Calculating Economic Metrics with Catch Advice

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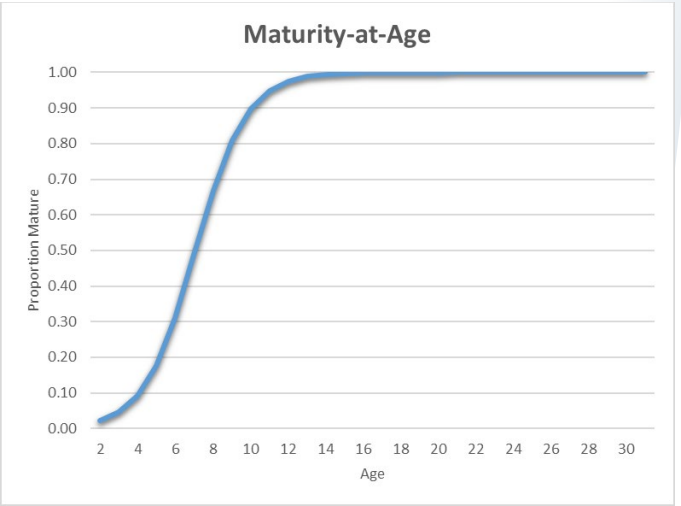
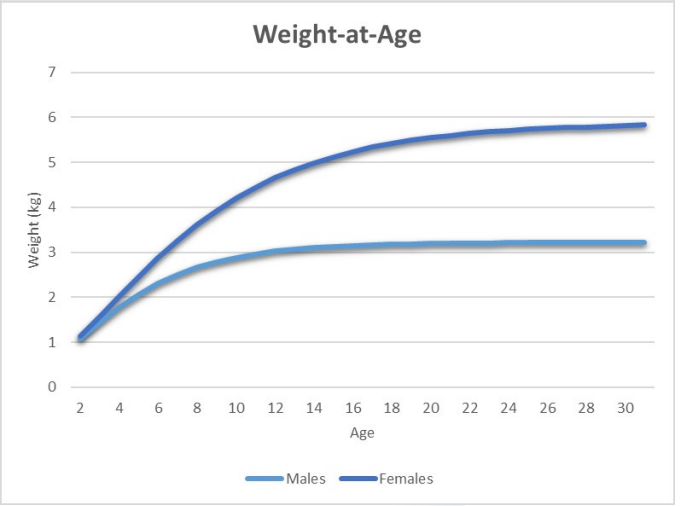
North Pacific Fisheries Management Council

Biology

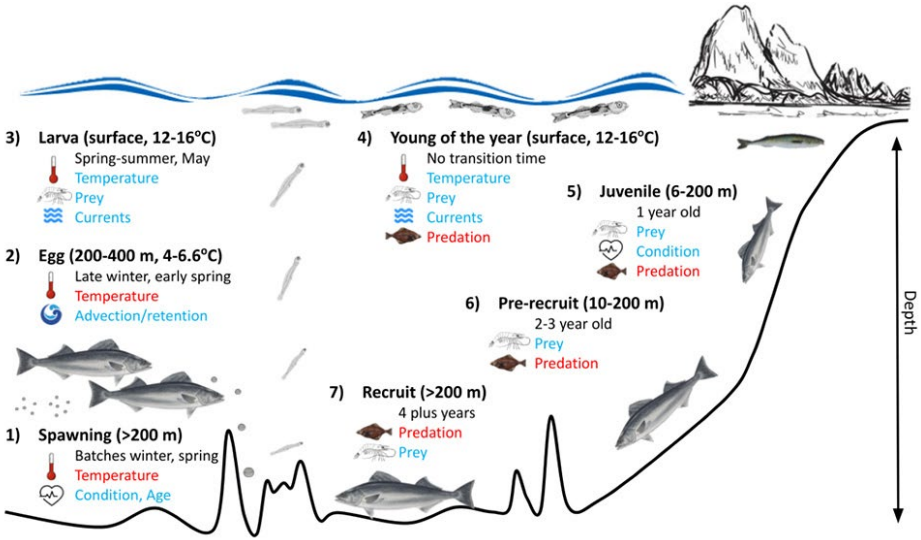
- Long-lived (>90 years), deep-dwelling (>200m) species
- No genetic diversity across their range in eastern Pacific Ocean
- Sexually dimorphic growth
- Fully mature at ~age-12



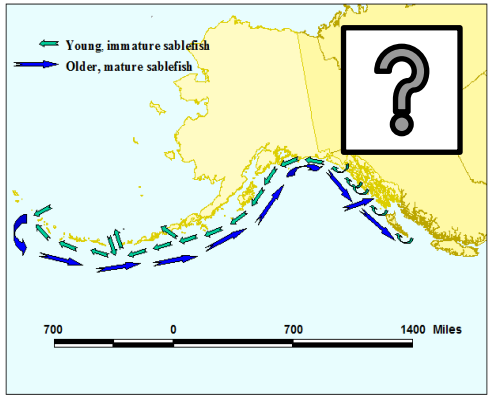


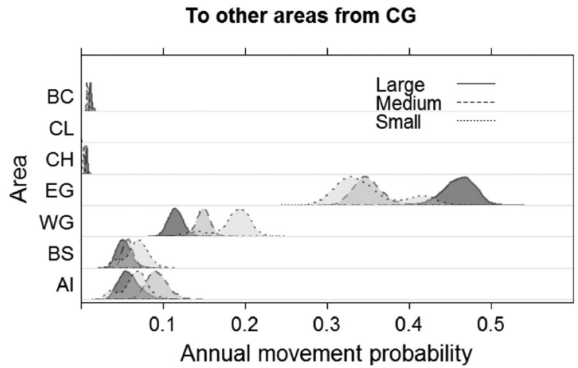
Life History

- Juveniles migrate from shallow inshore to deep offshore habitat
- Coastwide movement patterns not well understood
- High yearly movement potential



Shotwell et al. (2023)

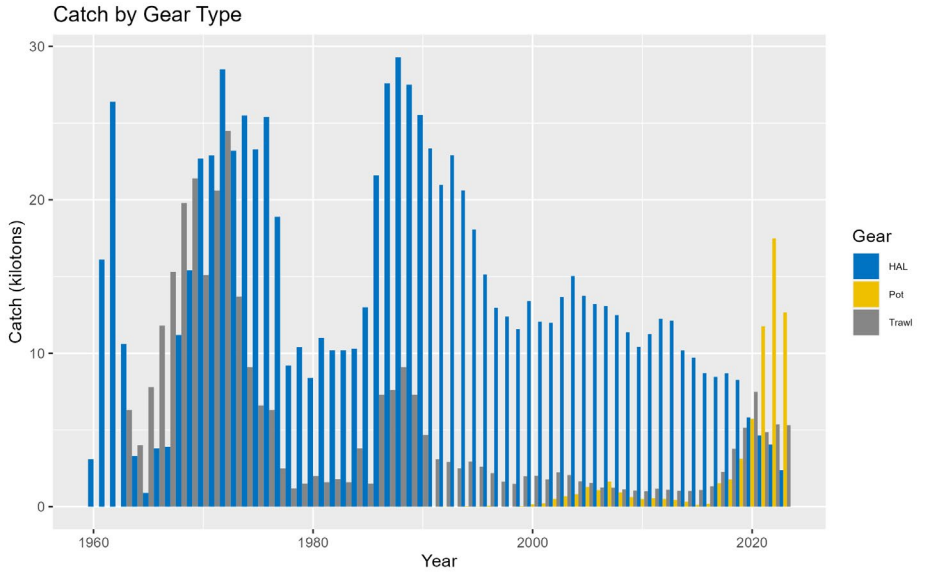


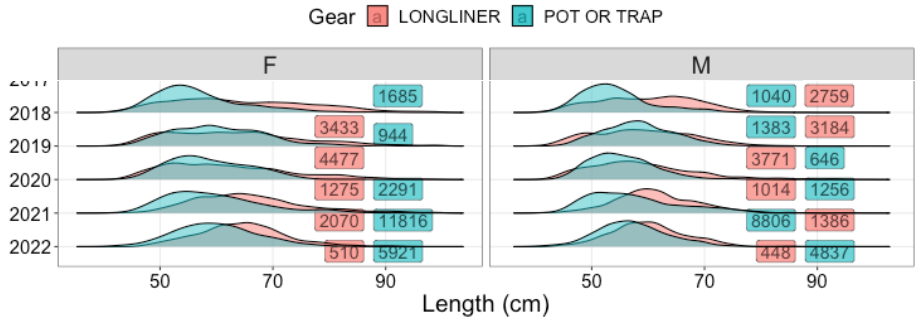


Hanselman et al. (2015)

Fishery

- Primarily a directed longline fishery
  - Trawl catch constitutes ~10—30% of catch
- Recent rapid transition from hook-and-line to longline pot gear (collapsible slinky pots)
  - Pots > 80% of catch in 2023
  - Pot gear may retain slightly smaller fish





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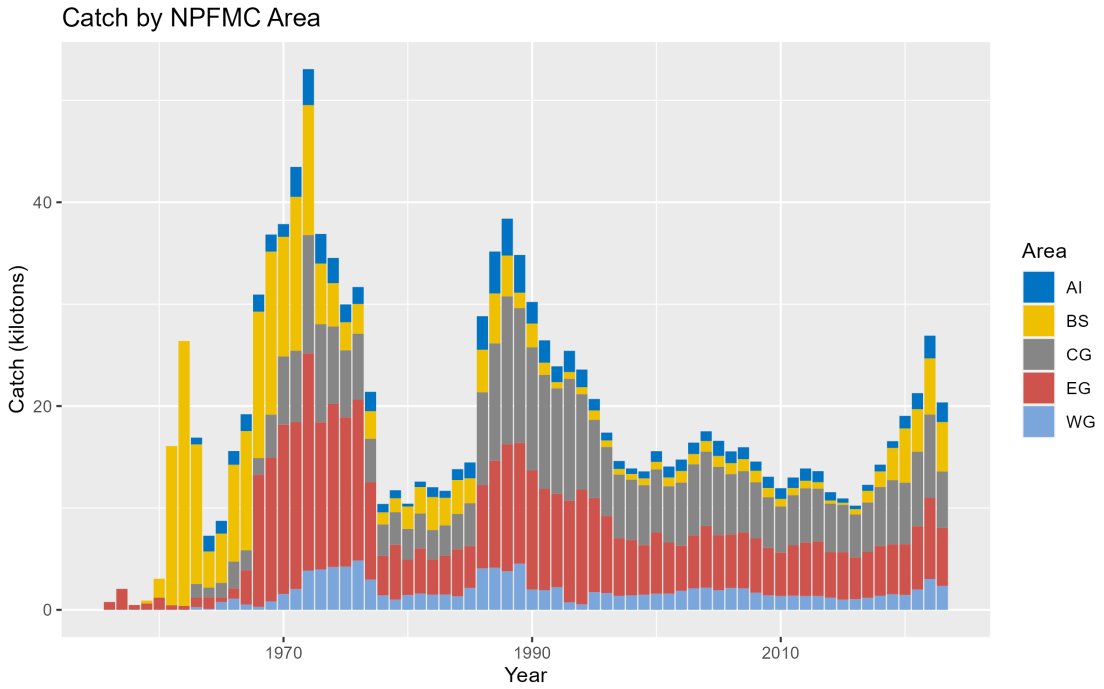
Fishery

- Full retention fishery
- ABC 70—85% utilized, except at very low quota levels (then fully utilized)
  - Utilization varies by region (generally lower in BSAI)
- Catch and resource distribution vary across management areas



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Economics

- Strong size-based price gradients
- Predominantly an export market
- Recent market saturation
- Smaller size grades decrease in value with influx from extreme recruitment events

Price per Pound

Price Grade

Year	1 to 2 Lbs	2 to 3 Lbs	3 to 4 Lbs	4 to 5 Lbs	5 to 7 Lbs	7 UP
2015	$4.22	$4.27	$5.19	$6.09	$7.55	$8.94
2016	$4.85	$5.05	$5.78	$6.63	$8.16	$10.04
2017	$5.70	$6.05	$7.16	$8.25	$9.34	$10.70
2018	$1.63	$2.89	$4.13	$5.28	$8.27	$9.14
2019	$1.49	$2.06	$2.71	$3.56	$5.88	$6.69
2020	$0.45	$1.19	$1.74	$2.17	$3.33	$4.97
2021	$0.96	$1.91	$2.46	$2.84	$3.78	$5.60
2022	$0.84	$1.75	$2.40	$3.57	$5.97	$6.94
2023	$0.43	$0.95	$1.34	$1.88	$4.33	$5.35
Mean	$2.29	$2.90	$3.66	$4.47	$6.29	$7.60

Sex	Age	Proportion Females Mature	Total length (in)	Dressed weight (lb)	Grade
Male	1	--	18.3	1.0	Grade 1/2
Male	2	--	20.3	1.5	Grade 1/2
Male	3	--	21.9	2.0	Grade 2/3
Male	4	--	23.1	2.5	Grade 2/3
Male	5	--	24.1	2.9	Grade 2/3
Male	6	--	24.9	3.2	Grade 3/4
Male	7	--	25.5	3.5	Grade 3/4
Male	8	--	26.0	3.7	Grade 3/4
Male	9	--	26.4	3.9	Grade 3/4
Male	10	--	26.7	4.0	Grade 4/5
Male	11	--	27.0	4.1	Grade 4/5
Male	12	--	27.2	4.2	Grade 4/5
Male	13	--	27.3	4.3	Grade 4/5
Male	14	--	27.5	4.3	Grade 4/5
Male	15	--	27.6	4.4	Grade 4/5
Female	1	0.01	18.1	1.0	Grade 1/2
Female	2	0.02	20.4	1.5	Grade 1/2
Female	3	0.05	22.4	2.1	Grade 2/3
Female	4	0.10	24.0	2.7	Grade 2/3
Female	5	0.18	25.4	3.3	Grade 3/4
Female	6	0.32	26.6	3.9	Grade 3/4
Female	7	0.49	27.6	4.4	Grade 4/5
Female	8	0.67	28.5	4.9	Grade 4/5
Female	9	0.81	29.2	5.3	Grade 5/7
Female	10	0.90	29.8	5.7	Grade 5/7
Female	11	0.95	30.3	6.1	Grade 5/7
Female	12	0.97	30.7	6.4	Grade 5/7
Female	13	0.99	31.1	6.6	Grade 5/7
Female	14	0.99	31.4	6.9	Grade 5/7
Female	15	1.00	31.6	7.0	Grade 7+

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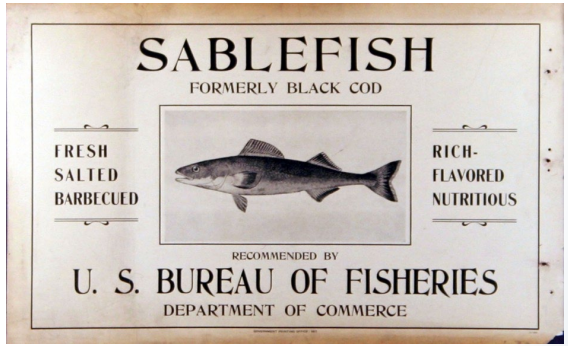
Management

- Management aims to maintain the population at 40% of the unfished size (i.e., a B40% harvest control rule)
- ABC apportioned to management region based on 5-year average survey biomass
- Region-specific distribution of ABC among gear sectors



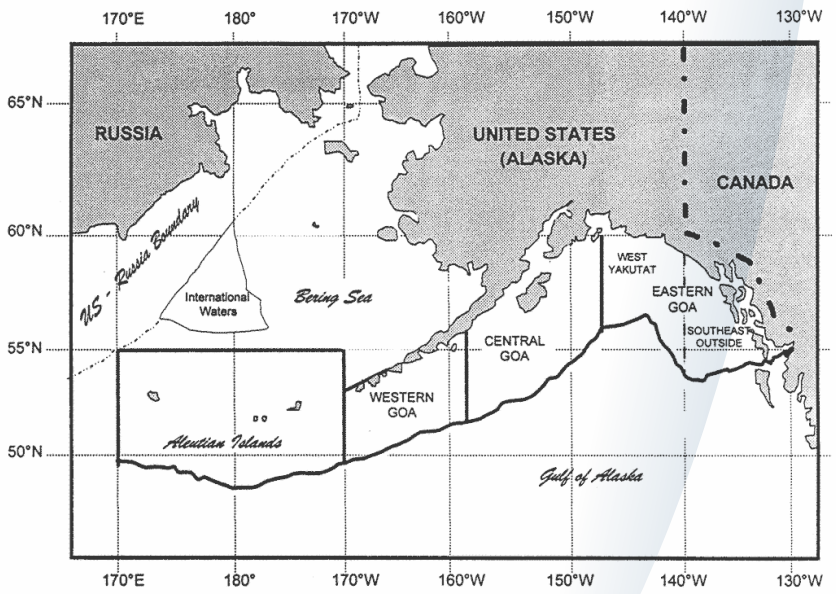


Figure 14 to Part 679. Sablefish Regulatory Areas and Districts

NOTE:Refer to Figures 1 and 3 for coordinates.

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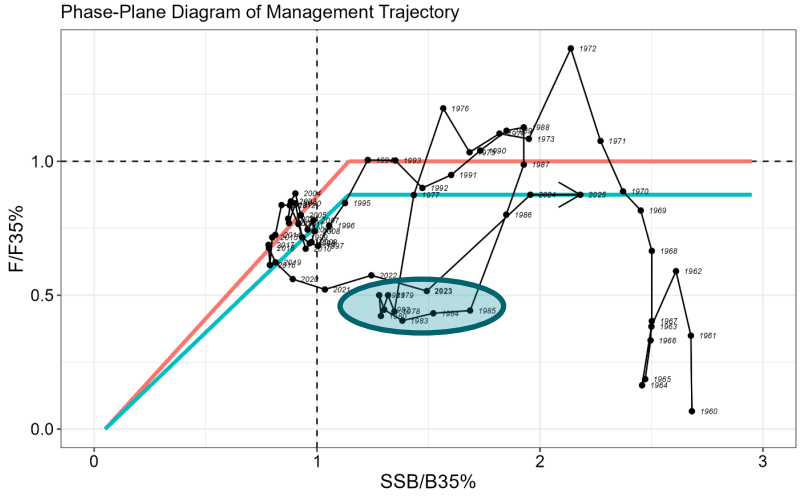
Stock Assessment and Catch Projections

- Age-based, sex-specific, statistical catch-at-age (SCAA) assessment model
  - Combined fixed gear fleet and separate trawl fleet
  - https://www.fisheries.noaa.gov/resource/data/2023-assessment-sablefish-stock-alaska
- Project future catch by simulating forward from terminal assessment year
- Catch based on the sloping HCR
- Assume terminal year dynamics continue into the future (e.g., biology, selectivity, and ratio of F among gears)
- Catch specified based on terminal year quota utilization
- ABC adjusted for whale depredation



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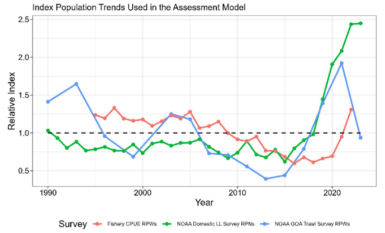
Current Status

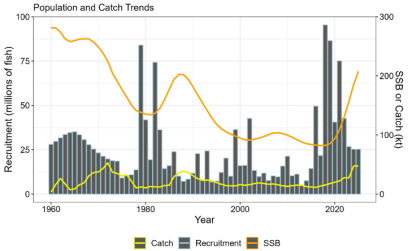
- Numerous extreme recent recruitment events
- High abundance/biomass
- Increasing SSB
  - >75% of SSB in age classes that are not fully mature
- Rapid increases in ABC
  - Largest quota on record since catch of late 1970s
  - Only 66% utilized in 2023

2023 Alaskan Sablefish SAFE (*Anoplopoma fimbria*)

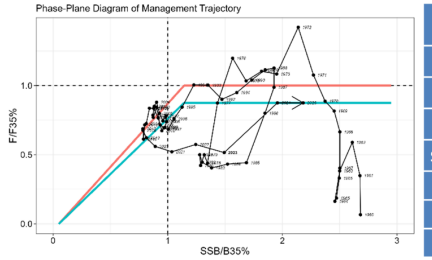
Data and Stock Assessment Model

- Following steady increases in abundance and biomass indices since 2015, the 2023 NOAA longline survey abundance was stable matching the 2022 value, the NOAA Gulf of Alaska trawl survey declined precipitously, and the fixed gear fishery CPUE continued to increase.
- The author proposed model (*23.5*) integrated minor data refinements and parametrization updates, but the main structure was consistent with the previously accepted model (*21.12*).
- The biomass and SSB continue to increase, while recruitment has been at or above the mean since 2014.





Stock Status and ABC Recommendations



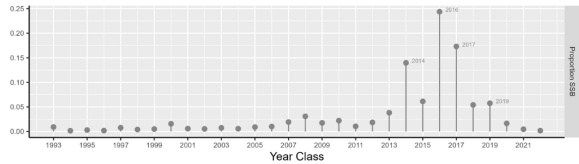
Quantity	2022 SAFE (Projections for 2023)	2023 SAFE (Projections for 2024)
$B_{100\%}$	305,595	299,901
$B_{40\%}$	122,238	119,960
$SSB_{(Terminal\_Yr+1)}$	159,788	185,079
$SSB_{(Terminal\_Yr+1)}/B_{100\%}$	52%	62%
$F_{ABC(Terminal\_Yr+1)}$	0.081	0.086
$ABC_{w(Terminal\_Yr+1)}$	40,502	47,146
$OFL_{w(Terminal\_Yr+1)}$	47,390	55,084

*SSB projections are based on specified catch for the terminal year. ABC_w and OFL_w are the recommended values after whale depredation has been taken into account.

- The resource is *not overfished* and *overfishing is not occurring*.
- Recent ABCs have not been fully utilized with catch averaging ~70% of the ABC over the last 3 years.
- The ABC increased by 16% due to continued maturation and growth (in weight) of the population.

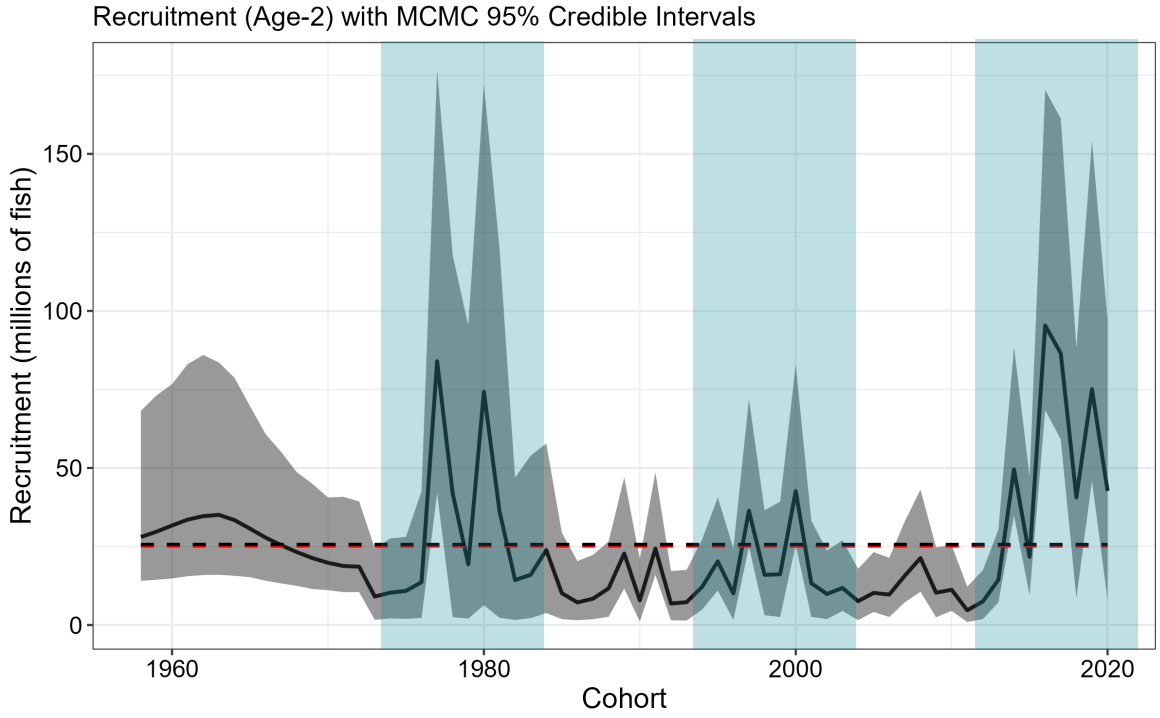
Other Considerations

- The population age-structure remains contracted relative to historic levels.
- 2014 – 2020 year classes comprise > 75% of projected 2024 SSB.

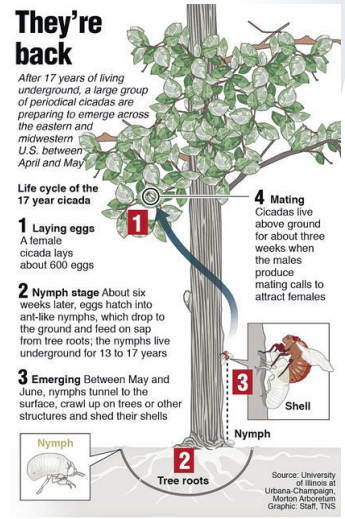


The Spasm Cycle

- Cyclical, spasmodic, and extreme recruitment occurs every ~20 years
  - Environmental/ecosystem related?

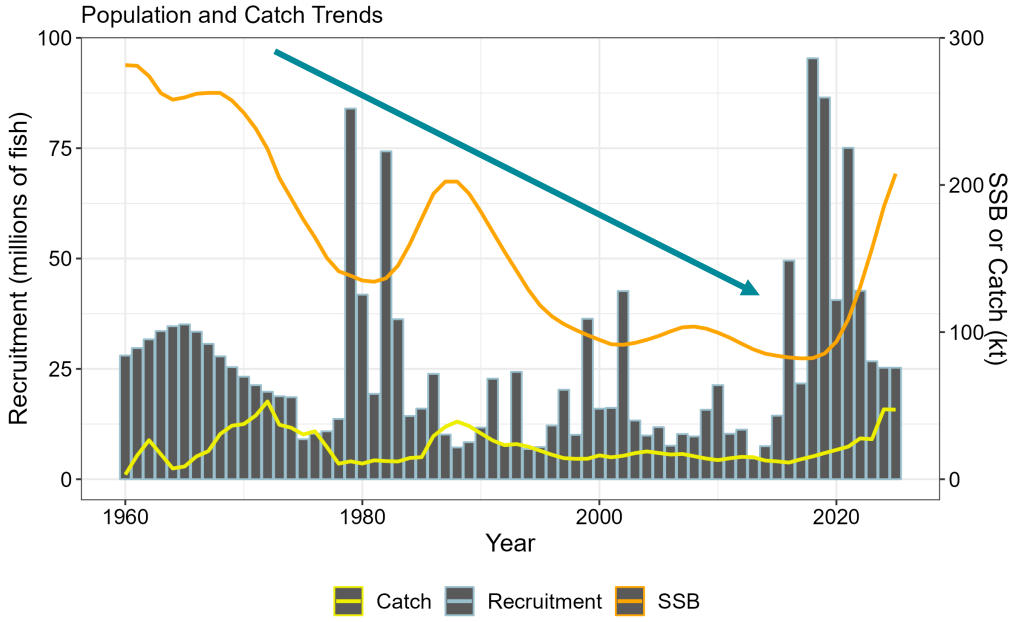


The Cicada of the Sea?



The Spasm Cycle

- Catch/quotas increase, primarily driven by small, young fish
- Economic downturns associated with flooded markets and low value following recruitment boons
- Delayed increase in spawning biomass (SSB)
- Subsequent increase of catch/quotas on maturing fish
- Long-term population decline



Socioeconomic Impacts

- Declining price
- Flooded markets
  - Lack of ABC utilization
- Interest in removing full retention policy
  - Reduce catch of low value small fish
- Revenue likely to lag population increases
  - Limited increases until fish reach age-7+

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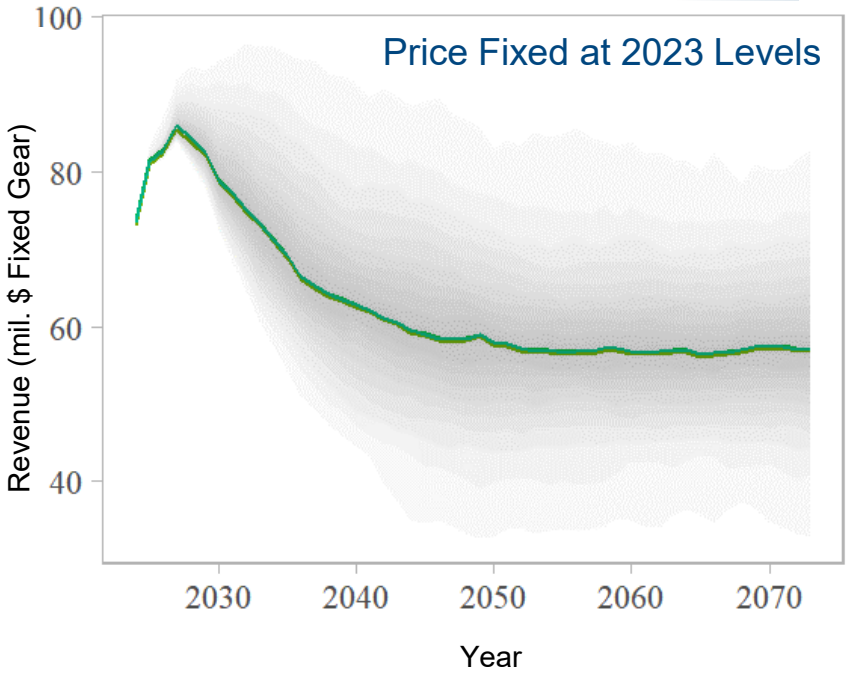
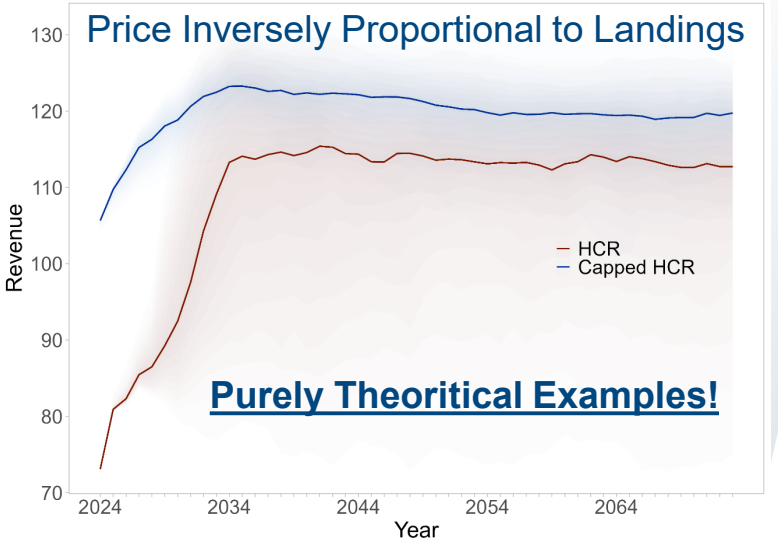
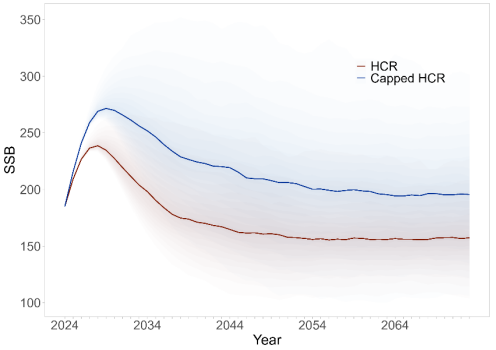
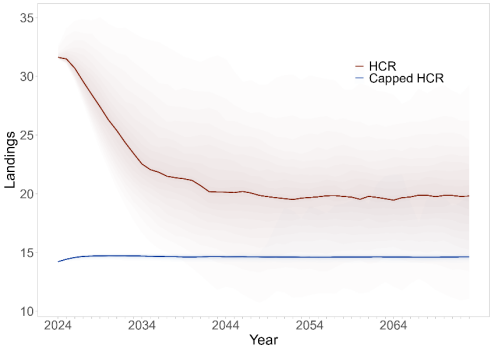


Addressing Economics: HCRs and Projections

- Basic economics can be shown in HCR projections (e.g., revenue curves)
- Socioeconomic metrics (e.g., catch stability) might be addressed in TAC setting (e.g., landings caps)
- Economic modules could be integrated with input from economists and the necessary economic data



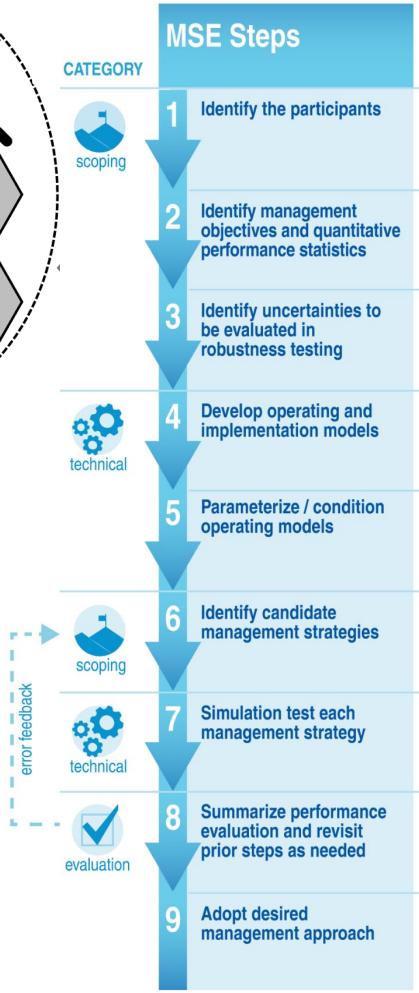




Addressing Economics: MSE

- MSE: Management Strategy Evaluation
  - MSE Tool = modeling framework
  - MSE Process = stakeholder-inclusive approach to set management options
- Purpose: simulation test tradeoffs among management options
  - Systems approach integrating feedback among management (HCR), population, and fishery
- "Laboratory testing a car's safety system before driving into rush hour traffic"
- Can implement socioeconomic sub-models and associated performance metrics

Goethel et al. (2019, 2023)



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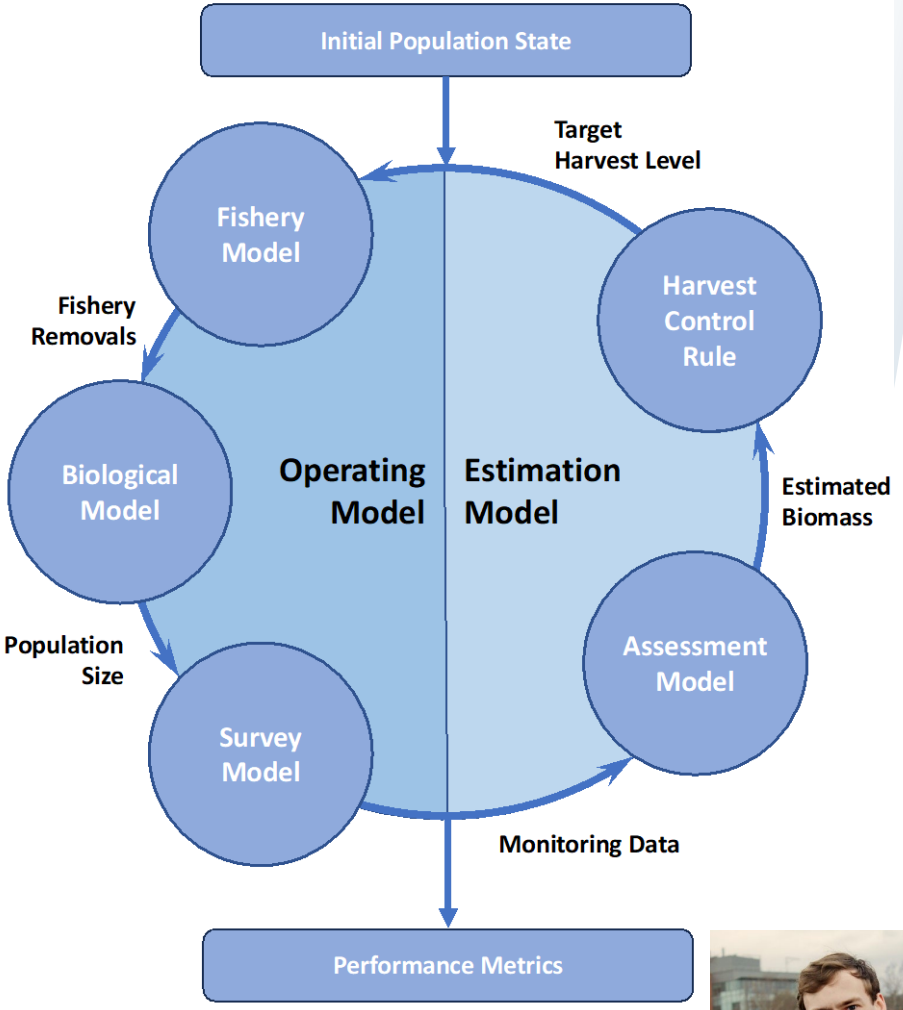
Alaska Sablefish MSE

- Age-structured, multi-sex, multi-fleet operating model (*afscOM*)
  - https://github.com/BenWilliams-NOAA/afscOM
  - https://github.com/Ovec8hkin/SablefishMSE
  - OM is highly generalized
  - Currently conditioned on AK sablefish biological and fishery dynamics
- Estimation model based on AK-wide sablefish assessment
- Simulated harvest control rules (HCRs) provide feedback to population and fishery
- Simple economics integrated
  - Feedback among ABC, landed catch, size selectivity, price, and revenue

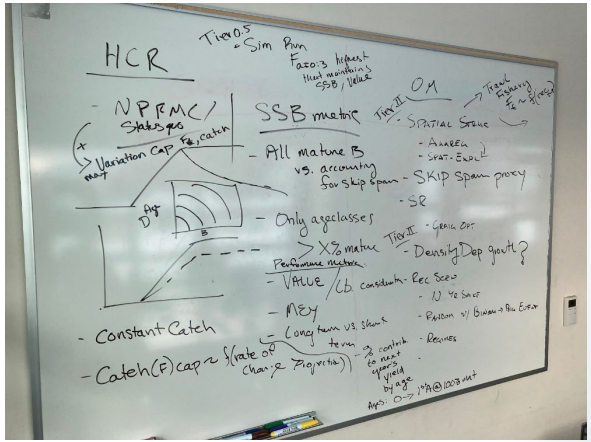


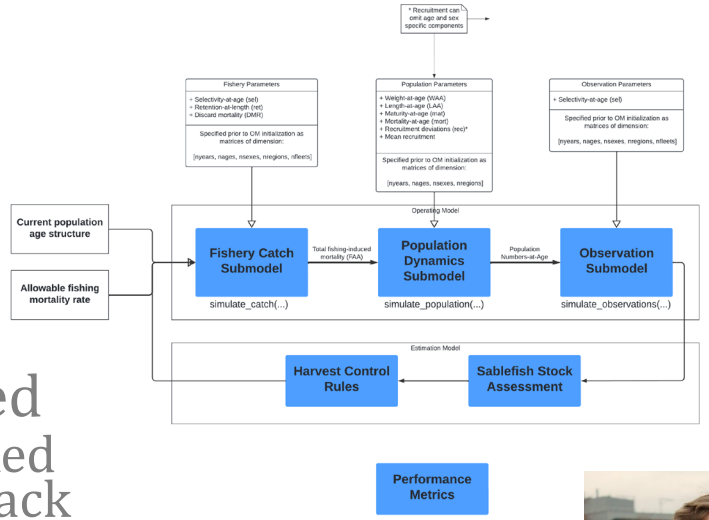
Zahner et al. (2024)
https://doi.org/10.1093/icesjms/fsad199

POC: Joshua Zahner (jazahner@alaska.edu)

Alaska Sablefish MSE

- Planned analyses:
  - Alternate HCRs
    - Current B40%
    - Capped
    - Age-diversity linked
  - Impacts of discarding
  - Secondary:
    - Consequences of reduced survey/assessment frequency
    - Spatial apportionment strategies
- Timeline
  - Initial modeling tool: 2024
  - Results: 2025
- Limited socioeconomics currently modeled
  - Could develop a socioeconomic module linked to various inputs/outputs with direct feedback to HCR, landings, etc.

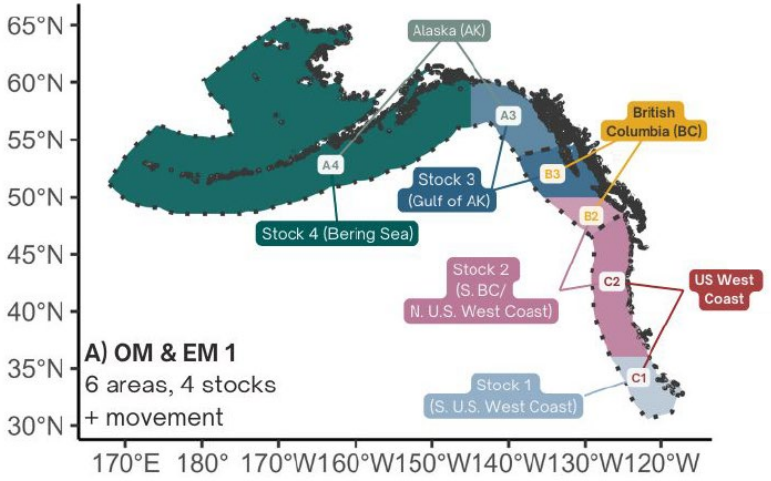




POC: Joshua Zahner (jazahner@alaska.edu)

Northeast Pacific Sablefish MSE

- Pacific Sablefish Transboundary Assessment Team (PSTAT)
- Key model features:
  - Entire Northeast Pacific, including BSAI, GOA, BC, WC
  - Data-conditioned OM models biological stocks with local stock-recruit relationships and includes movement among stocks
  - Can include regional or coastwide assessment (using delay-difference model) and management (HCRs)
- https://doi.org/10.1139/cjfas-2024-0008



Kapur et al. (2024)

POC: Maia Kapur (maia.kapur@noaa.gov)

Northeast Pacific Sablefish MSE

- MSE Next Steps
  - Investigate climate drivers of recruitment
  - Consider bio-economic performance measures
- Tool can be used for many questions!
  - Rapid run times
  - Can explore alternative hypotheses about population structure and management response
  - Easy to test alternative HCRs
- https://doi.org/10.1139/cjfas-2024-0008

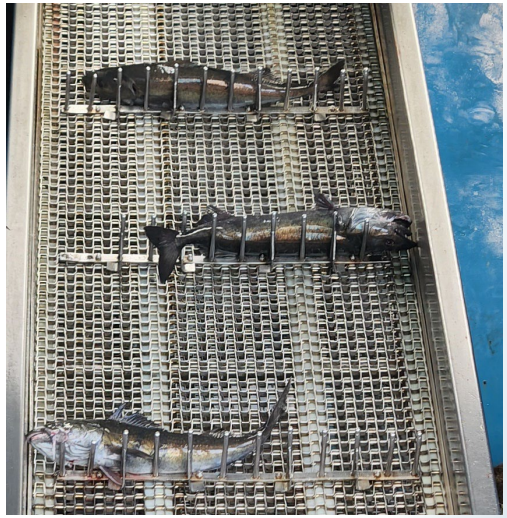
Multiple spatial hypotheses in MSE

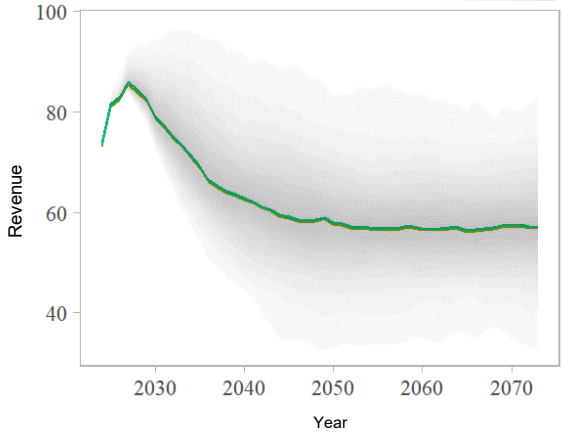
Kapur et al. (2024)

POC: Maia Kapur
(maia.kapur@noaa.gov)

Conclusions

- Sablefish biology and economics are complex
- Spasmodic recruitment results in boom-bust biological dynamics
  - Likely tied to ecosystem/climate dynamics, both of which are in uncharted territory
- Current B40% HCR leads to large SSB and catch fluctuations
- Existing simulation models could address basic economic metrics
- MSE tools better suited to integration of more realistic/complex socioeconomics
  - Requires input/oversight from economists
  - Not planned/feasible within current project
  - Requires a coder with knowledge of MSE tools










QUESTIONS?





Stock Assessment Model

3. Assessment of the Sablefish Stock in Alaska

Daniel R. Goethel, Matthew L.H. Cheng, Katy B. Echave, Craig Marsh, Cara J. Rodgveller, Kalei Shotwell, and Kevin Siwicke

November 2023

- Assessed as a single Alaska-wide resource
  - Starts in 1960, includes ages 2-31+
  - No assumed stock-recruit relationship
  - Single combined HAL and pot fleet, with trawl fleet explicitly modeled
    - Asymptotic selectivity for longline gear, domed selectivity for trawl gear
    - Time blocks to address management (IFQ) and availability changes
  - Longline and trawl surveys included/modeled
- Maximum likelihood estimation (MLE) used to fit observed data and estimate parameters
- Yearly estimates of abundance-at-age, SSB, biomass, recruitment, and fishing mortality
  - Selectivity estimated for each gear/time block
  - Catchability estimated for each survey
- https://www.fisheries.noaa.gov/resource/data/2023-assessment-sablefish-stock-alaska

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Biological Implications of Recruitment

- Evidence of density-dependent effects (i.e., reduced weight)
- Variability in recruitment across regions
  - Impacts regional quotas
- Changes in availability to survey and fishing gears(?)
  - Expansion of habitat utilization of juveniles (i.e., deeper)(?)
- Reestablishment of historical population centers (e.g., Bering Sea)(?)