Estimating post-release mortality and reducing encounters of green sturgeon (*A. medirostris*) in US trawl fishery

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Co-authors

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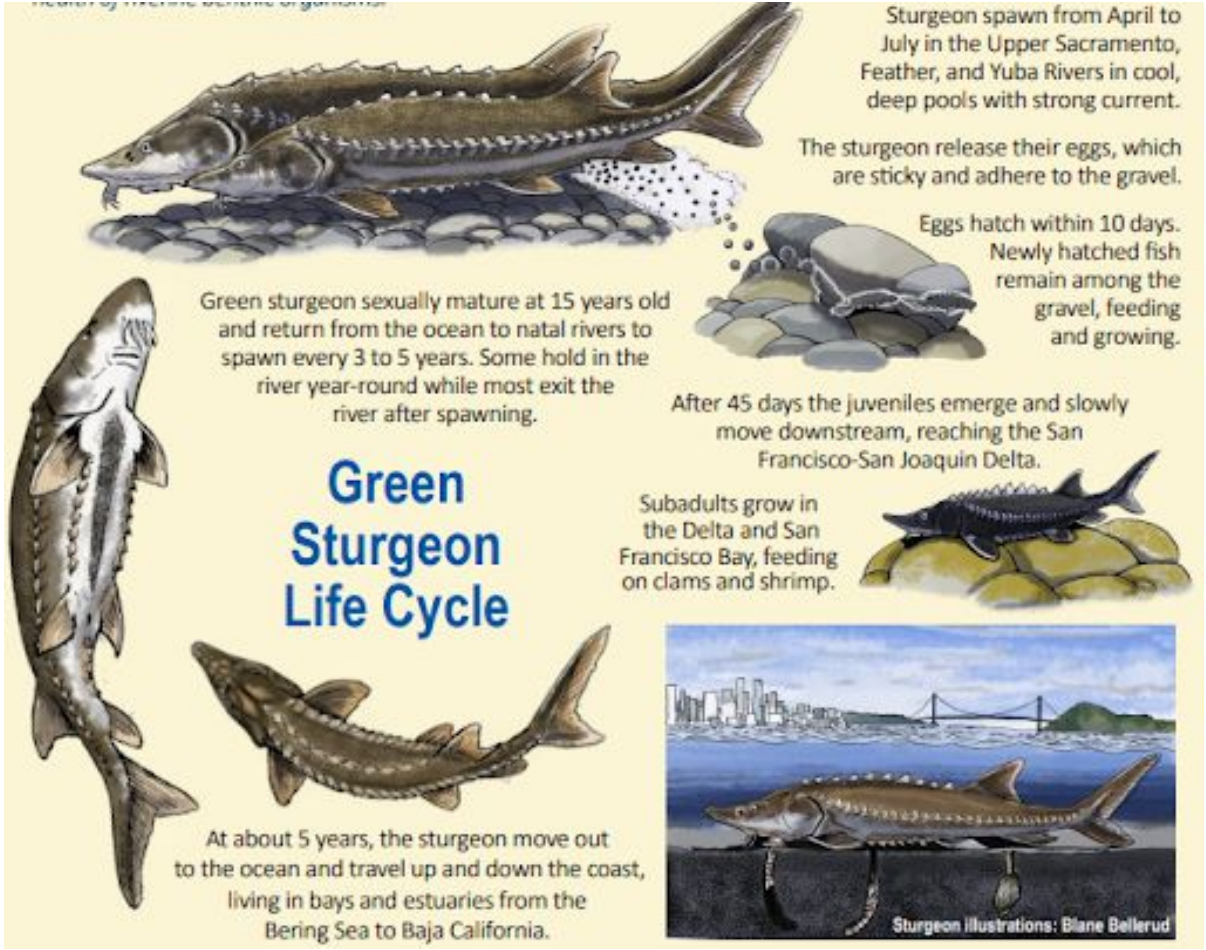
- **California Department of Fish and Wildlife:** Russ Bellmer, Kristine Lesyna, Paul Reilly, Travis Tanaka
- **NOAA West Coast Groundfish Observer Program:** Jon McVeigh, Jason Vestre, NOAA observers Andrew Corr, Kristen Duncan, Corrina Palomares, Kevin Stockmann, Jason Whitney, Marc Solano, Robert Hasagewa, Paul Stephens
- **NMFS SWFSC:** Ethan Mora†, Steve Lindley, Natnael Hamda, Nicholas Demetras, Peter Dudley; **NWFSC:** Mary Moser; **WCR:** Susan Wang, Dan Erickson
- **Applied Biomathematics:** Nicholas Friedenberg
- **Countless Interns & Students:** Sadie Gardiner, Taylor Clementz, Caity Rigg, Katelyn Saechao, Daniele Scroggins, Cole Svec, Yeandya Teklu

Green Sturgeon

- Main range: Graves Harbor, Alaska to Monterey Bay, CA western coast of the US
- Primarily occur within depths of 110 m (60 fm)
- Anadromous

- Northern & Southern Distinct Population Segment (DPS)
- Genetics, telemetry differentiate
- DPS coastal coexistence
- 2006 listing of the Southern DPS as Threatened under the ESA
  - Single spawning river
  - Habitat degradation
  - Numbers
  - Ship strikes more recent



- **Lifespan: 50 + years,**
- **Maturity: ~150cm, 15 years**
- **Spawning periodicity: 3-4 years (range 2-6)**

Sacramento River Barriers

- **Dams** (migration barriers; flow and temperature alterations)
- **Bypasses** (stranding)
- **Water diversions** (entrainment, flow and temperature rates and patterns)

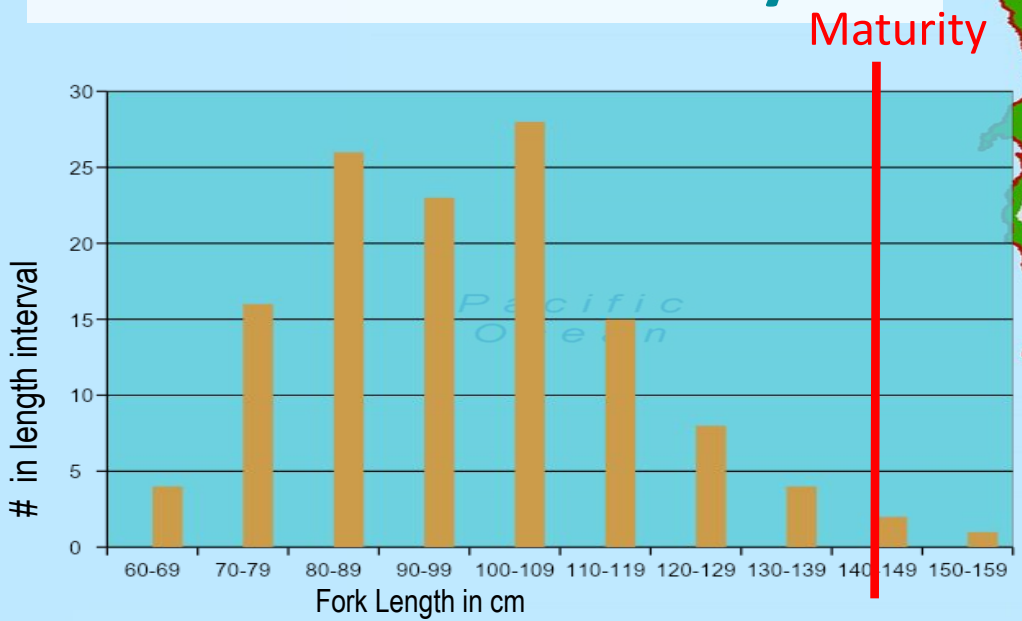
Recovery Plan

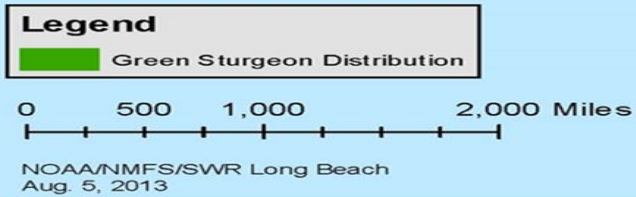
- Emphasis on Sacramento River and Delta
- Passage, flow and temperature, entrainment
- Climate change, invasive species, contaminants, predation
- Take: poaching, incidental take
- No directed fisheries take across range of GS

Fisheries Interactions

Fishery	Estimated SDPS catch	Estimated SDPS mortalities
Pacific halibut fishery	0 – 3	0 – 0.078
Pacific coast groundfish fishery	22 – 40	3 – 4
CA halibut bottom trawl fishery	28 – 631	3 – 65
CA recreational sturgeon fishery	89 – 202	3 – 5
OR recreational sturgeon fishery	0 – 33	0 – 2
L. Columbia River recreational fisheries	52	7-11
L. Columbia River commercial fisheries	271	14
WA State fisheries	375	18
Canada trawl fisheries	?	?
AK groundfish bottom trawl fisheries	1 – 3	1 – 3
TOTAL	**838 – 1,610**	**49 – 122**

GS Length Distribution in CA Halibut Fishery





Most sturgeon caught in fishery are alive

Study Questions

- What is the rate of green sturgeon post-release survival in the CA halibut fishery?
- Could bycatch have a population-level impact?
- How do we reduce green sturgeon bycatch while maintaining a healthy fishery?

Study Details

What's the rate of post-release survival in the CA halibut fishery?

- Collaborative, cooperative approach.
- CDFW, WGCOP, CA halibut fishermen workshop.

Observers and Fishermen Tagging

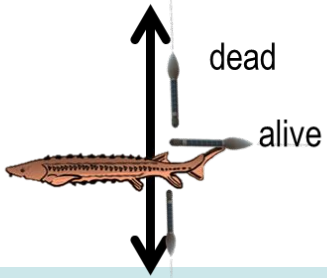
- Relatively rare event.
- No simulated fishing.

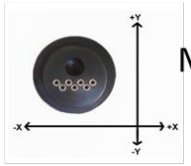
Satellite Tagging Data

- Desert Star SeaTag MOD; depth, temperature, accelerometer sensors
- 100cm average FL (69cm – 135cm); minimum 80cm FL after initial tagging, due to concerns over smaller animals and some tag loss.
- 3-4 week tag deployments.

Satellite Tagging Data Analysis

- Two ways we interpreted the data:
  - Using a “Training Dataset” for accelerometer:
    - Comparison to data from tag on known live (UC Davis tank) and dead (white) sturgeon.
    - Machine Learning to classify accelerometer readings as alive or dead.
  - Temperature, depth signatures; known behaviors.



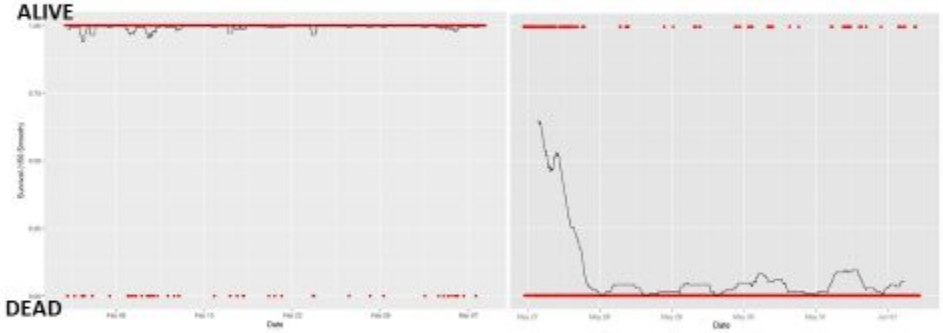


Measure gravitational pull on tag and tag orientation

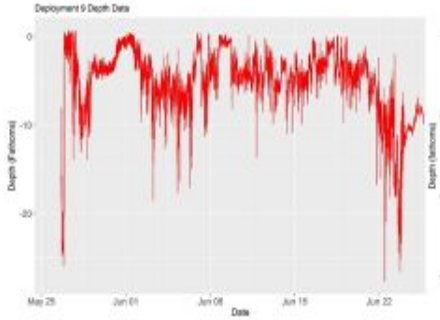
Determining Fate of Each Deployment

- Depth: Were tidal patterns visible? Is motion apparent from changing depths?
- Temperature: Were tidal patterns visible? Is movement apparent from changing temperatures?
- Accelerometer: Were accelerometer readings classified as mostly alive or dead?
- Geography: Where did the tag first broadcast? Where was it recovered?
- Tag Attachment: How long did the tag stay attached to the fish?

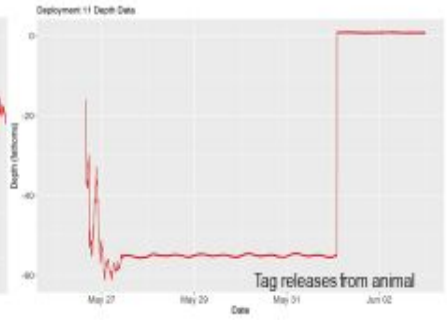
Accelerometer Data



Depth Data

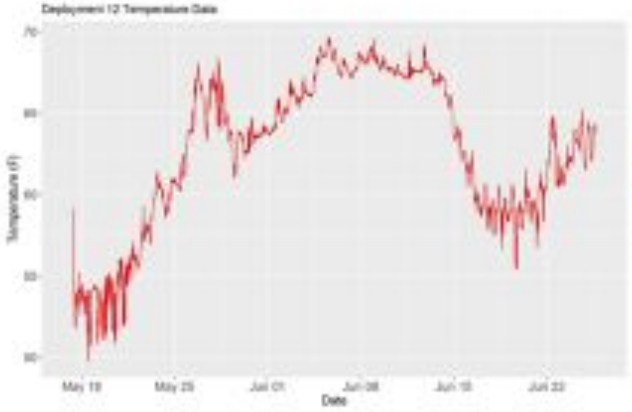


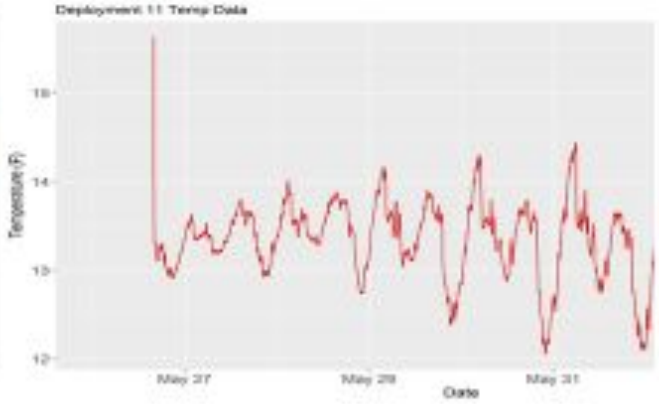
Random depth changes, as noted in satellite tagging studies done previously.



No active depth change; similar motion to dead test deployment

Temperature Data





Evidence of movement and changes in environments; swam into SF Bay after release.

Sensor detected the change in water temperature in a magnitude and period equal to the tides. Mean is stable and not variable.

Findings

- Tagged 76 green sturgeon (69–135 cm fork length) encountered as bycatch, yielding 51 useable data sets.
- 80% of green sturgeon survived; 11 sturgeon died within 21 day window.
- Most mortality within the first days.
- No correlation with the condition of the animal as recorded by the observer or any other metric.
- Doukakis et al. 2020, Fish. Bull. 118:63–73 (2020) doi: 10.7755/FB.118.1.6

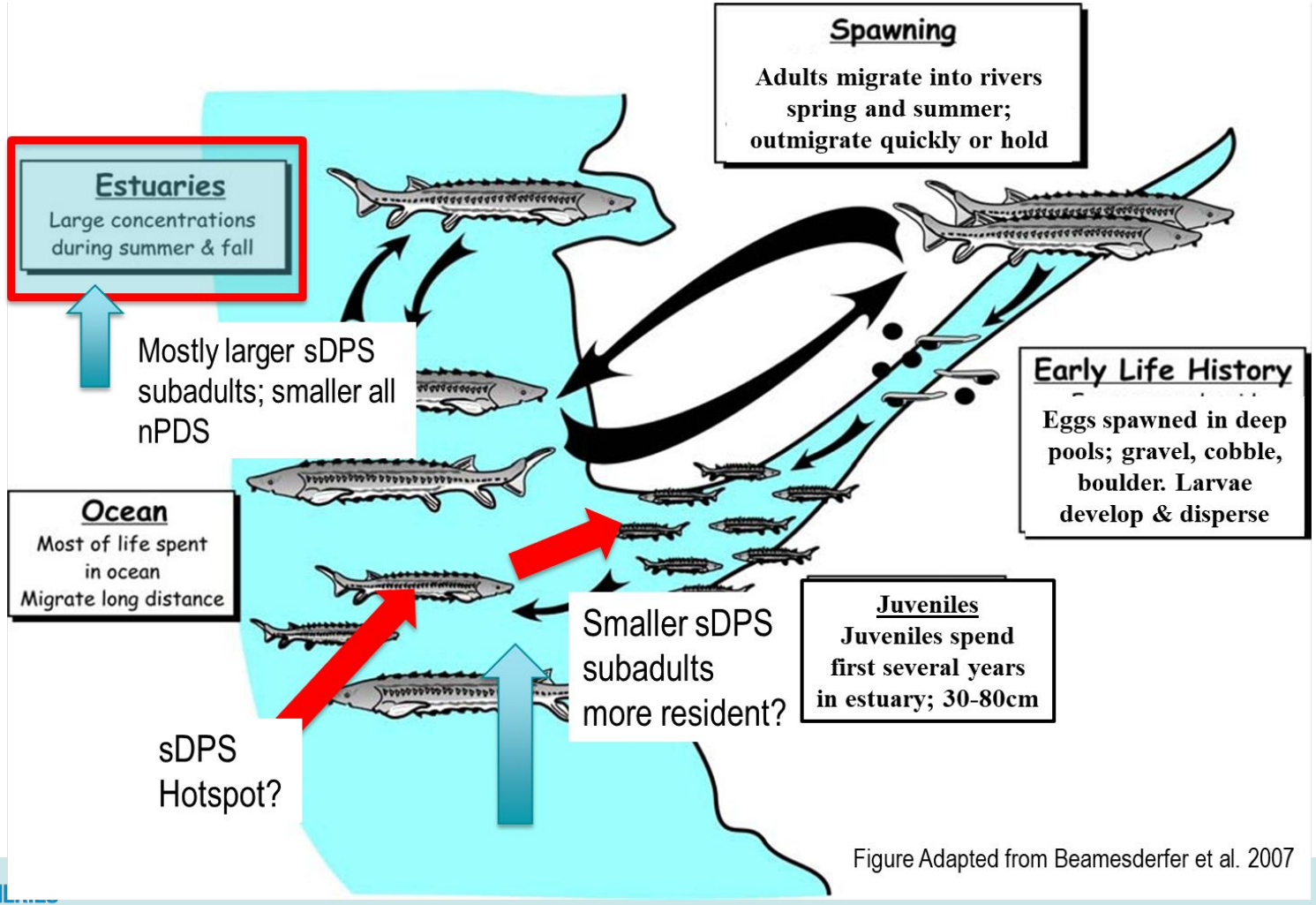


Figure Adapted from Beamesderfer et al. 2007

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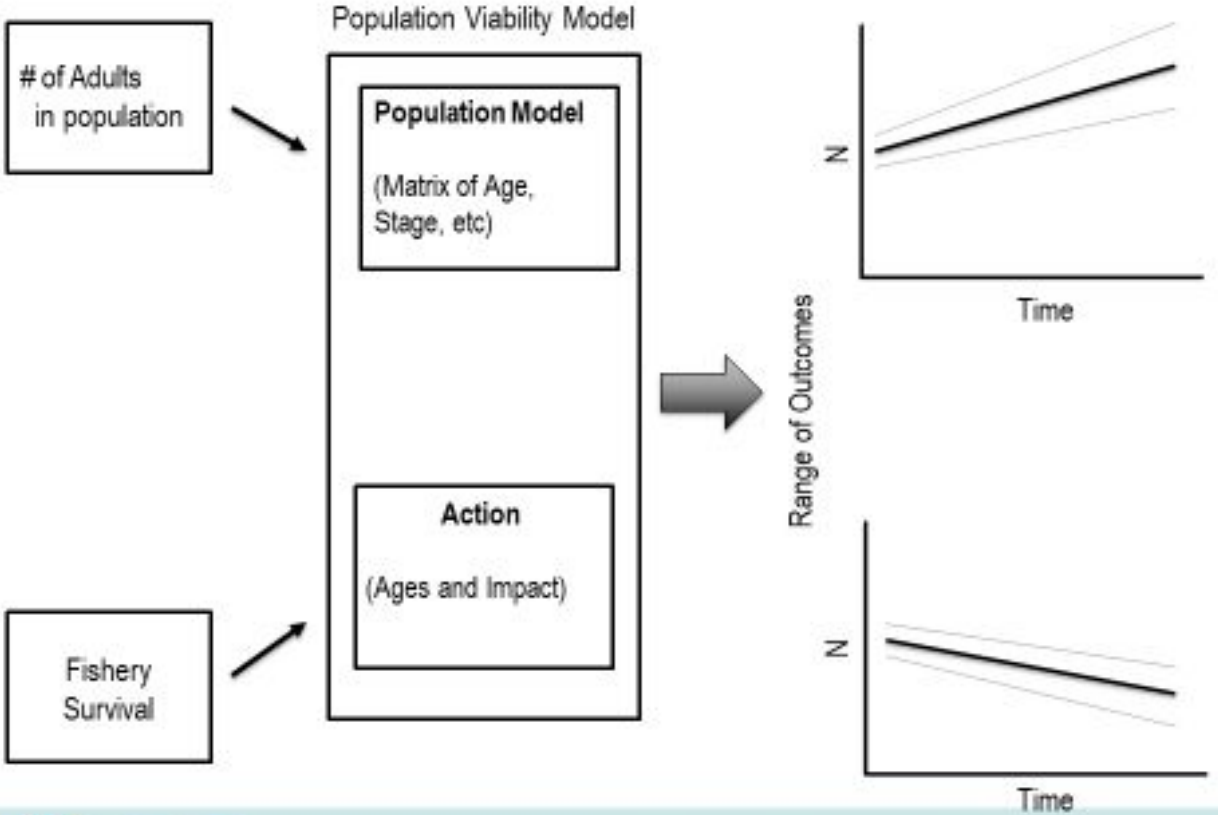
Integrates Population Estimate Research

- Dudley, Mora†, Friedenberg, Doukakis. 2024. An integrated population model and sensitivity assessment for a data-poor population of green sturgeon. Can. J. Fish. Aquat. Sci. 00: 1–10 (2024) | dx.doi.org/10.1139/cjfas-2023-0147



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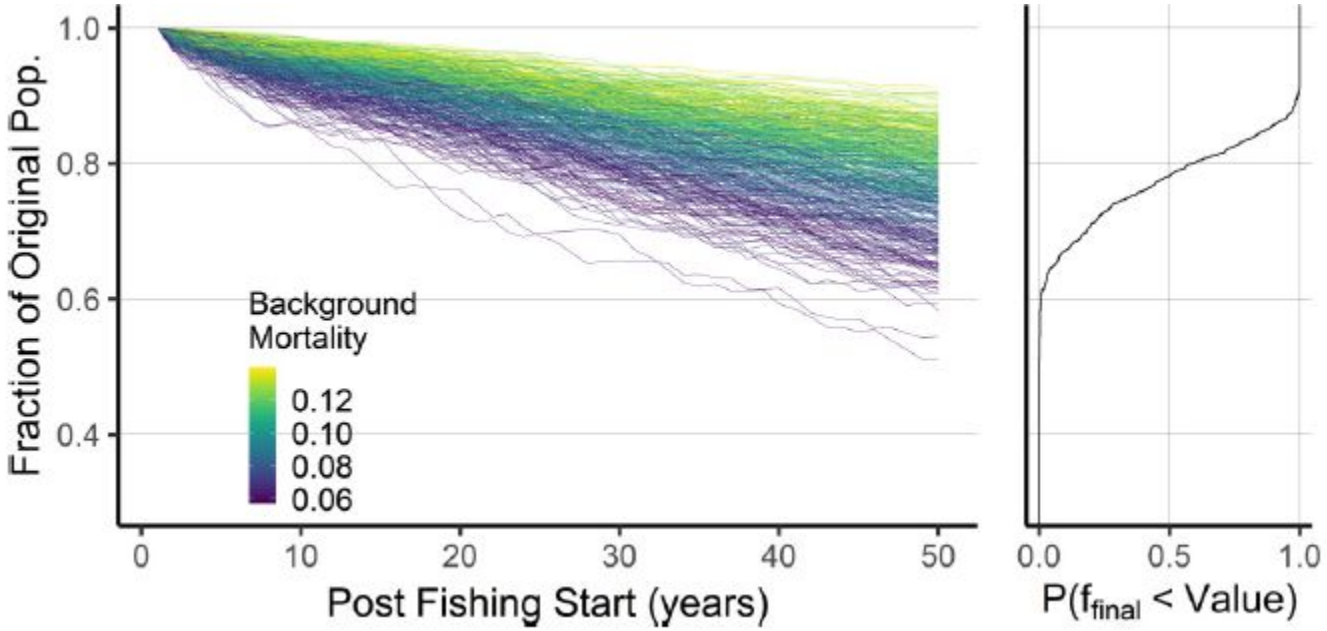
- Spawning census, growth, demographic data to build a population size and trajectory estimate.
- Generated distribution of population size estimates and trajectories reflecting uncertainty. Propagate through a demographic model to assess the potential impact of fishing bycatch.
- Model suggests the population is below the recovery goal of 3,000 adults -2,400 adults (2,197–2,624 95% HDI)
- Simulated fishing bycatch pressure on the adults and subadults reduced abundance by a median value of 0.4%per year,which could be an impediment to recovery.
- Fisheries bycatch is one of many threats; integrated framework may be used to assess how other threats may affect this population.

Fig. 5. The results from the bycatch sensitivity analysis simulation of fishing bycatch pressure on the southern DPS green sturgeon run over 100 years. (Left) The population trajectories over the 100-year period. Lines are colored with selected back- ground mortality of each parameter set. (Right) The cumulative distribution of final year results that have fraction of the initial population less than each value.



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Video Study

Purpose: Characterize GS interactions with bottom trawl gear

- When and where are GS getting caught
- How are GS interacting with CAHB and other catch in the net

Goal: Inform gear modifications

- Determine how gear interactions may contribute to catch and post-release effects
- Identify behaviors that increase susceptibility to capture for both GS and target species

Objectives

- Deploy cameras on multiple vessels
- Obtain underwater video footage across multiple years and seasons
- Characterize behavior of GS and target species
- Inform bycatch reduction via gear modifications

Video Study Details

Camera System and Placement:

- Group B Inc camera system plus lighting
- Floats for neutral buoyancy
- Optimal placement for most vessels:
  - On top mesh panel behind headrope
  - Pointed toward mouth of net
  - Angled to view bottom/footrope

Deployments 2021-2023:

- Observers, fishermen attach camera systems
- Record throughout day trips, normal fishing
- 5 vessels, 141 tows, most footage from 2 boats

Photo credit: Kyle Pemberton (F/V Moriah Lee). Note optimal placement on footrope for this vessel.

Video Study Results

Swimming direction	# observations
Swimming out of net or toward opening	11
Swimming with net (in direction of tow)	7
Swimming into net or toward the back of net	2
Not swimming	2

- 22 over 10 days; Mean size (TL): 127 cm (subadult to adult)
- Swim speed: most were faster or at the same speed as the net.
- Likelihood of escape: High for half (no GS observed on deck).
- Most swimming with the net, pointed toward mouth
- One caught in net during haul-up
- Vertical distribution: varied from footrope, middle, to top

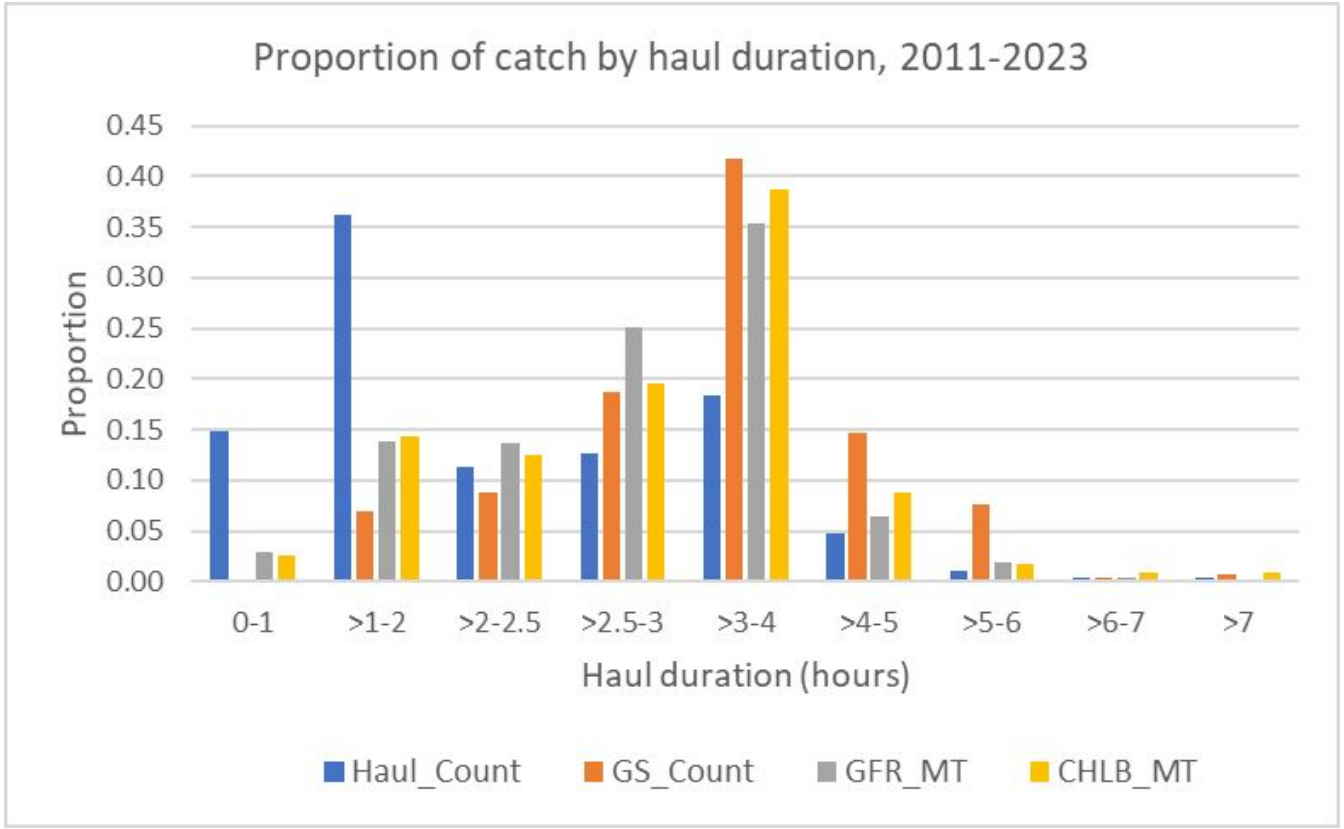
Video Footage

Behavior	Video link
Keeping pace with net (10/10/2022)	Green Sturgeon_10_10_2022_07:35:20.mp4
Swimming faster than net, may escape? (10/14/2022) - good video to show, longer view	Green Sturgeon_10_14_2022_12:38:47.mp4
Swimming in direction of tow (10/10/2022)	Green Sturgeon_10_10_2022_07:28:23.mp4
Swims faster than net, down and out of view (10/10/2022)	Green Sturgeon_10_10_2022_07:30:16.mp4
Net seems to overtake the GS swimming	Green Sturgeon_10_10_2022_07:32:51.mp4
Stationary, hit by camera (03/31/2021)	GreenSturgeon_03.31.2021_10:31:36.mp4 GreenSturgeon_03.31.2021_10:32:32.mp4
Stuck in net during haul-up (08/22/2021)	GreenSturgeon_8_22_2021_9:34:55.mov

Next Steps

- New partners
  - gear modification (selective trawls, sorting grids, exclusion devices, light touch trawl) (scientists)
  - data that might support new measures without decreasing target catch (prohibit nighttime trawling, reduce tow duration, adjust haul up procedures) (managers)

Discussion: Next Steps



Thank You to Collaborators & Organizers

In Memoriam - Ethan Alden Mora 1977 - 2019

Questions?