Impacts of Shrimp Trawl Bycatch and an Acute Mortality Event on the Recovery of Smalltooth Sawfish

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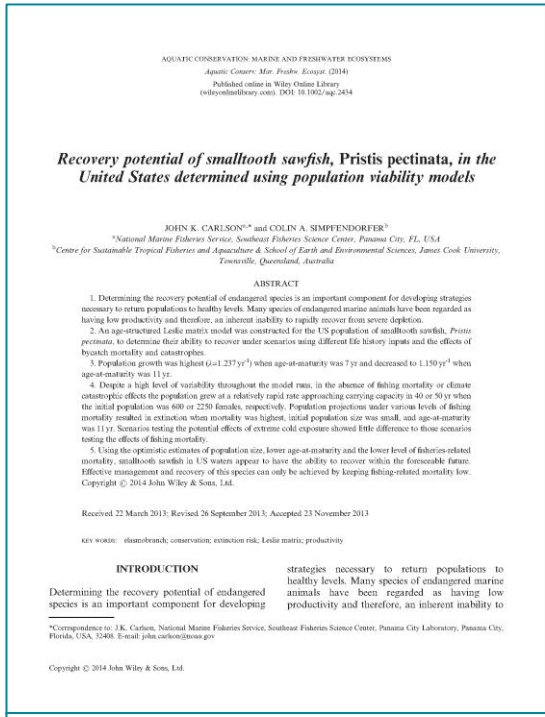
Population Viability Models

- Carlson and Simpfendorfer (2014)
  - An age-structured Leslie matrix model was constructed for the US population of smalltooth sawfish to determine their ability to recover under scenarios using different life history inputs and the effects of fishing and an extreme cold event
    - Despite a high level of variability throughout the model runs, in the absence of fishing mortality or extreme cold events, the population grew at a relatively rapid rate approaching carrying capacity in 40 or 50 yr when the initial population was 600 or 2250 females, respectively
- Carlson (2023)
  - Original model was updated and trajectories developed using different scenarios of initial population sizes, fishery catches and post-release mortality
    - The most pessimistic scenarios were when the initial population was lowest and post-release mortality in the shrimp trawl fishery was highest



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Recovery potential of smalltooth sawfish*, Pristis pectinata, *in the United States determined using population viability models

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ABSTRACT

1. Determining the recovery potential of endangered species is an important component for developing strategies necessary to return populations to healthy levels. Many species of endangered marine animals have been regarded as having low productivity and therefore, an inherent inability to rapidly recover from severe depletion.
2. An age-structured Leslie matrix model was constructed for the US population of smalltooth sawfish, *Pristis pectinata*, to determine their ability to recover under scenarios using different life history inputs and the effects of bycatch mortality and catastrophes.
3. Population growth was highest (λ=1.237 yr^{-1}) when age-at-maturity was 7 yr and decreased to 1.150 yr^{-1} when age-at-maturity was 11 yr.
4. Despite a high level of variability throughout the model runs, in the absence of fishing mortality or climate catastrophic effects the population grew at a relatively rapid rate approaching carrying capacity in 40 or 50 yr when the initial population was 600 or 2250 females, respectively. Population projections under various levels of fishing mortality resulted in extinction when mortality was highest, initial population size was small, and age-at-maturity was 11 yr. Scenarios testing the potential effects of extreme cold exposure showed little difference to those scenarios testing the effects of fishing mortality.
5. Using the optimistic estimates of population size, lower age-at-maturity and the lower level of fisheries-related mortality, smalltooth sawfish in US waters appear to have the ability to recover within the foreseeable future. Effective management and recovery of this species can only be achieved by keeping fishing-related mortality low.

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KEY WORDS: elasmobranch; conservation; extinction risk; Leslie matrix; productivity

INTRODUCTION

Determining the recovery potential of endangered species is an important component for developing strategies necessary to return populations to healthy levels. Many species of endangered marine animals have been regarded as having low productivity and therefore, an inherent inability to

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Trouble in the trawls: Is bycatch in trawl fisheries preventing the recovery of sawfish? A case study using the US population of smalltooth sawfish, *Pristis pectinata*

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ABSTRACT

All five species of sawfish (Family Pristidae), are among the most threatened families of elasmobranchs, and face significant threats from fishing, in particular trawl fisheries, and habitat loss. Unfortunately, there is little data on the level of sawfish taken in trawl fisheries outside Australia and the United States and case studies from these areas can provide a "risk analysis" for populations elsewhere. In the United States, bycatch risk for smalltooth sawfish is significantly higher for the southeast shrimp trawl fishery than all other fisheries assessed. Using new estimates of life history and population size, an updated population viability model was developed and trajectories using different scenarios of initial population sizes, fishery catches and post-release mortality were projected for 100 years. The simulated population trajectories for the assumed initial population sizes and fishing mortality ranged between population extinction, quasi-extinction, to a slight reduction in population size and in some cases the population continuing to recover. The most pessimistic scenarios were when the initial population was lowest and post-release mortality in the shrimp trawl fishery was highest. Quasi-extinction for some scenarios was between 0.9 and 22.8 years. While some scenarios suggest that smalltooth sawfish still can recover despite the potential for shrimp trawl fishing mortality, key input variables for these optimistic scenarios is the initial population size and the true level of fishing mortality. This uncertainty highlights the importance of improving our understanding of sawfish life history, captures in fisheries and their associated post-release mortality.

1. Introduction

The incidental capture or bycatch of non-targeted species in fishing gear is widely recognized as an important threat to the conservation status of many animal populations (Read et al., 2006; Gilman et al., 2010; Reeves et al., 2013). Bottom trawling is a relatively non-selective fishing method, and in many cases, bycatch often comprises a much higher proportion of the total catch than the target species (Saila, 1983; Andrew and Pepperell, 1992). Bottom trawl impacts on elasmobranchs have been widely documented globally in various fisheries and areas (see review in Molina and Cooke, 2012; Oliver et al., 2015). For example, elasmobranch bycatch in the shrimp trawl fishery in Pacific waters off Costa Rica comprised 25 species and 12 families (Clarke et al., 2014). In Australia's Northern Prawn Fishery, 56 species of elasmobranchs have been documented in this fishery and these species comprise around 4 % of the bycatch by weight (Stobutzki et al., 2001).

Globally, all five species of sawfish populations face significant threats from fishing and habitat loss. Sawfish are among the most threatened families of elasmobranchs (Dulvy et al., 2014, 2016). All species in the Family are now listed as Critically Endangered under

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Revisiting the Population Viability Model

- New information on life history, population size and new estimates of mortality

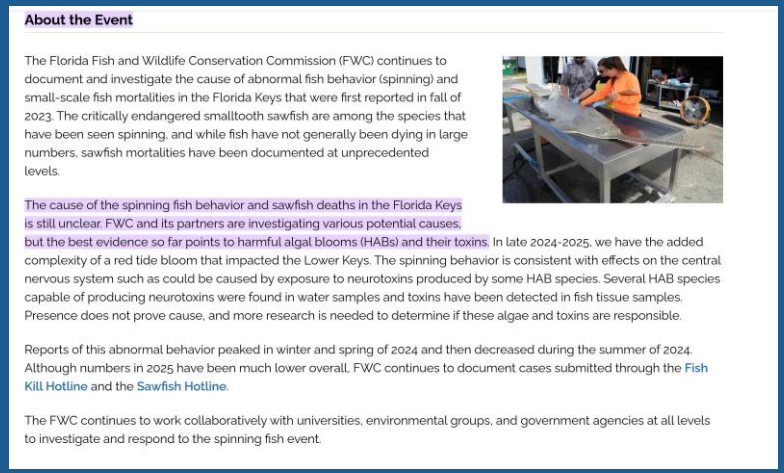
Parameter	Carlson and Simpfendorfer (2014)	Carlson (2023)	New inputs using results from Kroetz et al. (2025) and Swift et al. (unpublished)
Age-at-maturity	7 and 11 years	8 years	7.9 years
Maximum age	30 years	30 years	39 years
Litter size (yr)	3.1 (0.758)	2.62 (0.504)	2.62 (0.504)
Survivorship			
Age 0	0.87 (0.131)	0.87 (0.208)	0.78 (0.22)
Age 1	0.89 (0.104)	0.87 (0.131)	0.81 (0.13)
Age 2	0.90 (0.093)	0.89 (0.104)	0.81 (0.09)
Age 3	0.91 (0.087)	0.90 (0.093)	0.81 (0.07)
Age 4	0.92 (0.082)	0.91 (0.087)	0.81 (0.07)
Age 5-6	0.93 (0.080)	0.92 (0.082)	0.85 (0.09)
Age 7-11	0.94 (0.080)	0.93 (0.080)	0.86 (0.06)
Age 12-30	0.87 (0.131)	0.94 (0.080)	0.86 (0.06)
Initial total population size	600 females 2250 females	8075 females 2975 females 1255 females 1695 females	4300 females
Carrying capacity	45,000 females	45,000 females	45,000 females

New inputs

- Age-at-maturity- No difference from Carlson (2023)
- Maximum age now based on theoretical estimates from Kroetz et al. (2025)
- Litter size- no difference from Carlson (2023)
- Survivorship
  - Updated using revised estimates based on life history information from Kroetz et al. (2025)
  - New methods based on Then et al. (2015) and Dureuil et al. (2021)
    - Previous studies used the maximum estimates of survivorship to follow a population experiencing significant population declines ..density dependent response; sensu Cortes (2007)
    - Scenarios used median estimates of survivorship
- Initial population estimates based on close-kin mark-recapture

Updated bycatch inputs

- ✓ **Updated shrimp bycatch estimates** (2015–2023) using Bayesian generalized linear models (Babcock and Peterson 2025)
- ✓ **Mortality event**: During the winter and spring of 2024 and 2025 in the lower Florida Keys, a **mortality event** occurred with ~230 reports of smalltooth sawfish exhibiting abnormal behavior (spinning) with documented mortalities exceeding 50 individuals



About the Event

The Florida Fish and Wildlife Conservation Commission (FWC) continues to document and investigate the cause of abnormal fish behavior (spinning) and small-scale fish mortalities in the Florida Keys that were first reported in fall of 2023. The critically endangered smalltooth sawfish are among the species that have been seen spinning, and while fish have not generally been dying in large numbers, sawfish mortalities have been documented at unprecedented levels.

The cause of the spinning fish behavior and sawfish deaths in the Florida Keys is still unclear. FWC and its partners are investigating various potential causes, but the best evidence so far points to harmful algal blooms (HABs) and their toxins. In late 2024-2025, we have the added complexity of a red tide bloom that impacted the Lower Keys. The spinning behavior is consistent with effects on the central nervous system such as could be caused by exposure to neurotoxins produced by some HAB species. Several HAB species capable of producing neurotoxins were found in water samples and toxins have been detected in fish tissue samples. Presence does not prove cause, and more research is needed to determine if these algae and toxins are responsible.

Reports of this abnormal behavior peaked in winter and spring of 2024 and then decreased during the summer of 2024. Although numbers in 2025 have been much lower overall, FWC continues to document cases submitted through the Fish Kill Hotline and the Sawfish Hotline.

The FWC continues to work collaboratively with universities, environmental groups, and government agencies at all levels to investigate and respond to the spinning fish event.

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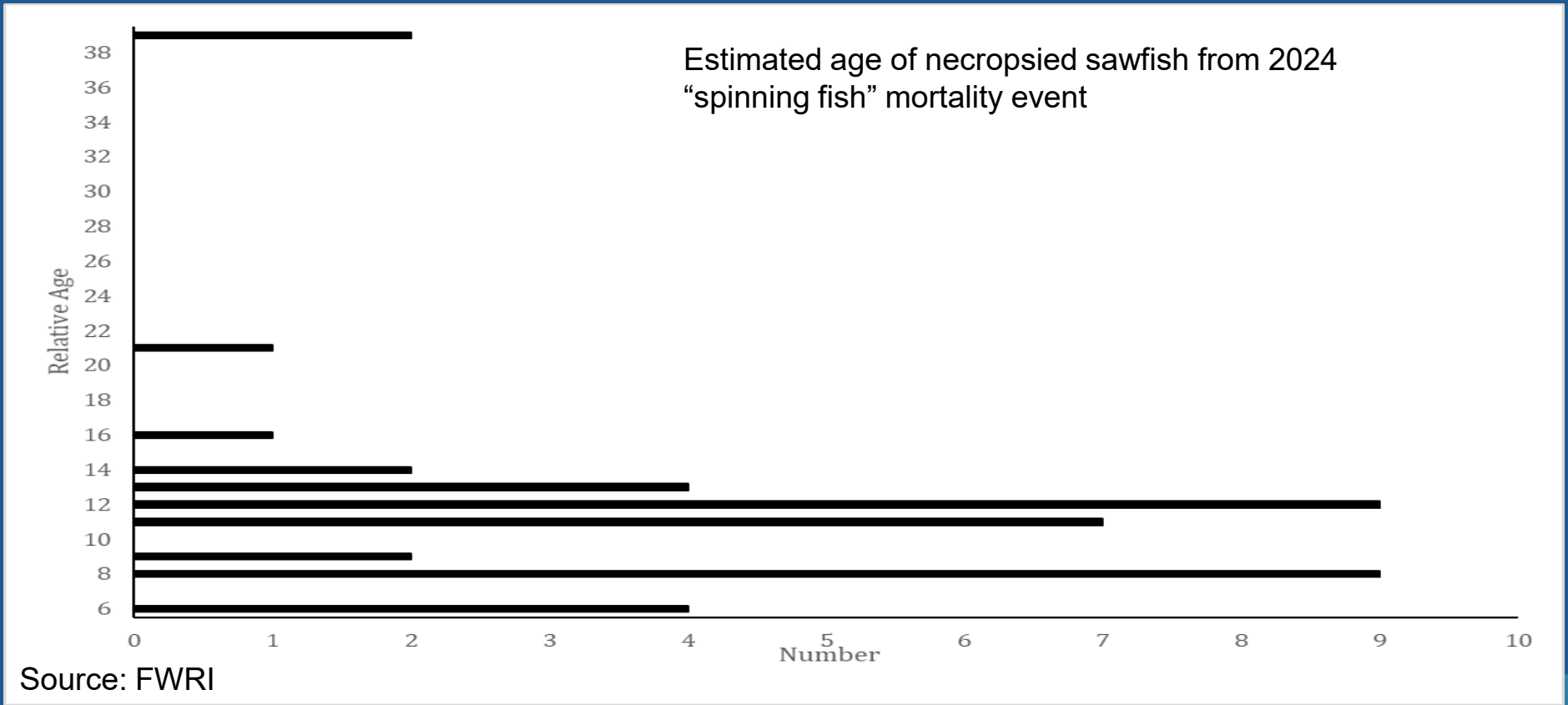
- **Commercial shrimp trawl bycatch:** Ages 6–30 based on observer data
- **Recreational fishery bycatch:** All ages
- **Shark bottom longline bycatch:** Ages 6–30 based on observer data
- **“Spinning Fish” Mortality:** Ages and sex ratio (0.51) based on FWRI data

Two scenarios for spinning fish mortality were evaluated:

(1) Total deaths = observed, necropsied individuals and

(2) Total deaths = necropsied + reported symptomatic individuals



Source: FWRI

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Updated Population Viability Model Results

- Inclusion of the 2024 and 2025 “spinning fish” mortality event led to substantially more pessimistic PVA results than those in Carlson (2023)
- In scenarios with low population size→ at least a 25% probability of population extinction but scenarios under higher population size slowly recovers from mortality event (>5 years), with faster recovery at lower bycatch levels

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Sources of Uncertainty

LIFE HISTORY PARAMETERS

- High variability in life history parameters leads to uncertainty in PVA outcomes
- Age0 survivorship
- Maximum age

Less productive species leads to delayed recovery

INITIAL POPULATION SIZE

- Population size estimates based on three genetic approaches: (1) effective genetic population size (Ne), (2) number of breeders (NB), and (3) close-kin mark recapture (CKMR)

Remote area sampling to strengthen CKMR estimates

SHRIMP BYCATCH MORTALITY

- All scenarios assumed bycatch 60-72/yr.
- 72/yr met or exceeded 5 of past 9 years.

Increased bycatch would lead to worse outcomes

Future mortality events would lead to worse outcomes

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Ways forward

- ✓ Refine bycatch estimates
  - ✓ Improve observer coverage and total effort for shrimp fishery
    - ✓ Potential for EM (Moncrief-Cox et al. 2020) and electronic logbooks

- ✓ Continue to monitor juvenile abudnance