Weak stock bycatch avoidance in the west coast ocean salmon fishery:

a bioeconomic model using spatio-temporal data from commercial fishermen

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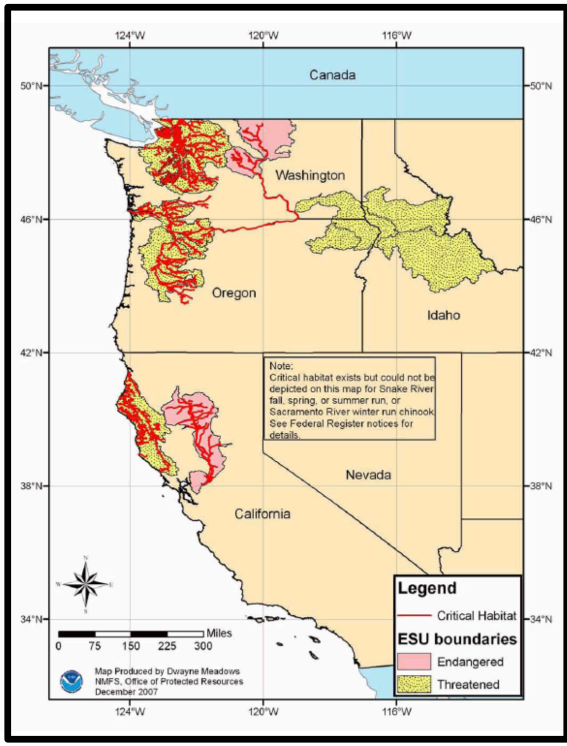
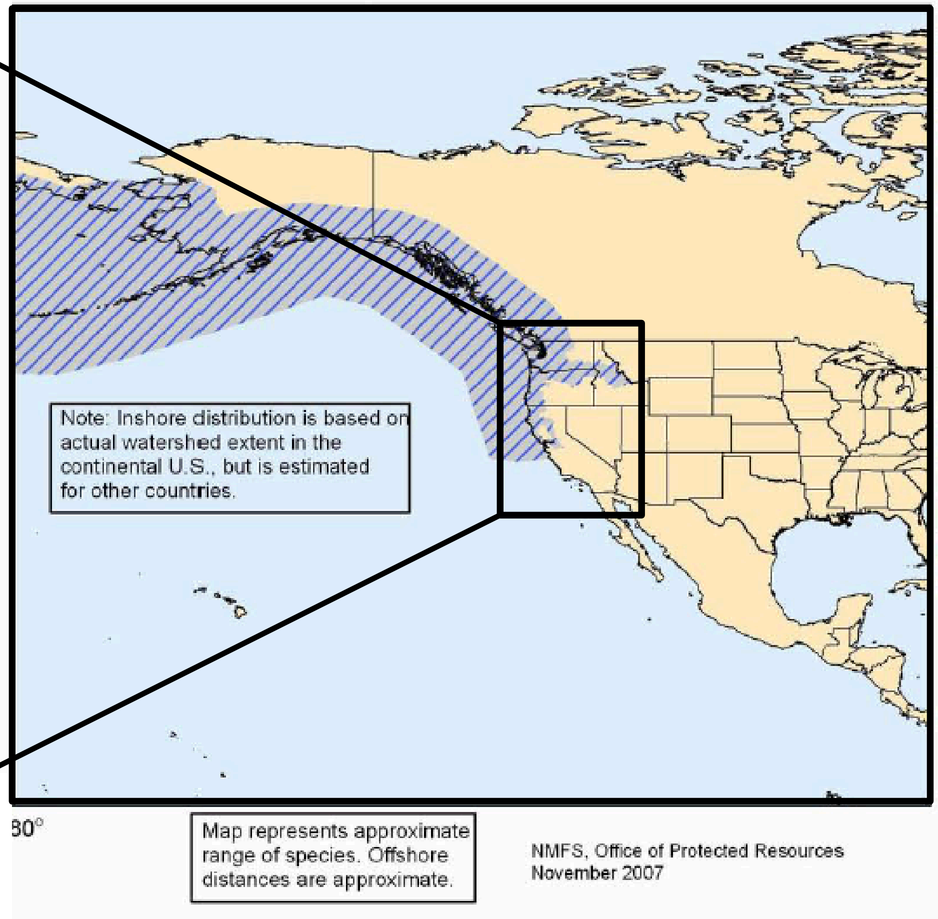
Distribution of Chinook Salmon Stocks





http://www.nmfs.noaa.gov/pr/species/fish/chinook-salmon.html

Current status of West Coast Chinook Salmon ESUs

ESA Species of Concern	ESA Threatened Species	ESA Endangered Species
Pacific-Central Valley, fall and late fall-run ESU	California coastal	Upper Columbia River spring-run
	Central Valley spring-run	Sacramento River winter-run
	Central Valley spring-run in the San Joaquin River, CA	
	Lower Columbia River	
	Upper Willamette River	
	Puget Sound	
	Snake River spring/ summer-run	
	Snake River fall-run	

Note: Since 1992, the federal government has declared 9 disasters related to the salmon fisheries on the West Coast (not including Alaska), paying out $276.1 millions.

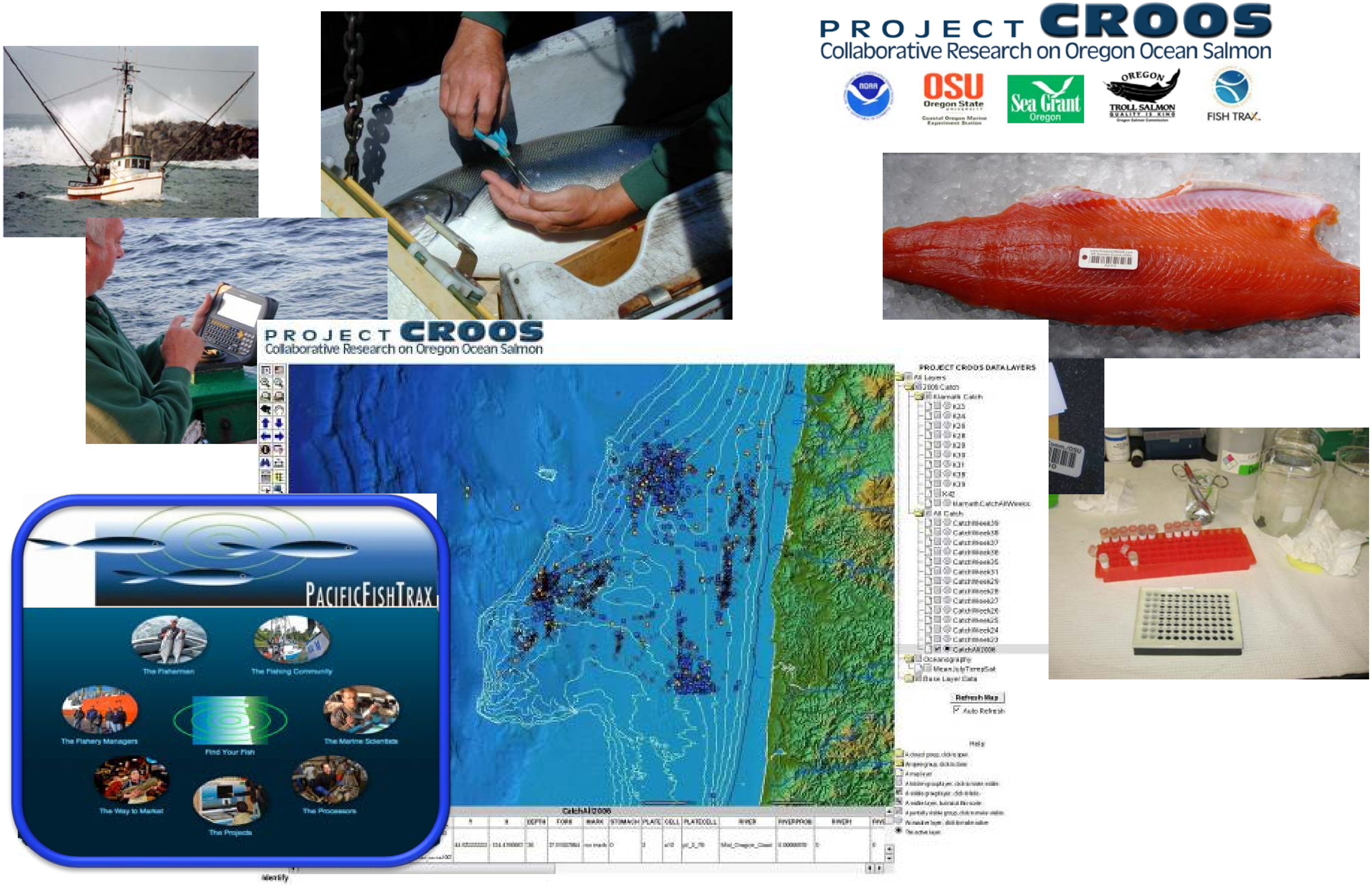
Bycatch as an impediment to recovery

- Not unique to salmon; a **chronic problem** in a wide range of fisheries in the US
- Solutions including
  - gear improvements,
  - incentives,
  - risk pools,
  - gear design
  - avoidance strategies to identify potential bycatch '**hotspots**'.
- However, the salmon bycatch problem is more complex than in many fisheries because the bycatch is 'weak stocks' of salmon and thus difficult to distinguish without using genetic techniques.

Aim

Use fine-scale genetic data from 2010-2013 to

- identify the **spatial and temporal patterns** of fishing effort and catch distribution in Oregon
- develop a **bioeconomic model** that maximizes net profits for four fleets in Oregon while reducing catch (and increasing abundance) of one stock (Klamath River-fall run)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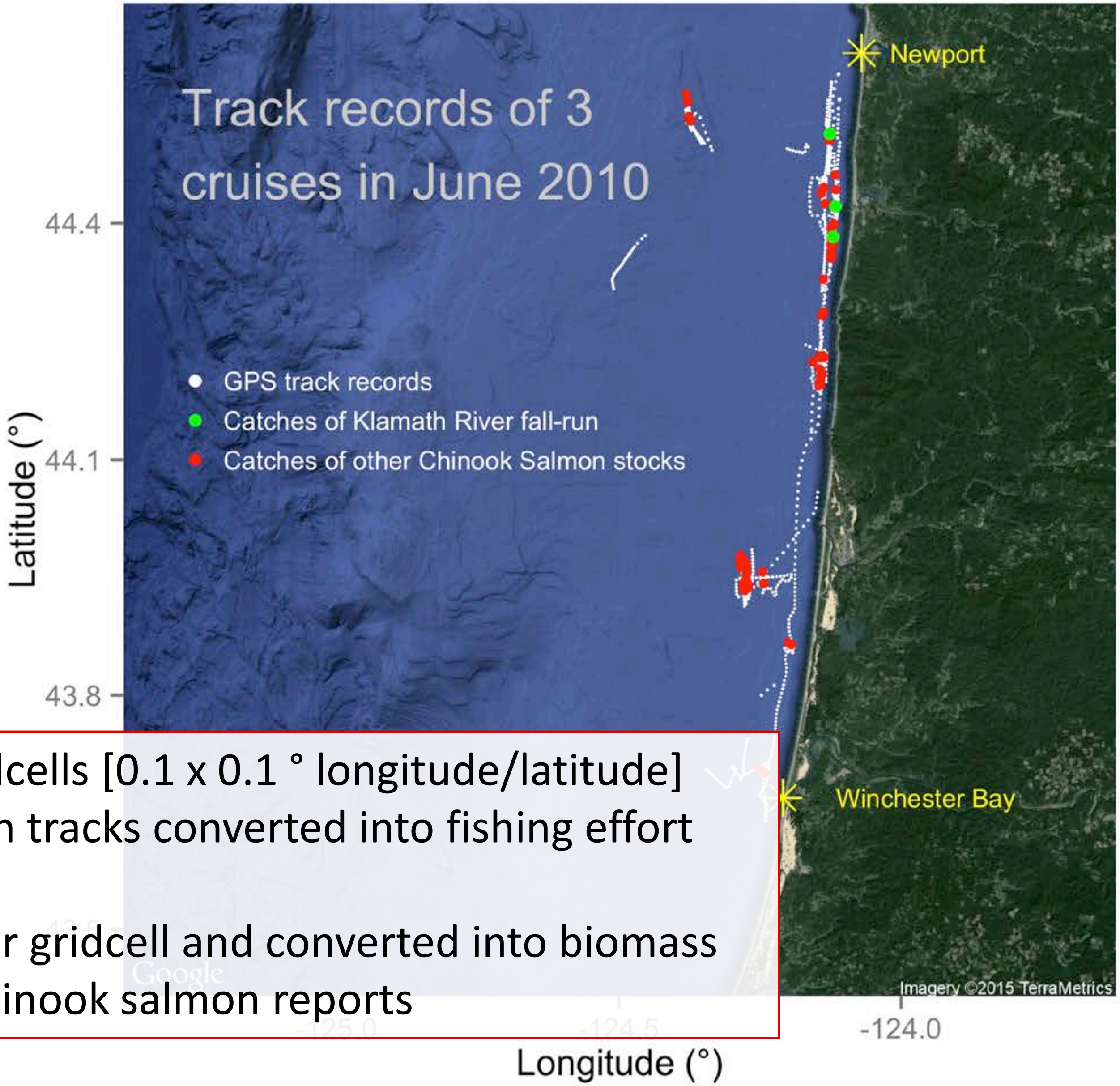
Find Your Fish
The Marine Scientists
The Way to Market
The Projects
The Processors

The GSI Data

- 2010-2013
- May-September
- 4 ports
- > 220,000 tracks (individual GPS signals) recorded during ~ 850 cruises
- 13,600 catch records ~ 13,000 with stock identification

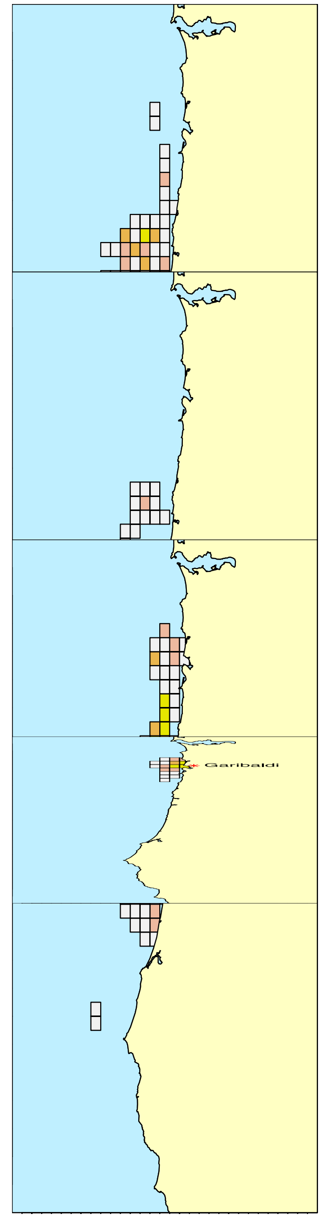


➢Data aggregated to gridcells [0.1 x 0.1 ° longitude/latitude]
➢Recorded time between tracks converted into fishing effort per unit day
➢Catches summed up per gridcell and converted into biomass (lb) based on annual Chinook salmon reports

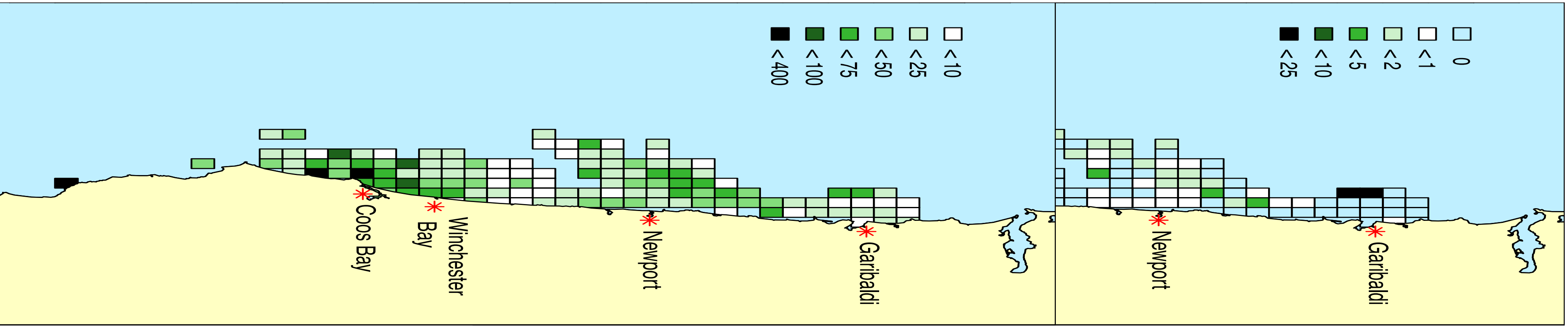
Annual fishing effort per port

Fishing effort in unit day

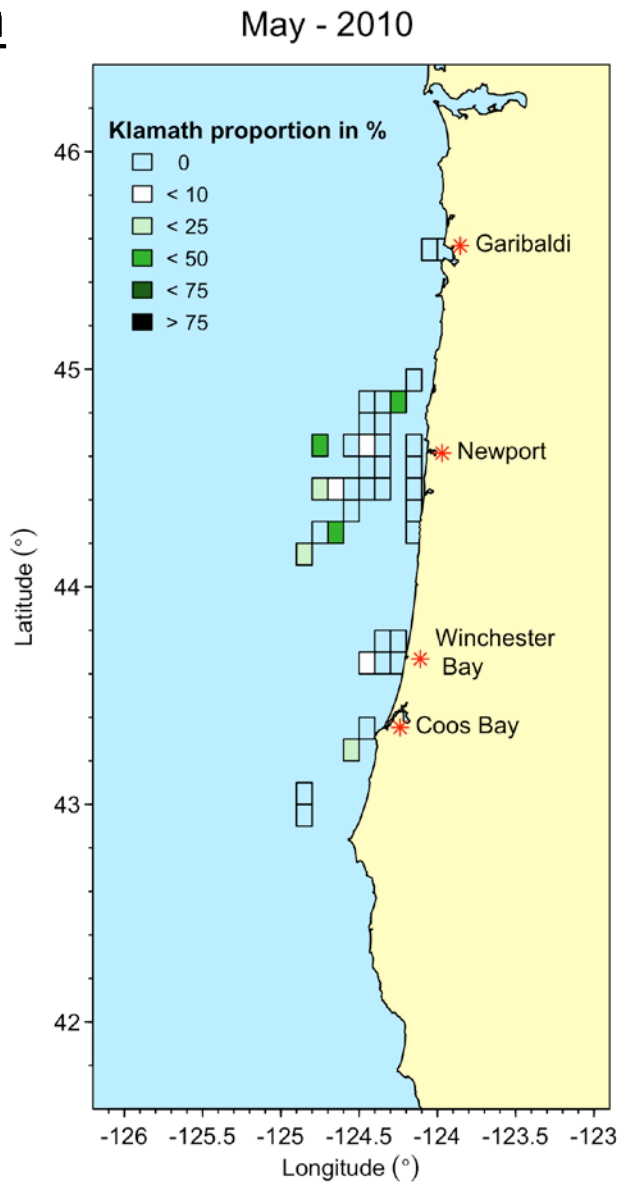
- < 0.25
- < 0.5
- < 1
- < 5
- < 10
- < 25



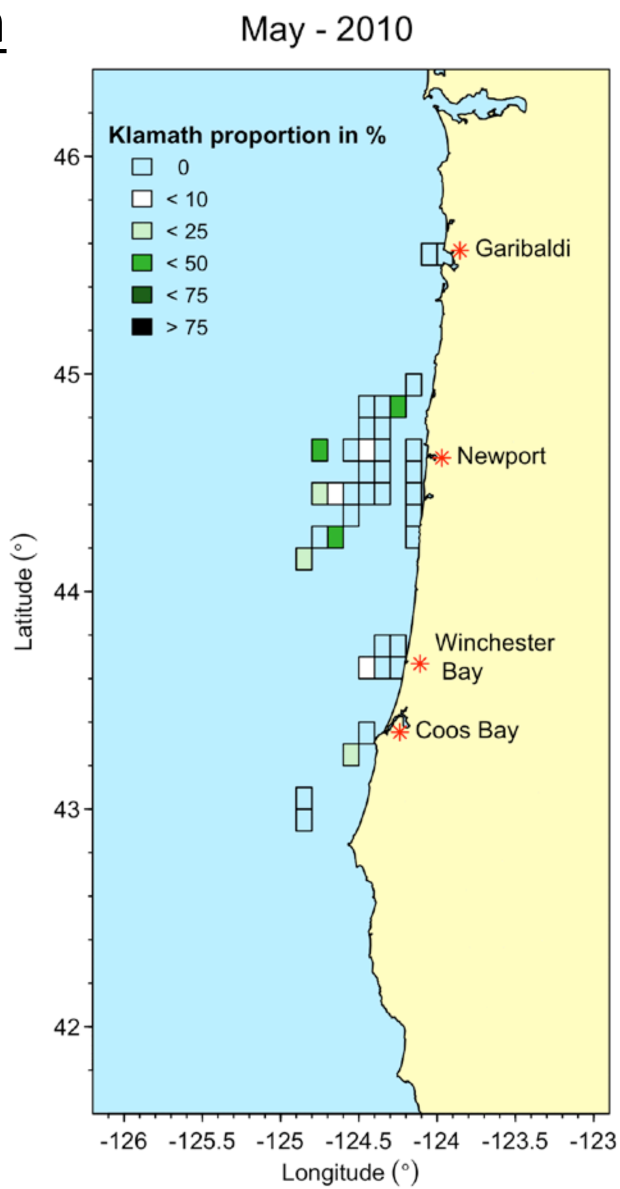
Annual distribution of total and Klamath catches



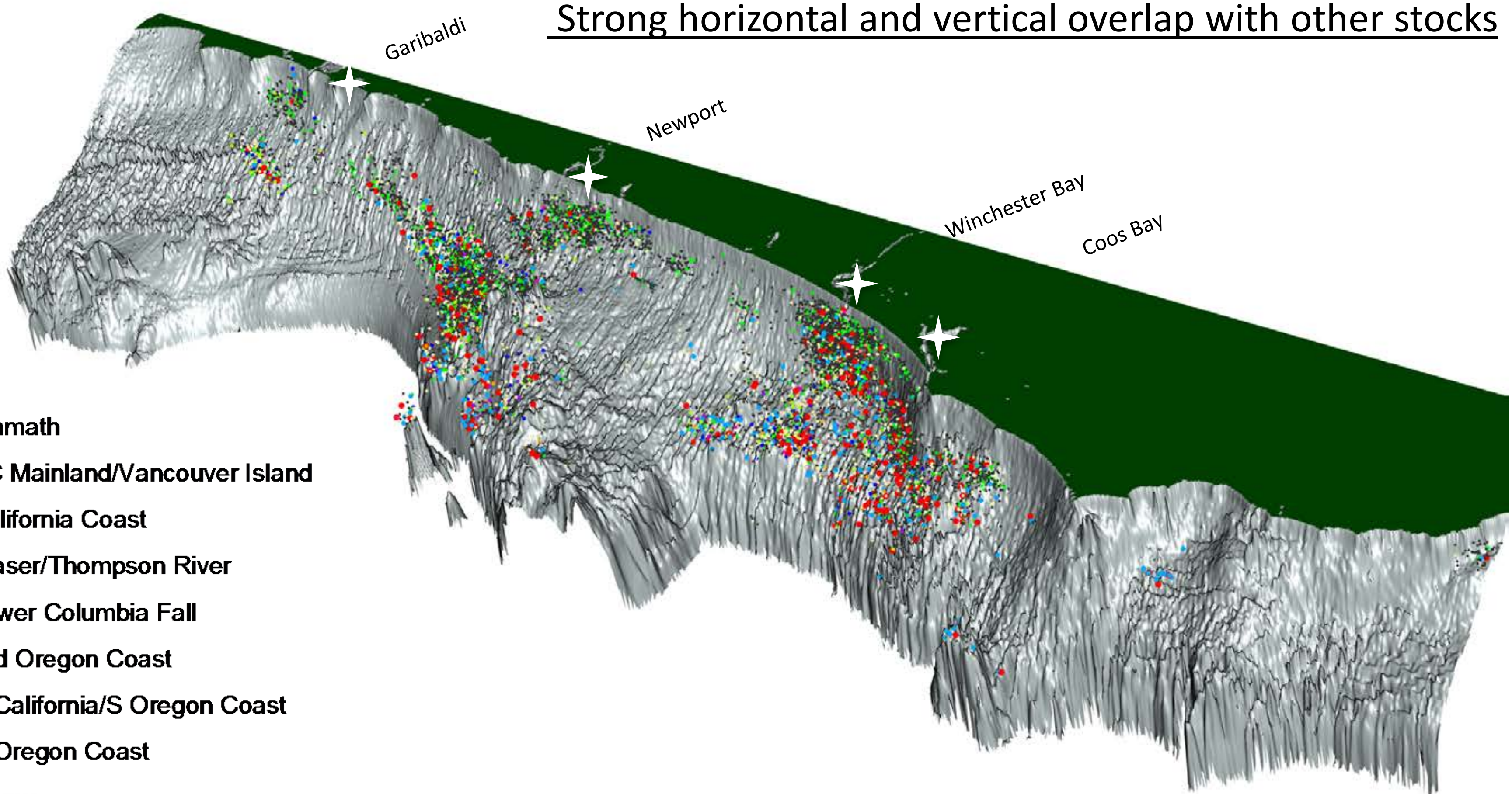
Klamath proportion from total catch per gridcell in each month



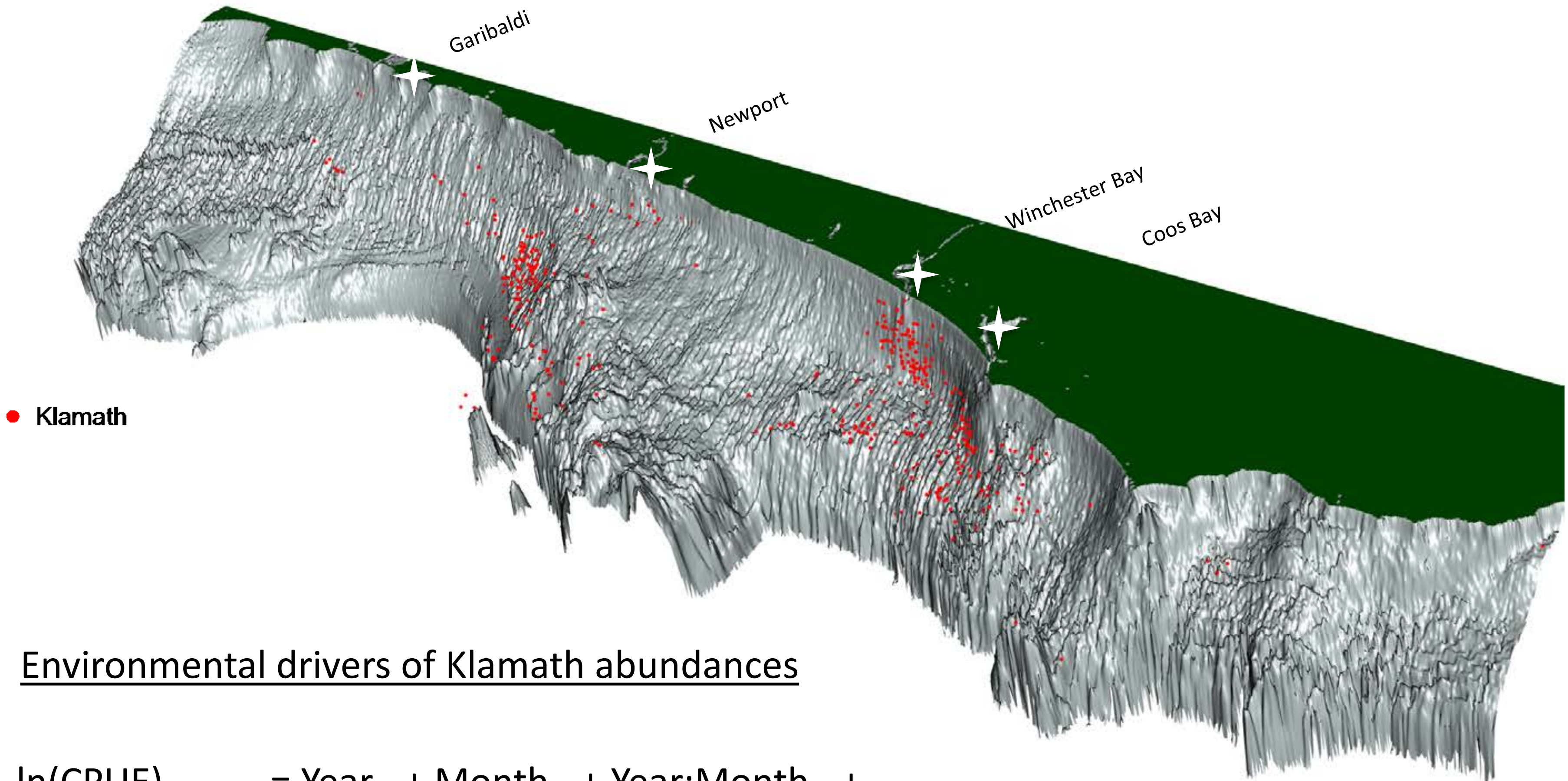
Klamath proportion from total catch per gridcell in each month



Strong horizontal and vertical overlap with other stocks



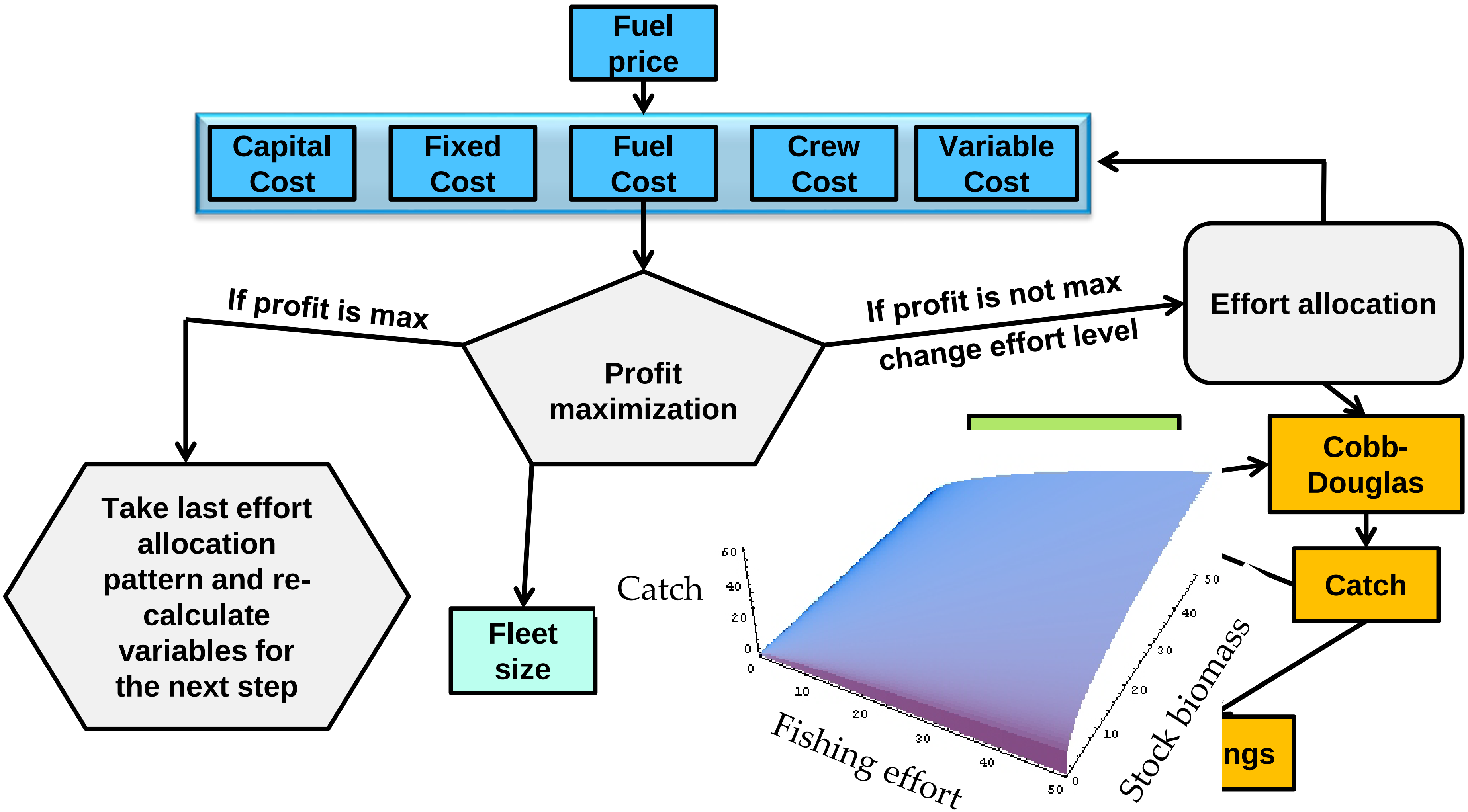
- Klamath
- BC Mainland/Vancouver Island
- California Coast
- Fraser/Thompson River
- Lower Columbia Fall
- Mid Oregon Coast
- N California/S Oregon Coast
- N Oregon Coast
- Rogue
- Washington Coast
- Other Stocks



Environmental drivers of Klamath abundances

$\ln(CPUE)_{gc,mo,yr}$ = $Year_{gc}$ + $Month_{gc}$ + $Year{:}Month_{gc}$ + $s(dist2KlamRiver)_{gc}$ + $MeanBottomDepth_{gc}$ + $\ln(DepthDiff_{gc})$ + $\varepsilon_{gc,mo,yr}$ with $\varepsilon_{gc,mo,yr} \sim N(0,\sigma^2)$

→ explains 41% of total variation



(Salz *et al*., 2011, Simons *et al*. 2014)

Outline of scenarios

Initial catch

Klamath = ~ 1500 lb

Others = ~ 38000 lb

Scenario0

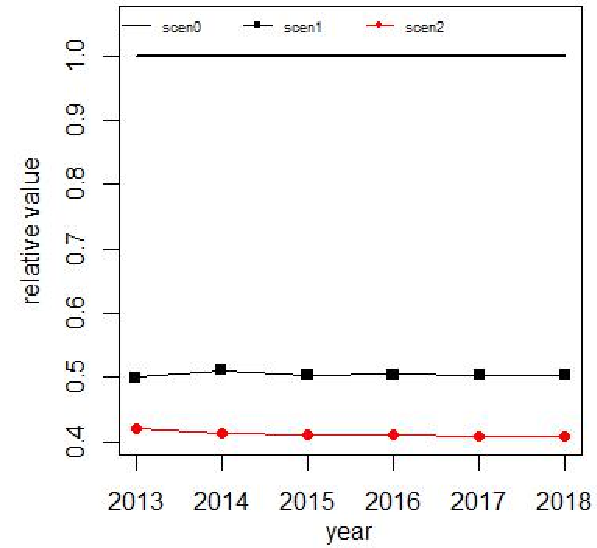
Allowed catch calculated

via Baranov Catch function

Scenario1

Half of allowed Klamath

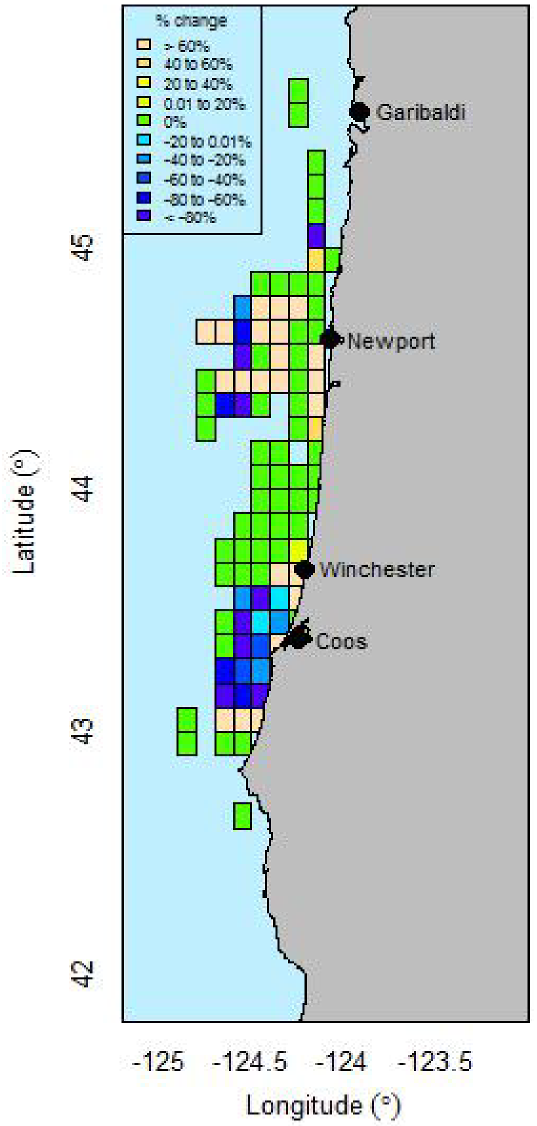
catch from Scenario0



Scenario2

Half of initial Klamath catch

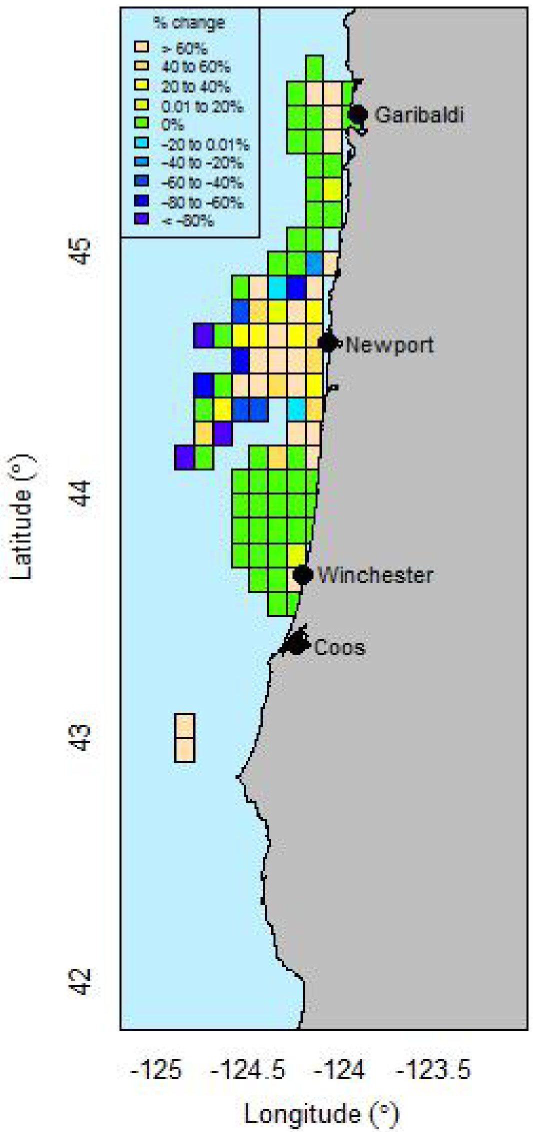
Effort distribution in scen1 relative to scen0



Changes for vessels from Coos Bay

Here come the new barplots (with relative scale, without scenario 2)

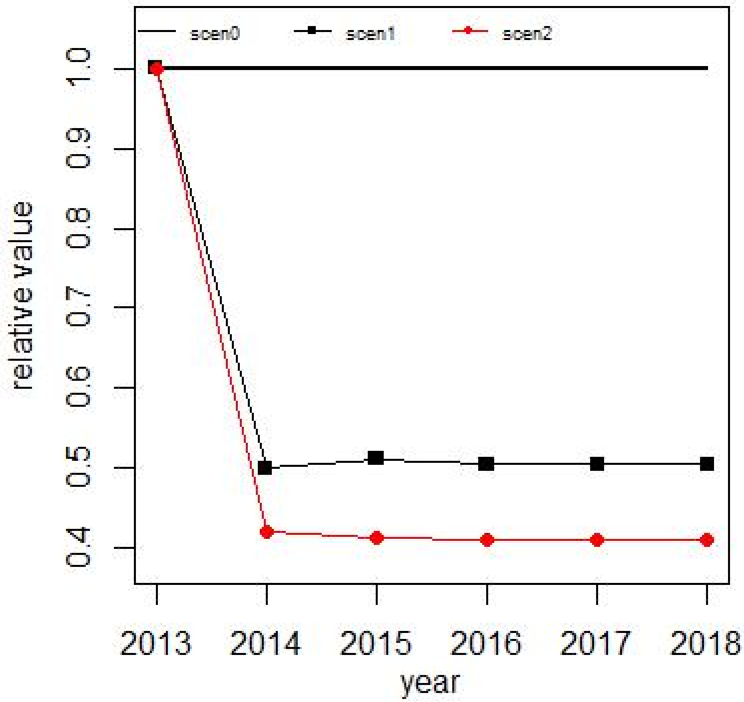
Effort distribution in scen1 relative to scen0



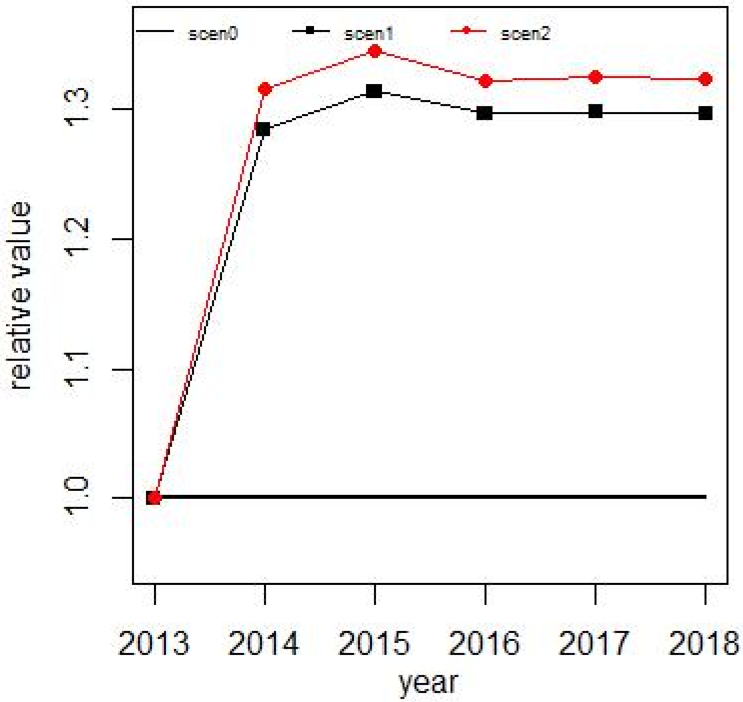
Changes for vessels from Newport

Here come the new barplots (with relative scale, without scenario 2)

Total catch of Klamath



Total stock biomass of Klamath



- The drastic reductions in allowed catches of Klamath (scen1 and scen2) allow a successful increase of the Klamath stock by 30% (scen1) or >30% (scen2)

So …… ?

- High spatio-temporal variability in Klamath stock distribution but generally strong horizontal and vertical overlap with particularly 7 other stocks → difficult to avoid catches of Klamath when targeting stronger stocks; changing the fishing depth would not be a solution
- Klamath stock in this region could increase when cutting the allowed catch of Klamath and adapting the allocation of fishing effort - without necessarily reducing net profits
- Oppositional economic implications for the 4 fleets
  - Coos bay is suffering (up to 25% reduction in net profits)
  - Newport would benefit (up to 14% increase in net profits)
  - Winchester would have short-term costs, but then no considerable changes compared to scen0
  - Garibaldi is not changing in our model → difficult case as data is missing

Conclusion

- Fine-scale data give us access to new insights.
- Possible to change relative impacts by changing fleet behavior.
- Fine-scale changes can be effective, but these are not easy to incorporate in management regulations
- Therefore, fishermen, given the appropriate information, may want to change their behavior in their own self-interest.
- Environmental factors may help predict future distributions, but more analysis needed.
- Finally -- this is the direction that fishery management needs to be headed.

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