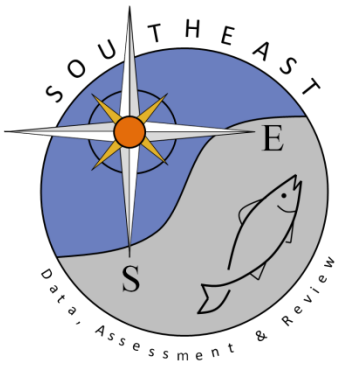
An Updated Literature Review of Post-release Live-discard Mortality Rate Estimates in Sharks for use in SEDAR 65

Dean Courtney and Alyssa Mathers

SEDAR65-DW20

recieved: 11/1/19
Revised: 12/4/19



Please cite this document as:

Courtney, Dean and Alyssa Mathers. 2019. An Updated Literature Review of Post-release Live-discard Mortality Rate Estimates in Sharks for use in SEDAR 65. SEDAR65-DW20. SEDAR, North Charleston, SC. 20 pp.

An Updated Literature Review of Post-release Live-discard Mortality Rate Estimates in Sharks for use in SEDAR 65

Dean Courtney[1] and Alyssa Mathers[2]

[1]NOAA Fisheries
Southeast Fisheries Science Center
Panama City Laboratory
3500 Delwood Beach Drive,
Panama City, FL 32408, USA
E-mail: dean.courtney@noaa.gov

[2]Riverside Technology for NOAA Fisheries Service
Southeast Fisheries Science Center
3500 Delwood Beach Drive
Panama City, FL 32408 USA

December, 2019

SUMMARY

This working paper summarizes literature reviewed for estimates of delayed discard-mortality rates (M_D) in sharks (Tables 1 – 3), and identifies those available for blacktip sharks (*Carcharhinus limbatus*). Estimates of immediate (i.e. at-vessel or acute) discard-mortality rates (M_A) are also identified. Previous SEDAR shark Assessment Process (AP) and Data Workshop (DW) post-release live-discard mortality (PRLDM) rate decisions are provided in Table 4.

REFERENCES

Afonso, A. S., and F. H. V. Hazin. 2014. Post-release survival and behavior and exposure to fisheries in juvenile tiger sharks, *Galeocerdo cuvier*, from the South Atlantic. Journal of Experimental Marine Biology and Ecology 454:55–62.

Barham, W. T., and F. J. Schwartz. 1992. Physiological responses of newborn smooth dogfish, *Mustelus canis*, during and following temperature and exercise stress. The Journal of the Elisha Mitchell Scientific Society 108:64–69.

Bell, J. D. and J. M. Lyle. 2016. Post-capture survival and implications for by-catch in a multi-species coastal gillnet fishery. PLoS One 11(11): e0166632. doi: 10.1371/journal.pone.0166632

Braccini, M., Van Rijn, J., and L. Frick. 2012. High post-capture survival for sharks, rays and chimaeras discarded in the main shark fishery of Australia? PloS One 7:e32547 (9 pages). doi:10.1371/journal.pone.0032547.

Bromhead, D., Clarke, S., Hoyle, S., Muller, B., Sharples, P., and S. Harley. 2012. Identification of factors influencing shark catch and mortality in the Marshall Islands tuna longline fishery and management implications. Journal of Fish Biology 80:1870–1894.

Brooks, E. J., Brooks, A. M. L., Williams, S., Jordan, L. K. B., Abercrombie, D., Chapman, D. D., Howey-Jordan, L. A., and R. D. Grubbs. 2015. First description of deep-water elasmobranch assemblages in the Exuma Sound, The Bahamas. Deep Sea Research Part II: Topical Studies in Oceanography 115: 81–91.

Brooks, E. J., Mandelman, J. W., Sloman, K. A., Liss, S., Danylchuk, A. J., Cooke, S. J., Skomal, G. B., Philipp, D. P., Sims, D. W., and C. D. Suski. 2012. The physiological response of the Caribbean reef shark (*Carcharhinus perezi*) to longline capture. Comparative Biochemistry and Physiology, Part A 162:94–100.

Brooks, E. J., Sloman, K. A., Liss, S., Hassan-Hassanein, L., Danylchuk, A. J., Cooke, S. J., Mandelman, J. W., Skomal, G. B., Sims, D. W., and C. D. Suski. 2011. The stress physiology of extended duration tonic immobility in the juvenile lemon shark, *Negaprion brevirostris* (Poey 1868). Journal of Experimental Marine Biology and Ecology 409:351–360.

Butcher, P. A., Peddemors, V. M., Mandelman, J. W., McGrath, S. P., and B. R. Cullis. 2015. At-vessel mortality and blood biochemical status of elasmobranchs caught in an Australian commercial longline fishery. Global Ecology and Conservation 3:878-889.

Cain, D. K., Harms, C. A., and A. Segars. 2004. Plasma biochemistry reference values of wild-caught southern stingrays (*Dasyatis americana*). Journal of Zoo and Wildlife Medicine 35:471–476.

Campana, S. E., Brading, J., and W. Joyce. 2011. Estimation of pelagic shark bycatch and associated mortality in Canadian Atlantic fisheries. DFO Canadian Science Advisory Secretariat (CSAS) Research Document 2011/067: vi + 19p. Available: http://www.dfo-mpo.gc.ca/csas-sccs/Publications/ResDocs-DocRech/2011/2011_067-eng.html (September, 2019).

Campana, S. E., Joyce, W., Fowler, M., and M. Showell. 2016. Discards, hooking, and post-release mortality of porbeagle (*Lamna nasus*), shortfin mako (*Isurus oxyrinchus*), and blue shark (*Prionace glauca*) in the Canadian pelagic longline fishery. ICES Journal of Marine Science 73:520–528.

Campana, S. E., Joyce, W., Francis, M. P., and M. J. Manning. 2009a. Comparability of blue shark mortality estimates for the Atlantic and Pacific longline fisheries. Marine Ecology-Progress Series 396:161–164.

Campana, S. E., Joyce, W., and M. J. Manning. 2009b. Bycatch and discard mortality in commercially caught blue sharks *Prionace glauca* assessed using archival satellite pop-up tags. Marine Ecology-Progress Series 387:241–253.

Chisholm, J. H. 2003. Survival of discard spiny dogfish (*Squalus acanthias* L.) in the Massachusetts trawl fishery. Master's thesis. University of Massachusetts, Dartmouth.

Cicia, A. M., Schlenker, L. S., Sulikowski, J. A., and J. W. Mandelman. 2012. Seasonal variations in the physiological stress response to discrete bouts of aerial exposure in the little skate, *Leucoraja erinacea*. Comparative Biochemistry and Physiology, Part A 162:130–138.

Clarke, S. 2011. A status snapshot of key shark species in the Western and Central Pacific and potential management options. Oceanic Fisheries Programme, Secretariat of the Pacific Community. WCPFC-SC7-2011/EB-WP-04, 36p.

Clarke, S. C., Francis, M. P., and L. H. Griggs. 2013. Review of shark meat markets, discard mortality and pelagic shark data availability, and a proposal for a shark indicator analysis. Ministry for Primary Industries. New Zealand Fisheries Assessment Report 2013/65, 74p.

Cliff, G., and G. D. Thurman. 1984. Pathological and physiological effects of stress during capture and transport in the juvenile dusky shark, *Carcharhinus obscurus*. Comparative Biochemistry and Physiology, Part A 78:167–173.

Coelho, R. Fernandez-Carvalho, J., Lino, P. G., and M. N. Santos. 2012. An overview of the hooking mortality of elasmobranchs caught in a swordfish pelagic longline fishery in the Atlantic Ocean. Aquatic Living Resources. 25:311–319.

Coelho, R., Infante, P., and M. N. Santos. 2013. Application of Generalized Linear Models and Generalized Estimation Equations to model at-haulback mortality of blue sharks captured in a pelagic longline fishery in the Atlantic Ocean. Fisheries Research 145:66–75.

Cosandey-Godin, A. ,and A. Morgan. 2011. Fisheries bycatch of sharks: Options for mitigation. Ocean Science Division, Pew Environment Group, Washington, DC.

Danylchuk, A. J., Suski, C. D., Mandelman, J. W., Murchie, K. J., Haak, C. R., Brooks, A. M. L., and S. J. Cooke. 2014. Hooking injury, physiological status and short-term mortality of juvenile lemon sharks (*Negaprion bevirostris*) following catch-and-release recreational angling. Conservation Physiology 2(1): doi:10.1093/conphys/cot036.

Dapp, D. R., Huveneers, C., Walker, T. I., Drew, M., and R. D. Reina. 2016a. Moving from measuring to predicting bycatch mortality: Predicting the capture condition of a longline-caught pelagic shark. Frontiers in Marine Science 2:126. doi: 10.3389/fmars.2015.00126.

Dapp, D. R., Huveneers, C., Walker, T. I., Mandelman, J., Kerstetter, D. W., and R. D. Reina. 2016b. Using logbook data to determine the immediate mortality of blue sharks (*Prionace glauca*) and tiger sharks (*Galeocerdo cuvier*) caught in the commercial U.S. pelagic longline fishery. Fishery Bulletin, 115: 27-41.

Dapp, D. R., Walker, T. I., Huveneers, C., and R. D. Reina. 2016c. Respiratory mode and gear type are important determinants of elasmobranch immediate and post-release mortality. Fish and Fisheries 17:507–524.

Diaz, G. A. 2011. A simulation study of the results of using different levels of observer coverage to estimate dead discards for the U.S. pelagic longline fleet in the Gulf of Mexico.

Collect. Vol. Sci. Pap. ICCAT, SCRS/2010/058, 2206–2212p. Available: https://www.iccat.int/en/pubs_CVSP.html (September, 2019).

Eddy, C., Brill, R., and D. Bernal. 2016. Rates of at-vessel mortality and post-release survival of pelagic sharks captured with tuna purse seines around drifting fish aggregating devices (FADs) in the equatorial eastern Pacific Ocean. Fisheries Research 174:109–117.

Ellis, J. R., McCully Phillips, S. R., and F. Poisson. 2017. A review of capture and post-release mortality of elasmobranchs. Journal of Fish Biology 90:653–722.

Francis M. P. 1989. Exploitation rates of rig (*Mustelus lenticulatus*) around the South Island of New Zealand. New Zealand Journal of Marine and Freshwater Research 23:239–245.

French, R. P., Lyle, J., Tracey, S., Currie, S., and J. M. Semmens. 2015. High survivorship after catch-and-release fishing suggests physiological resilience in the endothermic shortfin mako shark (*Isurus oxyrinchus*). Conservation Physiology 3: doi:10.1093/conphys/cov044.

Frick, L. H., Reina, R. D., and T. I. Walker. 2009. The physiological response of Port Jackson sharks and Australian swellsharks to sedation, gill-net capture, and repeated sampling in captivity. North American Journal of Fisheries Management 29:127–139.

Frick, L. H., Reina, R. D., and T. I. Walker. 2010a. Stress related physiological changes and post-release survival of Port Jackson sharks (*Heterodontus portusjacksoni*) and gummy sharks (*Mustelus antarcticus*) following gill-net and longline capture in captivity. Journal of Experimental Marine Biology and Ecology 385:29–37.

Frick, L. H., Walker, T. I., and R. D. Reina. 2010b. Trawl capture of Port Jackson sharks, *Heterodontus portusjacksoni*, and gummy sharks, *Mustelus antarcticus*, in a controlled setting: effects of tow duration, air exposure and crowding. Fisheries Research 106:344–350.

Frick, L. H., Walker, T. I. and R. D. Reina. 2012. Immediate and delayed effects of gill-net capture on acid-base balance and intramuscular lactate concentration of gummy sharks, *Mustelus antarcticus*. Comparative Biochemistry and Physiology, Part A 162:88–93.

Gallagher, A. J., Orbesen, E. S., Hammerschlag, N., and J. E. Serafy. 2014a. Vulnerability of oceanic sharks as pelagic longline bycatch. Global Ecology and Conservation 1:50–59.

Gallagher, A. J., Serafy, J. E., Cooke, S. J. and N. Hammerschlag. 2014b. Physiological stress response, reflex impairment, and survival of five sympatric shark species following experimental capture and release. Marine Ecology Progress Series 496:207–218.

Gallagher, A. J., Staaterman, E. R., Cooke, S. J., and N. Hammerschlag. 2017. Behavioural responses to fisheries capture among sharks caught using experimental fishery gear. Canadian Journal of Fisheries and Aquatic Sciences 74:1–7. doi 10.1139/cjfas-2016-0165

Godin, A. C., Carlson, J. K. and V. Burgener. 2012. The effect of circle hooks on shark catchability and at-vessel mortality rates in longlines fisheries. Bulletin of Marine Science 88:469–483.

Gulak, S. J. B., de Ron Santiago, A. J., and J. K. Carlson. 2015. Hooking mortality of scalloped hammerhead *Sphyrna lewini* and great hammerhead *Sphyrna mokarran* sharks caught on bottom longlines. African Journal of Marine Science 37:267-273.

Gurshin, C. W. D., and S. T. Szedlmayer. 2004. Short-term survival and movements of Atlantic sharpnose sharks captured by hook-and-line in the north-east Gulf of Mexico. Journal of Fish Biology 65:973–986.

Heberer, C., Aalbers, S. A., Bernal, D., Kohin, S., DiFiore, B., Sepulveda, C. A. 2010. Insights into catch-and-release survivorship and stress-induced blood biochemistry of common

thresher sharks (*Alopias vulpinus*) captured in the southern California recreational fishery. Fisheries Research 106:495–500.

Heupel, M. R., and C. A. Simpfendorfer. 2002. Estimation of mortality of juvenile blacktip sharks, *Carcharhinus limbatus*, within a nursery area using telemetry data. Canadian Journal of Fisheries and Aquatic Sciences 59:624–632.

Hight, B. V., Holts, D., Graham, J. B., Kennedy, B. P., Taylor, V., Sepulveda, C. A., Bernal, D., Ramon, D., Rasmussen, R., and N. C. Lai. 2007. Plasma catecholamine levels as indicators of the post-release survivorship of juvenile pelagic sharks caught on experimental drift longlines in the Southern California Bight. Marine and Freshwater Research 58:145–151.

Hoffmayer, E. R., Hendon, J. M., and G. R. Parsons. 2012. Seasonal modulation in the secondary stress response of a carcharhinid shark, *Rhizoprionodon terraenovae*. Comparative Biochemistry and Physiology, Part A 162:81–87.

Hoffmayer, E. R., and G. R. Parsons. 2001. The physiological response to capture and handling stress in the Atlantic sharpnose shark, *Rhizoprionodon terraenovae*. Fish Physiology and Biochemistry 25:277–285.

Holland, K. N., Wetherbee, B. M., Lowe, C. G., and C. G. Meyer. 1999. Movements of tiger sharks (*Galeocerdo cuvier*) in coastal Hawaiian waters. Marine Biology 134:665–673.

Holts, D. B., and D. W. Bedford. 1993. Horizontal and vertical movements of the shortfin mako shark, *Isurus oxyrinchus*, in the Southern California bight. Australian Journal of Marine and Freshwater Research 44:901–909.

Hueter, R. E., and C. A. Manire. 1994. Bycatch and catch-release mortality of small sharks in the Gulf coast nursery grounds of Tampa Bay and Charlotte Harbor. Technical Report No. 368 (Final report to NOAA/NMFS, MARFIN Project NA17FF0378-01)**,** 183 pp. Available from Mote Marine Laboratory.

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.

Hutchinson, M. R., Itano, D. G., Muir, J. A., and K. N. Holland, 2015. Post-release survival of juvenile silky sharks captured in a tropical tuna purse seine fishery. Marine Ecology Progress Series 521:143–154.

Hyatt, M. W., Anderson, P. A., and P. M. O'Donnell. 2016. Behavioral release condition score of bull and bonnethead sharks as a coarse indicator of stress. Journal of Coastal Research: 1464–1472.

Hyatt, M. W., Anderson, P. A., O'Donnell, P. M., and I. K. Berzins. 2012. Assessment of acid-base derangements among bonnethead (*Sphyrna tiburo*), bull (*Carcharhinus leucas*), and lemon (*Negaprion brevirostris*) sharks from gillnet and longline capture and handling methods. Comparative Biochemistry and Physiology a-Molecular & Integrative Physiology 162(2):113–120.

Mandelman, J. W., and M. A. Farrington. 2007a. The estimated short-term discard mortality of a trawled elasmobranch, the spiny dogfish (*Squalus acanthias*). Fisheries Research 83:238–245.

Mandelman, J. W., and M. A. Farrington. 2007b. The physiological status and mortality associated with otter-trawl capture, transport, and captivity of an exploited elasmobranch, *Squalus acanthias*. ICES Journal of Marine Science 64:122–130.

Mandelman, J. W., and G. B. Skomal. 2009. Differential sensitivity to capture stress assessed by blood acid-base status in five carcharhinid sharks. Journal of Comparative Physiology, Part B 179:267–277.

Manire, C., Hueter, R., Hull, E., and R. Spieler. 2001. Serological changes associated with gill-net capture and restraint in three species of sharks. Transactions of the American Fisheries Society 130:1038–1048.

Marshall, H., Field, L., Afiadata, A., Sepulveda, C., Skomal, G., and D. Bernal. 2012. Hematological indicators of stress in longline-captured sharks. Comparative Biochemistry and Physiology a-Molecular & Integrative Physiology 162:121–129.

Marshall, H., Skomal, G., Ross, P. G., and D. Bernal. 2015. At-vessel and post-release mortality of the dusky (*Carcharhinus obscurus*) and sandbar (*C. plumbeus*) sharks after longline capture. Fisheries Research 172:373–384.

McLoughlin, K., and G. Eliason. 2008. Review of information on cryptic mortality and survival of sharks and rays released by recreational fishers, Australian Government Bureau of Rural Resources, GPO Box 858, Canberra ACT 2601, Australia, 22 p.

Morgan, A., and G. H. Burgess. 2007. At-vessel fishing mortality for six species of sharks caught in the northwest Atlantic and Gulf of Mexico. Gulf and Caribbean Research 19:123–129.

Morgan, A., Carlson, J., Ford, T., Siceloff, L., Hale, L., Allen, M. S., and G. Burgess. 2010. Temporal and spatial distribution of finfish bycatch in the U.S. Atlantic bottom longline shark fishery. Marine Fisheries Review 72:34–38.

Morgan, A., and J. K. Carlson. 2010. Capture time, size and hooking mortality of bottom longline-caught sharks. Fisheries Research 101:32–37.

Moyes, C. D., Fragoso, N., Musyl, M. K., and R. W. Brill. 2006. Predicting postrelease survival in large pelagic fish. Transactions of the American Fisheries Society 135:1389–1397.

Musyl, M. and E. L. Gilman. 2019. Meta-analysis of post-release fishing mortality in apex predatory pelagic sharks. Fish and Fisheries, doi: 10.1111/faf.12358

Musyl, M. K., Brill, R. W., Curran, D. S., Fragoso, N. M., McNaughton, L. M., Nielsen, A., Kikkawa, B. S., and C. D. Moyes. 2011. Postrelease survival, vertical and horizontal movements, and thermal habitats of five species of pelagic sharks in the central Pacific Ocean. Fishery Bulletin 109:341–368.

Musyl, M. K., Moyes, C. D., Brill, R. W., and N. M. Fragoso. 2009. Factors influencing mortality estimates in post-release survival studies. Marine Ecology Progress Series 396:157–159.

NEFSC (Northeast Fisheries Science Center). 2006. Report of the 43rd Northeast Regional Stock Assessment Workshop (43rd SAW), Stock Assessment Review Committee (SARC) consensus summary of assessments. NEFSC Ref. Doc. 06-25. Available: http://nefsc.noaa.gov/publications/crd/crd0625/ (Oct 2019).

NMFS (National Marine Fisheries Service). 2011a. Southeast Data Assessment and Review (SEDAR) 21 stock assessment report; Highly Migratory Species (HMS) Atlantic blacknose shark. October, 2011. DOC/NOAA/NMFS, Highly Migratory Species Management Division, 1315 East-West Highway, Silver Spring, Maryland 20910. Available: https://sedarweb.org/sedar-21 (October, 2019).

NMFS (National Marine Fisheries Service). 2011b. Southeast Data Assessment and Review (SEDAR) 21 stock assessment report; Highly Migratory Species (HMS) dusky shark. October, 2011. DOC/NOAA/NMFS, Highly Migratory Species Management Division,

1315 East-West Highway, Silver Spring, Maryland 20910. Available: https://sedarweb.org/sedar-21 (October, 2019).

NMFS (National Marine Fisheries Service). 2011c. Southeast Data Assessment and Review (SEDAR) 21 stock assessment report; Highly Migratory Species (HMS) Gulf of Mexico blacknose shark. October, 2011. DOC/NOAA/NMFS, Highly Migratory Species Management Division, 1315 East-West Highway, Silver Spring, Maryland 20910. Available: https://sedarweb.org/sedar-21 (October, 2019).

NMFS (National Marine Fisheries Service). 2011d. Southeast Data Assessment and Review (SEDAR) 21 stock assessment report; Highly Migratory Species (HMS) sandbar shark. October, 2011. DOC/NOAA/NMFS, Highly Migratory Species Management Division, 1315 East-West Highway, Silver Spring, Maryland 20910. Available: https://sedarweb.org/sedar-21 (October, 2019).

NMFS (National Marine Fisheries Service). 2012. Southeast Data Assessment and Review (SEDAR) 29 stock assessment report: Highly Migratory Species (HMS) Gulf of Mexico blacktip shark. July, 2012. DOC/NOAA/NMFS SEDAR, 4055 Faber Place Drive, Suite 201, North Charleston, SC 29405. Available: https://sedarweb.org/sedar-29 (October, 2019).

NMFS (National Marine Fisheries Service). 2013a. Southeast Data Assessment and Review (SEDAR) 34 stock assessment report: Highly Migratory Species (HMS) Atlantic sharpnose shark. September, 2013. DOC/NOAA/NMFS SEDAR, 4055 Faber Place Drive, Suite 201, North Charleston, SC 29405. Available: https://sedarweb.org/sedar-34 (October, 2019).

NMFS (National Marine Fisheries Service). 2013b. Southeast Data Assessment and Review (SEDAR) 34 stock assessment report: Highly Migratory Species (HMS) bonnethead shark. September, 2013. DOC/NOAA/NMFS SEDAR, 4055 Faber Place Drive, Suite 201, North Charleston, SC 29405. Available: https://sedarweb.org/sedar-34 (October, 2019).

NMFS (National Marine Fisheries Service). 2018. Update assessment to SEDAR 29 HMS Gulf of Mexico blacktip shark. SEDAR, 4055 Faber Place Drive, Suite 201, North Charleston, SC 29405. 99 pp. Available: http://sedarweb.org/2018-update-sedar-29-hms-gulf-mexico-blacktip-shark (October, 2019).

Oliver, S., Braccini, M., Newman, S. J., and E. S. Harvey. 2015. Global patterns in the bycatch of sharks and rays. Marine Policy 54:86-97.

Poisson, F., Crespo, F. A., Ellis, J. R., Chavance, P., Pascal, B., Santos, M. N., Séret, B., Korta, M., Coelho, R, Ariz, J., and H. Murua. 2016. Technical mitigation measures for sharks and rays in fisheries for tuna and tuna-like species: turning possibility into reality. Aquatic Living Resources 29:402. doi:10.1051/alr/2016030.

Poisson, F., Filmalter, J. D., Vernet, A.-L., and L. Dagorn. 2014. Mortality rate of silky sharks (*Carcharhinus falciformis*) caught in the tropical tuna purse seine fishery in the Indian Ocean. Canadian Journal of Fisheries and Aquatic Sciences 71:795–798.

Raby, G. D., Packer, J. R., Danylchuk, A. J. and S. J. Cooke. 2013. The understudied and underappreciated role of predation in the mortality of fish released from fishing gears. Fish and Fisheries, doi: 10.1111/faf.12033.

Renshaw, G. M. C., Kutek, A. K., Grant, G. D., and S. Anoopkumar-Dukie. 2012. Forecasting elasmobranch survival following exposure to severe stressors. Comparative Biochemistry and Physiology, Part A 162:101–112.

Rogers, P. J., Knuckey, I., Hudson, R. J., Lowther, A. D., and L. Guida. 2017. Post-release survival, movement, and habitat use of school shark *Galeorhinus galeus* in the Great Australian Bight, southern Australia. Fisheries Research 187:188–198.

Rulifson, R. A. 2007. Spiny dogfish mortality induced by gill-net and trawl capture and tag and release. North American Journal of Fisheries Management 27:279-285.

Sepulveda, C. A., Heberer, C., Aalbers, S. A., Spear, N., Kinney, M., Bernal, D., and S. Kohin. 2015. Post-release survivorship studies on common thresher sharks (*Alopias vulpinus*) captured in the southern California recreational fishery. Fisheries Research 161:102–108.

Skomal, G. B. 2007. Evaluating the physiological and physical consequences of capture on post-release survivorship in large pelagic fishes. Fisheries Management and Ecology 14:81–89.

Skomal, G. B., and J. W. Mandelman. 2012. The physiological response to anthropogenic stressors in marine elasmobranch fishes: A review with a focus on the secondary response. Comparative Biochemistry and Physiology, Part A 162:146–155.

Stobutzki, I. C., Miller, M. J., Heales, D. S., and D. T. Brewer. 2002. Sustainability of elasmobranchs caught as bycatch in a tropical prawn (shrimp) trawl fishery. Fishery Bulletin 100:800–821.

Thorpe, T., and D. Frierson. 2009. Bycatch mitigation assessment for sharks caught in coastal anchored gillnets. Fisheries Research 98:102–112.

Whitney, N. M., White, C. F., Anderson, P. A., Hueter, R. E., and G. B. Skomal. 2017. The physiological stress response, postrelease behavior, and mortality of blacktip sharks (*Carcharhinus limbatus*) caught on circle and J-hooks in the Florida recreational fishery. Fishery Bulletin 115:532-543.

Whitney, N. M., White, C. F., Gleiss, A. C., Schwieterman, G. D., Anderson, P., Hueter, R. E., and G. B. Skomal. 2016. A novel method for determining post-release mortality, behavior, and recovery period using acceleration data loggers. Fisheries Research, 183: 210-221.

Worm, B., Davis, B., Kettemer, L., Ward-Paige, C. A., Chapman, D., Heithaus, M. R., Kessel, S. T. and S. H. Gruber. 2013. Global catches, exploitation rates, and rebuilding options for sharks. Marine Policy 40:194–204.

Table 1. Literature reviewed for post-release live-discard mortality (PRLDM) rate estimates.

Primary Literature	Species		Gear type					Study type				Notes
	Blacktip	Other	Pelagic longline	Demersal longline	Hook and Line	Gillnet	Trawl	Physi-ological	Electronic tagging	Lab.	Other	
Longline (pelagic)												
Bromhead et al. (2012)		Pelagic sharks - Tropical Pacific	X								Commercial fisheries research	GAM analysis of factors influencing catch rates
Campana et al. (2016)		Blue, porbeagle, shortfin mako	X						X		Observer data	At-vessel mortality and PRLDM
Campana et al. (2009a, 2009b)		Blue	X						X			PRLDM
Coelho et al. (2012)		Pelagic sharks - Atlantic	X								Observer data	At-vessel mortality rate models GLM and GAM
Coelho et al. (2013)		Blue	X								Observer data	At-vessel mortality rate models GLM and GEE
Dapp et al. (2016a)		Bronze whaler	X	X				X			Research longline	At-vessel mortality
Dapp et al. (2016b)		Blue and tiger	X								Commercial logbook	At-vessel mortality
Diaz (2011)	X	Many	X								Observer data	At-vessel mortality
Gallagher et al. (2014a)		Pelagic sharks - Atlantic	X								Observer data	At-vessel mortality - logistic regression, integrated with reproductive potential
Moyes et al. (2006)		Blue	X					X	X			PRLDM
Musyl et al. (2009)		Blue	X					X	X			PRLDM
Musyl et al. (2011)		Blue, mako, others	X						X		Meta-analysis	PRLDM

Table 1. Continued.

Primary Literature	Species		Gear type					Study type				Notes
	Blacktip	Other	Pelagic longline	Demersal longline	Hook and Line	Gillnet	Trawl	Physi-ological	Electronic tagging	Lab.	Other	
Longline (demersal)												
Afonso and Hazin (2014)		Tiger		X						X		PRLDM
Brooks et al. (2015)		Deep-water elasmobranch assemblage - Bahamas		X						X	Research longline	At-vessel mortality and PRLDM
Butcher et al. (2015)	X	Many		X				X			Commercial fisheries research	At-vessel mortality, stress response
Gallagher et al. (2014b)	X	5 species of coastal sharks						X		X	Drum-line	PRLDM, stress response
Gallagher et al. (2017)	X	Blacktip, nurse, tiger		X							Drum-line	Behavioral response to capture measured with accelerometers attached to the fishing gear
Gulak et al. (2015)	X	Many		X							Commercial fisheries research	At-vessel mortality
Marshall et al. (2015)		Dusky, sandbar		X						X	Commercial fisheries research	At-vessel mortality, PRLDM
Morgan and Burges (2007)	X	Many		X							Observer data	At-vessel mortality
Morgan and Carlson (2010)	X	Many		X							Research/ commercial longline	At-vessel mortality
Morgan et al. (2010)	X	Many		X							Observer data	Bycatch composition
Rogers et al. (2017)		School shark		X						X	PAT	PRLDM

Table 1. Continued.

Primary Literature	Species		Gear type					Study type				Notes
	Blacktip	Other	Pelagic longline	Demersal longline	Hook and Line	Gillnet	Trawl	Physi-ological	Electronic tagging	Lab.	Other	
Hook and line												
Bullock et al. (2015)		Lemon			X					X	Net pen	Post-release behavior of tagged sharks in net pens and in situ
Danylchuk et al. (2014)		Lemon (majority neonate)			X			X		X	Reflex indices	PRLDM - 15 min. Not clear how sharks were tracked
French et al. (2015)		Shortfin mako			X			X		X	sPAT	PRLDM
Gurshin and Szedlmayer (2004)		Atlantic sharpnose			X					X		PRLDM
Heberer et al. (2010)		Common thresher			X			X		X	PSAT	PRLDM
Heupel and Simpfendorfer (2002)	X	Blacktip			X					X		PRLDM
Holland et al. (1999)		Tiger			X					X		Movement rates
Holts and Bedford (1993)		Shortfin mako			X					X		Movement rates
Mandelman and Farrington (2007a)		Spiny dogfish			X		X				Captured and held in net-pen (72 hrs.)	PRLDM
Sepulveda et al. (2015)		Common thresher			X						PSAT	PRLDM
Whitney et al. (2016 and 2017)	X	Blacktip			X					X		PRLDM

Table 1. Continued.

Primary Literature	Species		Gear type					Study type				Notes
	Blacktip	Other	Pelagic longline	Demersal longline	Hook and Line	Gillnet	Trawl	Physi-ological	Electronic tagging	Lab.	Other	
Gillnet												
Bell and Lyle (2016)		Australian swellshark (*Cephaloscyllium laticeps*)				X					Tank trials	PRLDM
Braccini et al. (2012)		Many species				X					Risk assessment	Post Capture Survival (PCS)
Francis (1989)						X	X				Large scale tagging study	Noted that recapture rates were lower for trawl than set-net
Hueter and Manire (1994)	X	Many				X				X	Tagging study	PRLDM
Hueter et al. (2006)	X	Bonnethead and Blacktip				X						PRLDM
Rulifson (2007)		Spiny dogfish				X	X				Captured and held in net-pen (48 hrs.)	PRLDM
Thorpe and Frierson (2009)	X	Many species				X					Bycatch mitigation	At-vessel mortality
Trawl												
Stobutzki et al. (2002)		Many species					X					At-vessel mortality
Purse seine												
Eddy et al. (2016)		Silky, scalloped hammerhead								X	Tuna purse seine around FAD	At-vessel mortality, PRLDM
Hutchinson et al. (2015)		Silky						X		X	Tuna purse seine	At-vessel mortality, PRLDM
Poisson et al. (2014)		Silky								X	Tuna purse seine	At-vessel mortality, PRLDM

Table 1. Continued.

Primary Literature	Species		Gear type					Study type				Notes
	Blacktip	Other	Pelagic longline	Demersal longline	Hook and Line	Gillnet	Trawl	Physi-ological	Electronic tagging	Lab.	Other	
Physiology												
Barham and Schwartz (1992)											X	
Brooks et al. (2011)		Lemon						X			X	
Brooks et al. (2012)		Caribbean reef		mid-water longlines				X				
Cain et al. (2004)		Southern stingray					X	X				
Cicia et al. (2012)		Skates						X			X	Aerial exposure and acute thermal stress
Cliff and Thurman (1984)		Dusky			X			X				
Frick et al. (2009)		Benthic sharks				X		X			X	
Frick et al. (2010a)		Benthic sharks		X		X		X			X	
Frick et al. (2010b)		Benthic sharks					X	X			X	
Frick et al. (2012)		Benthic sharks				X		X			X	
Hight et al. (2007)		Pelagic sharks	X		X			X				
Hoffmayer and Parsons (2001)		Atlantic sharpnose			X			X				
Hoffmayer et al. (2012)		Atlantic sharpnose			X			X				Seasonal component
Hyatt et al. (2016)		Bonnethead, bull				X		X				behavioral release condition score (BRCS)
Hyatt et al. (2012)		Bonnethead, bull, lemon						X				Stress response
Mandelman and Farrington (2007b)		Spiny dogfish					X	X				
Mandelman and Skomal (2009)	X	Carcharhinid sharks		X				X				Stress response
Marshall et al. (2012)	X	Eleven pelagic and coastal species	X	X				X				Stress response
Manire et al. (2001)	X	Bonnethead, blacktip, bull				X		X				Behavioral and serological response
Skomal (2007)		pelagic species						X		X		Review article
Skomal and Mandelman (2012)		Many species						X				Review article

Table 1. Continued.

Primary Literature	Species		Gear type					Study type				Notes
	Blacktip	Other	Pelagic longline	Demersal longline	Hook and Line	Gillnet	Trawl	Physi-ological	Electronic tagging	Lab.	Other	
General review												
Dapp et al. (2016c)	X	Many									Meta-analysis	Reviews published results of PRLDM and at-vessel-mortality
Ellis et al. (2017)	X	Many									Review article	Reviews published results of PRLDM and at-vessel-mortality
Godin et al. (2012)		Pelagic sharks	X								Review	meta-analysis and analysis of covariance to test the effects of circle hooks on catchability and at-vessel mortality rates
Musyl and Gilman (2019)		Pelagic									Meta-analysis	
Oliver et al. (2015)	X	Many									Review article	Reviews published results of PRLDM and at-vessel-mortality
Poisson et al. (2016)	X	Many	X								Review article	bycatch-mitigation
Raby et al. (2013)											Review	
Renshaw et al. (2012)		Many species						X			Review article	
Worm et al. (2013)											Review	PRLDM pelagic longline
Government report												
Campana et al. (2011)		Blue, porbeagle, shortfin mako	X								Review	Estimation of bycatch mortality in Canadian pelagic longline
Clarke (2011)		Pelagic sharks									Review report	Status of sharks WCPFC
McLoughlin and Eliason (2008)		Many species			X						Review report	
Non-governmental agency(NGO) report												
Clarke et al. (2013)		Many species									Review report	Studies of mortality to Sharks
Cosandey-Godin and Morgan (2011)	X	Many species									Review report	Fisheries bycatch of sharks

Table 2. Delayed discard-mortality rates, M_D, by gear type obtained from a review of the primary scientific literature (Table 1).

	Species				
Gear/Source	Blacktip	genus	Other species	Delayed discard mortality rate (M_D)	Notes
Longline (pelagic)					
Campana et al. (2016)			Blue, porbeagle, shortfin mako	9.8% (s.e. = 4.7%); 27.2% (s.e. = 12%); 31.3% (s.e. = 18%)	Tagged injured and healthy animals with PRLDM expanded by the proportion of each category observed in the fishery. Authors indicate that the blue shark estimate is likely a minimum estimate.
Campana et al. (2011)			Blue	19%	Estimation of blue shark total bycatch mortality in pelagic longline fisheries based on PRLDM of 19% citing Campana et al. (2009b)
Campana et al. (2009b)			Blue	19%* (10 – 29%)	Tagged both injured and healthy animals; Range is 95% confidence interval.
Musyl et al. (2011)			Blue shark	15% (8.5 – 25.1%)	Meta-analysis; Range is 95% confidence interval.
Worm et al. (2013)			All sharks	15%	Assumed 15% post-release mortality of all sharks released alive based on PRLDM of pelagic sharks from Campana et al. (2011) and Musyl et al. (2011).
Longline (demersal)					
Brooks et al. (2015)			Deep-water elasmobranch assemblage - Bahamas	NA	16 PSATs deployed, only two reported via the Argos system. Consequently, the exact proportion of PRLDM by species is unknown.
Afonso and Hazin (2014)			Tiger	0%	Tiger sharks (19) captured with demersal longline, tagged with PSAT, and tracked for up to 30 days
Frick et al. (2010a)			Mustelus sp	Average within captive lab study of 8%	The average delayed mortality (M_D, up to 72 hr. after treatment) for *M. antarcticus* captured in longlines under laboratory conditions (8.3%) was calculated here from simulated longline fishing under laboratory conditions for 30 min (M_D = 12.5%), 120 min (M_D = 12.5%), and 360 min (M_D = 0.0%); May not reflect commercial fishery.
Gallagher et al. (2014b)			5 species of coastal sharks	Tiger (0%), bull (25.9%, and great hammerhead (42.9%)	Gallagher et al. (2014b) noted that the use of research drum-lines with long gangions (23m) may have allowed for a higher potential for ram-ventilating than in other studies (citing Brooks et al. 2012).
Marshall et al. (2015)			Dusky, sandbar	29% (Dusky) 20% (Sandbar)	Dusky sharks exhibited 29% (n = 6) post-release mortality, with 11% of sharks dying after time-on-the-line ≤3-hours and 42% >3-hours; Sandbar sharks exhibited 20% (n = 2) post-release mortality, with 100% survival if captured up to 3 h on the longline, but showing mortalities at ~7–8 h.
Rogers et al. (2017)			School shark	0%	All (10) satellite tags released prematurely and tag retention periods ranged between 5 and 44 days (average = 24 ± 13.7 d). Tags were deployed on uninjured sharks.

Table 2. Continued.

	Species				
Gear/Source	Blacktip	genus	Other species	Delayed discard mortality rate (M_D)	Notes
Hook and line					
Bullock et al. (2015)			Lemon	0%	Post-release behavior of tagged sharks in net pens and in situ
Danylchuk et al. (2014)			Lemon (majority neonate)	12.5%	Four sharks (12.5%) died following release during the 15 min tracking period following catch-and release angling. Not clear how sharks were tracked.
French et al. (2015)			Shortfin mako	10% (3 – 20%)	Three mortalities (10%) were observed after 30 days at liberty. All mortalities occurred within 24 h of release. Range is 95% confidence interval obtained from the program Release Mortality version 1.1.0 developed by Goodyear (2002) as described by Kerstetter and Graves (2006)
Gurshin and Szedlmayer (2004)			Atlantic sharpnose	10%*	Tagged both injured and healthy animals (n = 10).
Heberer et al. (2010)			Common thresher	26%	Five mortalities (26%) were observed over 10 day PSAT deployment.
Heupel and Simpfendorfer (2002)	X	*C. limbatus*		About 5%	Five of 92 sharks died within 24 hrs. of release; May reflect stress from anesthetic, tagging and resuscitation, as well as hook and line capture.
Holts and Bedford (1993)			Shortfin mako	0%	Tagged large healthy sharks (n = 3).
Mandelman and Farrington (2007a)			Spiny dogfish	24 ± 6% (mean ± S.D.)	Five squid-baited standard circle hooks hung in the water-column and retrieved in 3 min; Mandelman and Farrington (2007a) concluded that the M_D estimate reflected both the stress of hook and line capture plus the additional stress of being held in a net-pen after capture (72 hrs.).
Sepulveda et al. (2015)			Common thresher	78% (with trailing tail hook gear) 0% (with mouth hook and release)	Six mortalities within 5 days and one mortality after 81 days (78%) with trailing tail hook gear. No mouth-hooked mortalities (n=7) within 10 days.
Whitney et al. (2016 and 2017)	X	*C. limbatus*		9.7%	(Whitney et al. 2016 and 2017) used acceleration data loggers (ADLs) for blacktip sharks (n=31) caught on rod and reel by recreational fishermen. Mortalities (n=3; 9.7%) all occurred within 2 h after release.

* 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).

Goodyear CP (2002) Factors affecting robust estimates of the catch-and-release mortality using pop-off tag technology. In Lucy JA, Studholme AL, eds, Catch and Release in Marine Recreational Fisheries. American Fisheries Society, Bethesda, MD, USA, pp 172–179.

Kerstetter DW, Graves JE (2006) Survival of white marlin (Tetrapturus albidus) released from commercial pelagic longline gear in the western North Atlantic. Fish B-NOAA 104: 434–444.

Table 2. Continued.

	Species				
Gear/Source	Blacktip.	Genus	Other species	Delayed discard mortality rate (M_D)	Notes
Gillnet					
Bell and Lyle (2016)			Australian swellshark (*Cephaloscyllium laticeps*)	0%	Tank trial mortality up to 3 days post capture (n = 39 condition 1 and n = 32 condition 2)
Braccini et al. (2012)			*Mustelus antarcticus*	Average risk analysis result of 36.2%	The average risk of delayed PCS of *M. antarcticus* in a southern Australia commercial gillnet shark fishery (S_D = 63.8%, n = 3,726) was obtained from Braccini et al. (2012 their Table 2); PRLDM was then calculated as $M_D = (1- S_D)$ = 36.2%.
Frick et al. (2010a)			*Mustelus antarcticus*	Average within captive lab study of 31%	The average delayed mortality (M_D, up to 72 hr. after treatment) for *M. antarcticus* captured in gillnets under laboratory conditions (30.7%) was calculated here from gillnet fishing under laboratory conditions for 30 min (M_D = 70%), 120 min (M_D = 0%), and 180 min (M_D = 22%); May not reflect commercial fishery.
Frick (2012)			*Mustelus antarcticus*	Average within captive lab study of 6.5% (2/31 = 0.065)	The average delayed mortality (M_D, up to 72 hr. after treatment) for *M. antarcticus* captured in gillnets under laboratory conditions was calculated here from simulated gillnet fishing under laboratory conditions for 60 min; May not reflect commercial fishery.
Hueter and Manire (1994)	X		Coastal sharks	34.8%	Tag return data was used to estimate delayed mortality for all juvenile and small adult sharks, combined, captured with research gillnets in Florida Gulf Coast estuaries.
Hueter et al. (2006)	X		Blacktip Bonnethead	31% (blacktip); 40% (bonnethead)	Juvenile and small adult sharks captured with research gillnets in Florida estuaries.
Rulifson (2007)			Spiny dogfish	33%	Held in net-pen after capture (48 hrs. North Carolina).

Table 2. Continued.

	Species				
Gear/Source	Blacktip	Genus	Other species	Delayed discard mortality rate (M_D)	Notes
Trawl					
Francis (1989)			*Mustelus lenticulatus*	NA	Francis (1989) noted that reported recapture rates of trawl-tagged rig, *M. lenticulatus,* were lower than those of set-net tagged *M. lenticulatus,* suggesting that delayed mortality of *M. lenticulatus* was higher in trawls than set-nets.
Frick et al. (2010b)			*Mustelus antarcticus*	Average within captive lab study of 27%	The average delayed mortality (M_D, up to 72 hr. after treatment) for *M. antarcticus* captured in trawl-nets under laboratory conditions (26.9%) was calculated here from simulated trawl-net fishing under laboratory conditions for 30 min (M_D = 37.5%), 60 min (M_D = 0.0%), 120 min (M_D = 85.7%), 60 min + air (M_D = 0.0%), and 60 min + crowding (M_D = 11.1%); May not reflect commercial fishery.
Mandelman and Farrington (2007a)			Spiny dogfish	29 ± 12% (mean ± S.D.)	Mandelman and Farrington (2007a) concluded that post-release mortality was significantly affected by the weight of the trawl catch and also likely reflected both the stress of trawl capture plus the additional stress of being held in a net-pen after capture (72 hrs.).
Rulifson (2007)			Spiny dogfish	0%	Held in net-pen after capture (48 hrs.); Rulifson (2007) noted that the research trawl used in this study were probably not comparable to commercial trawls – especially large New England trawl gear.
Purse seine					
Eddy et al. (2016)			Silky, scalloped hammerhead	62%, 100%	Eight silky sharks (62 %) showed evidence of post-release mortality and three scalloped hammerhead (100%) showed evidence of immediate post-release mortality.
Hutchinson et al. (2015)			Silky	36%	Percentage of satellite tagged sharks that died after being released alive (tag deployment ≥10 d, n = 9) and those that died post release (0−9 d, n = 5). However, total mortality (at-vessel plus live post release) was much higher (84.2%).
Poisson et al. (2014)			Silky	48% (brailed) 0% (entangled)	Percentage of satellite tagged sharks that died after being released alive. However, total mortality (at-vessel plus live post release) was much higher (81%).

Table 3. Delayed discard-mortality rates, M_D, by gear type obtained from primary scientific literature reviews (Panel A) and meta-analyses (Panel B).

A

	Species				
Gear/Source	Blacktip.	genus	Other species	Delayed discard mortality rate (M_D)	Notes
Reviews					
Dapp et al. (2016c)	X	*C. limbatus*	Many	Table S3. Contains published results of post-release and total discard mortality studies on elasmobranchs. e.g., Blacktip Gillnet PRLDM 31% Hueter et al. (2006)	Model predicted mean total discard mortality as combined immediate and post-release mortality to obtain percentages of obligate ram-ventilating elasmobranchs caught in longline, gillnet and trawl gear types as 49.8, 79.0 and 84.2%, respectively, and total discard mortality percentages of stationary-respiring species as 7.2, 25.3, and 41.9%, respectively.
Ellis et al. (2017)	X	*C. limbatus*	Many	e.g., Blacktip Gillnet PRLDM 31% Hueter et al. (2006)	Review published results of PRLDM and at-vessel-mortality
Oliver et al. (2015)	X	*C. limbatus*	Many		Develop global shark bycatch estimates from a literature review of shark bycatch and estimates of post-release mortality
Poisson et al. (2016)	X	*C. limbatus*	Many		Review shark bycatch mitigation measures in pelagic tuna fisheries

B

Meta-analyses					
Musyl and Gilman (2019)					
	Species	Gear	Estimate	LCI	UCI
	Blue shark		0.17	0.107	0.259
	Silky shark	Purse-seine	0.475	0.31	0.645
	Silky shark	Longline	0.164	0.008	0.819
	Common thresher		0.353	0.072	0.793
	Shortfin mako		0.254	0.137	0.42
	Oceanic white-tip		0.163	0.008	0.831
	Bigeye thresher		0.225	0.081	0.49
	Scalloped hammerhead		0.875	0.266	0.993
	Overall		0.268	0.193	0.36
	Species	Condition	Estimate	LCI	UCI
	Pelagic sharks	Healthy	0.199	0.148	0.263
	Pelagic sharks	Unhealthy	0.647	0.507	0.763

Table 4. Previous SEDAR shark post-release live-discard mortality (PRLDM) rate decisions from recent stock assessments.

Working group	Discard mortality rates by gear type: Longline	Hook and line	Gillnet	Trawl
		A. SEDAR 21[1]		
		Sandbar shark		
LH WG	38.24%	3.25%	NA	NA
Catch WG	2% (Pelagic longline); 5% (Bottom longline)	NA	5%	NA
DW*	28.5% (Pelagic longline); 28.5 – 38.0% (Bottom longline)	3.2%	5 – 10%	NA
		Blacknose shark		
LH WG	71.18%	6.6%	NA	67.0%
Catch WG	50% (Bottom longline)	NA	50% (Drift gillnet); 5% (Strike gillnet); 25% (Sink gillnet)	NA
DW*	50 – 71% (Bottom longline)	6.6%	Same as Catch WG	67.0%
		Dusky shark		
LH WG	65.17%	6.0%	NA	NA
Catch WG	5% (Pelagic longline); 35% (Bottom longline)	NA	50%	NA
DW*	44.2% (Pelagic longline); 44.2 – 65% (Bottom longline)	6.0%	50%	NA
		B. SEDAR 29[2]		
		Gulf of Mexico blacktip shark		
	31% (Base)	10% (Base)		
AP *	19 – 73% (Range)	5 – 15% (Range)	31% (Base)	NA
		C. SEDAR 34[3]		
		Atlantic sharpnose shark		
	35% (Base)	10% (Base)	58.5% (Base)	
AP *	19 – 82% (Range)	5 – 15% (Range)	35 – 82% (Range)	NA
		Bonnethead shark		
	40% (Base)	10% (Base)	65.5% (Base)	
AP *	19 – 91% (Range)	5 – 15% (Range)	40 – 91% (Range)	NA
		D. SEDAR 29 Update[4]		
		Gulf of Mexico blacktip shark		
AP *	31% (Base)	9.7% (Base)	31% (Base)	NA
AP *	NA	10 – 19% (Range)	NA	NA

*Final decisions adopted for stock assessment.

[1]SEDAR 21 life history (LH) working group (WG) decisions adopted by NMFS (2011a, 2011b, 2011c, 2011d their sections II Data Workshop Report, sub-section 2.5 Discard Mortality); SEDAR 21 catch WG and final data workshop (DW) panel decisions adopted by NMFS (2011a, 2011b, 2011c, 2011d their sections II Data Workshop Report, sub-section 3.4.2. Post Release Mortality); [2] SEDAR 29 assessment process (AP) decisions adopted by NMFS (2012 their sections 2.2.2.3—Commercial Discards Datasets—and 2.2.2.5—Recreational Discards Datasets and Decisions); [3] SEDAR 34 assessment process (AP) decisions adopted by NMFS (2013a, 2013b their sections 2.2.2.3 and 2.2.2.4); [4] SEDAR 29 update assessment process (AP) decisions adopted by NMFS (2018).