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Literature Review of Delayed Mortality Rate Estimates for use in SEDAR 77

SEDAR 77 (Data Workshop)

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December 2021

Delayed Mortality Rates for SEDAR 77

- Outline
  - Direct estimates (by species and gear type)
  - Compare to indirect estimates (meta-analysis)
    - Musyl and Gilman (2019)
    - Dapp et al. (2016c)
  - Compare to indirect estimates (other species and gear types)
    - Studies that tagged both healthy and injured
  - Compare to SEDAR 65 Data Workshop decisions and methods
    - Bottom longline
    - Gillnet
    - Recreational
  - Provide combined estimates and their range of uncertainty for evaluation in SEDAR 77
    - Bottom longline
    - Gillnet
    - Recreational

Delayed Mortality Rates for SEDAR 77

- A literature database of post-release live-discard mortality (PRLDM) rates in sharks (Courtney and Mathers 2019; 91 existing records, and <u>25</u> new records that were primarily at-vessel mortality) was searched for hammerhead sharks (Sphyrnidae)
  - Scalloped Hammerhead (*Sphyrna lewini*)
  - Great Hammerhead (*Sphyrna mokarran*)
  - Smooth Hammerhead (*Sphyrna zygaena*)
  - Carolina Hammerhead (*Sphyrna gilberti*)
  - [Bonnethead (Sphyrna tiburo)]

Delayed Mortality Rates for SEDAR 77

- Previous SEDAR AP panels (NMFS 2012, 2013a, 2013b, 2018, 2020) emphasized that post-release live-discard (PRLDM) rates are only applied to live discards, and used an equation from Hueter and Manire (1994) to describe the relationship between total discard mortality and PRLDM

- (1) Total discard mortality rate = (Dead-discard rate) + (PRLDM) * (Live-discard rate).

- The same approach was used here. However, in order to be consistent with more recent literature, as described below, the following definitions were also used interchangeably

- (2) MT = MA + MD *SA.

- MT = Total discard-mortality rate, defined as the immediate plus delayed discard-mortality rate resulting from the fishing event.

- MA = Immediate (i.e., at-vessel or acute) discard-mortality rate resulting from the fishing event.

- MD = PRLDM = Delayed discard-mortality rate resulting from the fishing event, defined as the proportion released alive that die as a result of the fishing event.

- SA = Acute survival rate (i.e., the proportion released alive).

Delayed Mortality Rates for SEDAR 77

- Direct estimates by species and high priority gear types (Data Webinar III)
  - Recreational
    - NA
  - Bottom longline
    - Gallagher et al. (2014b) Great Hammerhead
      - 42.9% (Satellite tag SPOT, N = 28; non-reporting = 12 after 2 wks)
      - 46.4% (Satellite tag SPOT, N = 28; non-reporting = 13 after 3 and 4 wks)
        - Florida (Everglades National Park and Florida Keys) and off Grand Bahama Island, Bahamas.
        - 101-345 cm TL; 289.8 ± 30.6 (mean ± SD); 10 baited drumlines soaked 1 hr.
        - Satellite tagged sharks were alive and responsive (i.e. swimming away)..
        - SPOT tags used to generate tag reporting rates, upon which post-release survival inferred.
    - Drymon and Wells (2017) Great Hammerhead
      - 0% (Satellite double tagged SPOT and sPAT, N = 3, non-reporting = 0)
        - Northen Gulf of Mexico.
        - 187-250 cm STL, 100 gangions baited bottom longline soaked for 1 hr.
        - Tagged sharks were in ”good condition”.
        - 23-30 days at liberty (sPAT).
        - One of the three tagged sharks may have been presumed dead if used SPOT tags alone.
    - Preliminary recommendations
      - Use data from both studies to determine post-release live-discard rate (Bottom longline)
      - Pool satellite tag numbers (N = 31) and number non-reporting (13) after 3 and 4 weeks
      - 41.9% post-release live discard mortality rate (bottom longline)

Delayed Mortality Rates for SEDAR 77

- Direct estimates by species and high priority gear types (Data Webinar III)
  - Gillnet
    - Braccini et al. (2012) Smooth Hammerhead
      - 43.2%
        - Indirect estimate based on an assessment of at-vessel condition in southern Australia commercial gillnet shark fishery (n = 122)..
    - Hueter et al. (2006) Bonnethead
      - 39.9%
      - 95% range (29.8% LCI, 55.1% UCI)
        - Juvenile and small adult sharks captured with research gillnets in Florida estuaries. Based on relative numerical tag and recapture events assuming that sharks in the best condition survived to the same degree as sharks that were not captured (n tagged = 4,352; n recaptured = 155).
    - Preliminary recommendations
      - Use data from both studies to determine post-release live-discard rate
      - Average the study results [(43.2%+39.9%)/2]
      - Obtain a range (95% LCI and UCI) from Hueter et al. (2006)
      - 41.5% average post-release live discard mortality rate (Gillnet)
      - 29.8% LCI (Gillnet)
      - 55.1% UCI (Gillnet)

Delayed Mortality Rates for SEDAR 77

- Direct estimates by species and high priority gear types (Data Webinar III)
  - Recreational
    - NA (from literature review)
    - SEDAR77_DW07-v1_11292021
    - SEDAR77_DW22-V1_1252021

Delayed Mortality Rates for SEDAR 77

- Direct estimates by species and high priority gear types (Data Webinar III)

Report on the post-release mortality rates of great hammerhead sharks *Sphyrna mokarran* in the recreational, catch and release, shore-based fishery in Florida, USA.

Hannah B. Medd and Jill L. Brooks

SEDAR77-DW22

Received: 12/5/2021

  - Recreational
    - SEDAR77-DW22 Great Hammerhead
      - 7.7% (Satellite tag; N = 13, n = 1)
    - Preliminary recomendations
      - Use the estimates

Delayed Mortality Rates for SEDAR 77

- Direct estimates by species and high priority gear types (Data Webinar III)
  - Recreational

Preliminary post-release mortality estimates for the shore-based recreational shark fishery in Texas

John A. Mohan , R.J. David Wells, Marcus Drymon, Gregory Stunz, and Matthew Streich

SEDAR77-DW07

Received: 11/29/2021

- SEDAR77-DW07 Great Hammerhead
  - 50% (Satellite tag; N = 2, n = 1; immideate mortality)
  - 100% (Satellite tag; N = 2, n = 2; immideate + 5 day delayed mortality)
- Preliminary recomendation
  - Use the estimates from immideate + 5 day delayed mortality

Delayed Mortality Rates for SEDAR 77

- Direct estimates by species and high priority gear types (Data Webinar III)
  - Recreational
    - NA (from literature review)
    - SEDAR77_DW07-v1_11292021
    - SEDAR77_DW22-V1_1252021
    - Preliminary recommendation
      - Pool tag and recapture data DW07 and DW22
        - 20.0% (Satellite tag; N = 15, n = 3; immideate + 5 day delayed mortality)

Delayed Mortality Rates for SEDAR 77

- Compare to indirect estimates (meta-analysis)
  - Pelagic sharks (longline, purse-seine, rod & reel)
    - Musyl and Gilman (2019)
      - All pelagic shark studies (33)
        - 26.8% (19.3% LCI, 36.0% UCI)
        - (longline, purse-seine, rod & reel):
        - Dead = 95, Tagged = 401
      - Scalloped Hammerhead (One study)
        - 87.5% (26.6% LCI, 99.3% UCI)
        - One study (Eddy et al. 2016, Purse-seine)
        - Dead = 3, Tagged = 3.

Delayed Mortality Rates for SEDAR 77

- Compare to indirect estimates (meta-analysis)
  - Elasmobranch (Obligate ram-ventilators)
    - Dapp et al. (2016c)
      - Gillnet (35.9% Obligate ram-ventilators)
      - Longline (19.51% Obligate ram-ventilators)
      - Trawl – Scenario 1 (22.12 % Obligate ram-ventilators)
      - Trawl – Scenario 2 (54.42% Obligate ram-ventilators)
      - Trawl – Scenario 3 (58.02% Obligate ram-ventilators)
  - Predicted mean total discard mortality (TDM) obtained from immediate mortality (IM; 83 species) and post-release mortality (PM; 40 species) of obligate ram-ventilating elasmobranchs caught in longline, gillnet and trawl gear types using Bayesian models (immediate mortality), non-parametric tests (gillnet post-release mortality), arithmetic average (longline post-release mortality) and three approximation scenarios (trawl post-release mortality).

Delayed Mortality Rates for SEDAR 77

- Compare to indirect estimates (other species and gear types)
  - Previous SEDAR decisions
    - **Table A.2**. Summary of delayed discard-mortality rates, M_D, in sharks by gear type obtained from the literature search.

Gear/Source	Hammer-head(s)	Scientific name	Other species	Delayed discard mortality rate (M_D)	Notes
Longline (pelagic)					
Campana et al. (2009b)			Blue shark	19%* (10 – 29%)	Tagged both injured and healthy animals; Range is 95% confidence interval.
Hook and line					
Gurshin and Szedlmayer (2004)			Atlantic sharpnose shark	10%*	Tagged both injured and healthy animals (n = 10).

Delayed Mortality Rates for SEDAR 77

- Compare to SEDAR 65 Data Workshop decisions

SEDAR 65				
Atlantic blacktip shark				
Working group	Longline	Hook and line	Gillnet	Trawl
DW*	44.2% (Base - BLL)	18.5% (Base)	31% (Base)	NA
	34.0–54.8% (Range)	10.8–28.7% (Range)	8.7–44.4% (Range)	NA

Delayed Mortality Rates for SEDAR 77

- Compare to SEDAR 65 Data Workshop methods
  - Range of uncertainty
    - Bottom longline
    - Recreational
      - Range of uncertainty = 95% CI
      - Obtained from R library "binom" (Dorai-Raj 2014)

Dorai-Raj, S. 2014. binom: Binomial confidence intervals for several parameterizations. R package version 1.1-1. https://CRAN.R-project.org/package=binom.

    - Gillnet
      - Range of uncertainty = 95% CI
      - Adapted from Hueter et al. (2006) assuming all tagged sharks released in condition 1 (healthy) survived the capture and release event, which may underestimate post-release mortality.

Hueter, R. E., Manire, C. A., Tyminski, J. P., Hoenig, J. M., and D. A. Hepworth. 2006. Assessing mortality of released or discarded fish using a logistic model of relative survival derived from tagging data. Transactions of the American Fisheries Society 135:500–508.

Delayed Mortality Rates for SEDAR 77

- Provide combined estimates and their range of uncertainty for evaluation in SEDAR 77
  - Use the same methods as SEDAR 65 to obtain a range of uncertainty (95% CI) by gear type
    - Bottom longline
    - Gillnet
    - Recreational

Delayed Mortality Rates for SEDAR 77

- Combined direct estimate and range (95% CI) (R library "binom" (Dorai-Raj 2014))
  - Bottom longline
    - Gallagher et al. (2014b) Great Hammerhead
      - 42.9% (Satellite tag; N = 28, n = 12; after 2 wks)
      - Range 24 – 63%
        - binom.confint(x = 12, n = 28, method = "exact")
      - 46.4% (Satellite tag; N = 28, n = 13; after 3 and 4 wks)
      - Range 28 – 66%
        - binom.confint(x = 13, n = 28, method = "exact")

    - Drymon and Wells (2017) Great Hammerhead
      - 0% (Satellite tag; N = 3, n = 0)

    - Combined (Pooled); Same species; Similar gear and methods
      - 38.7% (Satellite tag; N = 31, n = 12; after 2 wks)
      - Range 22 – 58%
        - binom.confint(x = 12, n = 31, method = "exact")
      - 41.9% (Satellite tag; N = 31, n = 13; after 3 and 4 wks)
      - Range 25 – 61%
        - binom.confint(x = 13, n = 28, method = "exact")

Delayed Mortality Rates for SEDAR 77

- Combined direct estimate and range (95% CI)
  - Gillnet
    - Braccini et al. (2012) Smooth Hammerhead
      - 43.2% Indirect estimate based on an assessment of at-vessel condition in southern Australia commercial gillnet shark fishery (n = 122).
    - Hueter et al. (2006) Bonnethead
      - 39.9%
      - Range 29.8 – 55.1%
        - Same methods as in SEDAR 65 applied to bonnethead (Adapted from Hueter et al. 2006).
    - Combined (Average); Different species; Different methods
      - 41.5%
        - Average of Smooth Hammerhead and Bonnethead.
      - Range 29.8 – 55.1%
        - Bonnethead, adapted from Hueter et al. (2006).

Delayed Mortality Rates for SEDAR 77

- Combined direct estimate and 95% CI (R library "binom" (Dorai-Raj 2014))
  - Recreational
    - SEDAR77-DW22 Great Hammerhead
      - 7.7% (Satellite tag; N = 13, n = 1)
        - Range 0-36% binom.confint(x = 1, n = 13, method = "exact")
    - SEDAR77-DW07 Great Hammerhead
      - 50% (Satellite tag; N = 2, n = 1; immideate mortality)
      - 100% (Satellite tag; N = 2, n = 2; immideate + 5 day delayed mortality)
    - Combined (Pooled sample – Same species; Similar gear and methods)
      - 13.3% (Satellite tag; N = 15, n = 2; immideate mortality)
        - Range 2-40% binom.confint(x = 2, n = 15, method = "exact")
      - 20.0% (Satellite tag; N = 15, n = 3; immideate + 5 day delayed mortality)
        - Range 4-48% binom.confint(x = 3, n = 15, method = "exact")

- Thank you

- Additional information
    - If needed

Musyl and Gilman (2019)

Table X. Musyl and Gilman (2019) delayed discard-mortality rates, M_D, by gear type obtained from meta-analyses. Random-effects meta-analysis synthesized *F*r in seven pelagic shark species captured, tagged and released with 401 pop-up satellite archival tags compiled from 33 studies and three gears (longline, purse-seine, rod & reel); Number of tags indicating mortality and total sample size (i.e. Dead; N) adapted from Musyl and Gilman (2019, their Figures 3 and 6).

Species	Gear or disposition	Estimate	LCI	UCI	Dead	N
Blue (9 studies)		0.17	0.107	0.259	28	158
Silky (8 studies)	Purse-seine	0.475	0.31	0.645	29	63
Silky (3 studies)	Longline	0.164	0.008	0.819	7	45
Common Thresher (3 studies)		0.353	0.072	0.793	12	35
Shortfin Mako (5 studies)		0.254	0.137	0.42	15	67
Oceanic White-tip (2 studies)		0.163	0.008	0.831	1	15
Bigeye Thresher (2 studies)		0.225	0.081	0.49	3	15
Scalloped Hammerhead (1 study)[1]		0.875	0.266	0.993	3	3
Overall		0.268	0.193	0.36	95	401
Pelagic sharks	Healthy (27 studies)[2]	0.199	0.148	0.263	59	346
Pelagic sharks	Unhealthy (6 studies)	0.647	0.507	0.763	36	55

[1] Scalloped Hammerhead sharks were captured in tuna purse seine sets around FADs (Eddy et. al 2016).

[2] Scalloped Hammerhead sharks were included in the healthy pelagic shark grouping.

Dapp et al. (2016c)

Table X. Dapp et al. (2016c, their Table 2) predicted mean total discard mortality (TDM) obtained from immediate mortality (IM; 83 species) and post-release mortality (PM; 40 species) of obligate ram-ventilating elasmobranchs caught in longline, gillnet and trawl gear types using Bayesian models (immediate mortality), non-parametric tests (gillnet post-release mortality), arithmetic average (longline post-release mortality) and three approximation scenarios (trawl post-release mortality).

Gear type	Respiratory mode	IM (%)	PM (%)	TDM (%)
Gillnet	Obligate ram-ventilating	67.3	35.9	79
Longline	Obligate ram-ventilating	37.6	19.51	49.8
Trawl – Scenario 1	Obligate ram-ventilating	62.5	22.12	70.8
Trawl – Scenario 2	Obligate ram-ventilating	62.5	54.42	82.9
Trawl – Scenario 3	Obligate ram-ventilating	62.5	58.02	84.2

Trawl – Scenario 1 "[A]ssumed that respiratory mode did not affect post-release mortality and we used the mean post-release mortality percentage of stationary-respiring species to model the post-release mortality percentage of obligate ram ventilating species."
Trawl – Scenario 2 "[A]ssumed that changes in immediate mortality percentages caused by respiratory mode would be similar to changes in post-release mortality percentages caused by respiratory mode in trawl-caught species."
Trawl – Scenario 3 "[A]ssumed that the impact of respiratory mode on post-release mortality percentages of trawl-caught species was similar to the impact of respiratory mode on post-release mortality percentages of gillnet-caught elasmobranchs."
Immediate mortality studies comprised primarily pelagic longline (83% of studies), benthic gillnet (64%), and benthic trawls (100%).
Post-release mortality studies comprised a greater proportion of species capable of stationary respiration 76% (24 of 33 data points) compared to the immediate mortality analysis 55% (61 of 111 data points).
TDM = [1-(1-IM/100)×(1-PM/100)]×100.

Dapp et al. (2016c)

- TDM = [1-(1-IM/100)×(1-PM/100)]×100.
  - Sample size $n \geq 15$ in each study.

- Higher at-vessel mortality than post-release mortality may be an artifact of species available within each study group.
  - Immediate mortality studies comprised primarily pelagic longline (83% of studies), benthic gillnet (64%), and benthic trawls (100%).
  - In contrast, post-release mortality studies comprised a greater proportion of species capable of stationary respiration 76% (24 of 33) compared to the immediate mortality analysis 55% (61 of 111).

- Post-release mortality of obligate ram ventilating species under-represented in trawls.
  - Trawl – Scenario 1 "[A]ssumed that respiratory mode did not affect post-release mortality and we used the mean post-release mortality percentage of stationary-respiring species to model the post-release mortality percentage of obligate ram ventilating species."
  - Trawl – Scenario 2 "[A]ssumed that changes in immediate mortality percentages caused by respiratory mode would be similar to changes in post-release mortality percentages caused by respiratory mode in trawl-caught species."
  - Trawl – Scenario 3 "[A]ssumed that the impact of respiratory mode on post-release mortality percentages of trawl-caught species was similar to the impact of respiratory mode on post-release mortality percentages of gillnet-caught elasmobranchs."

Delayed Mortality Rates for SEDAR 77

- Compare to indirect estimates (other species and gear types)
  - Previous SEDAR decisions
    - **Table A.2**. Summary of delayed discard-mortality rates, M_D, in sharks by gear type obtained from the literature search.

* Previous SEDAR AP panels considered the delayed discard mortality rate estimates, M_D, provided by Campana et al. (2009b) and by Gurshin and Szedlmayer (2004) to be the best available estimates for post-release live-discard mortality, PRLDM, in pelagic longlines and hook and line, respectively, because both studies included injured as well as healthy animals (NMFS 2012, 2013a, 2013b).