Characterizing the Spatio-temporal Extent of Acoustic Telemetry Research in the National Marine Sanctuaries

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Overview

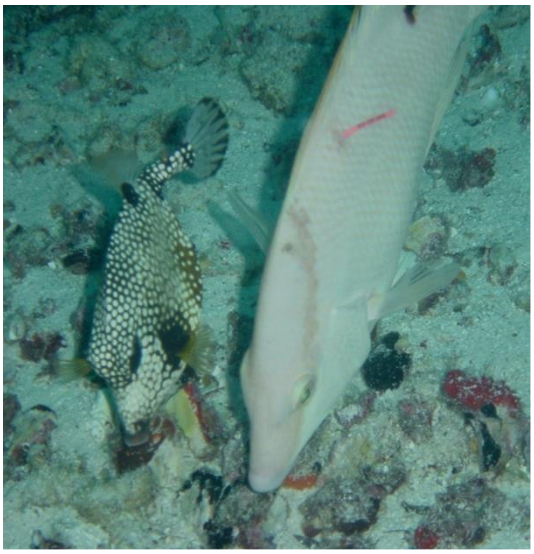
Satellite tags, archival tags, external flag tags, and acoustic (sonic) tags have increasingly widespread application in tracking the movements of mobile marine organisms from relatively sessile invertebrates to wider-ranging fishes and (see for instance Lindholm, 2005; Heupel et al., 2006; Lowe & Bray, 2006). Acoustic telemetry in particular can reveal information about animals that are too small to carry a satellite transmitter or do not surface regularly enough for satellite communication to occur (Block *et al.* 2016). Underwater acoustic receivers detect the presence of an individual as a tagged animal moves within the range of a receiver (with range varying widely depending local environmental conditions and the strength of a given transmitter's output). Receivers are often deployed for extended periods of time, providing important insight into a species' interaction with the marine environment over the course of days, months, and years.

The use of marine protected areas (MPAs), and other spatial management approaches, for the conservation and management of the marine environment is also now widespread (Lindholm, 2005). Acoustic telemetry offers a powerful tool with which to inform marine management. In the United States, animal telemetry research is currently conducted at a "grassroots level" (Moustahfid et al. 2014). There is a substantial amount of acoustic telemetry research conducted by academic institutions and government agencies, but little coordination on a national level.

The Institute for Applied Marine Ecology (IfAME) at California State University Monterey Bay collaborated with the Office of National Marine Sanctuaries to characterize the extent of acoustic telemetry research and partnerships across the Sanctuary system that are focused on the movement of fishes and other marine organisms. This report summarizes the findings of this effort.

Review of Published Literature

We first conducted a review of the literature for all acoustic animal telemetry research conducted within or near Sanctuary waters around the country. The search was constrained to electronic articles published as reports, theses, or peer-reviewed journal articles that used passive monitoring with underwater receivers, active tracking at the surface with hydrophones, or both. Satellite telemetry and acoustic vocal detection projects were excluded. The review began in broad terms by searching the online CSU Monterey Bay library database and Google scholar for terms such as “acoustic telemetry” or “tracking”, and place-specific names such as “Monterey Bay National Marine Sanctuary”. We then searched for telemetry studies in electronic issues of marine science journals such as the *Marine Ecology Progress Series*.



Each publication was apportioned into bins by the following regions:

- Pacific: Papahānaumokuākea Marine National Monument, Hawaiian Islands Humpback Whale National Marine Sanctuary (NMS), NMS of American Samoa
- *West Coast:* Olympic Coast NMS, Greater Farallones NMS, Cordell Bank NMS, Monterey Bay NMS, Channel Islands NMS
- *Gulf and Southeast:* Flower Garden Banks NMS, Florida Keys NMS, Gray’s Reef NMS
- *Northeast*: Stellwagen Bank NMS, Monitor NMS
- *Great Lakes*: Thunder Bay NMS

Table 1 reports the results of the literature review. The complete database is available on a Google Doc shared with the ONMS leadership, as is a folder with PDF versions of each of the peer-reviewed journal articles in the data base. We realize, based on conversations with colleagues around the country, that there are multiple on-going telemetry efforts that were not included in this review. Those projects will be included in the telemetry database as they are published.

Table 1. List of 183 articles identified in the vicinity of Sanctuaries, including authors, year of publication, article title, region, and relevant Sanctuary. Studies conducted within Sanctuary waters are emphasized with bold text.

Author(s)	Year Published	Title	Journal Name	Location	General Region	NMS Site
Ackerman JT, Kondratieff MC, Matern SA, Cech JJ	**2000**	**Tidal influence on spatial dynamics of leopard sharks, *Triakis semifasciata*, in Tomales Bay, California**	**Environmental Biology of Fishes 58:33-43**	**Tomales Bay, CA**	**West Coast**	**Greater Farallones**
Andrews KS, Harvey CJ	2013	Ecosystem-level consequences of movement: seasonal variation in the trophic impact of a top predator	Marine Ecology Progress Series 473:247-260	Puget Sound	West Coast	Olympic Coast
Andrews KS, Levin PS, Katz SL, Farrer D, Gallucci VF, Bargmann G	2007	Acoustic monitoring of sixgill shark movements in Puget Sound: evidence for localized movement	Canadian journal of zoology 85(11):1136-1143	Puget Sound	West Coast	Olympic Coast
Andrews KS, Quinn TP	2012	Combining fishing and acoustic monitoring data to evaluate the distribution and movements of spotted ratfish *Hydrolagus colliei*	Marine Biology 159:769-782	Puget Sound, WA	West Coast	Olympic Coast
Andrews KS, Williams GD, Farrer D, Tolimieri N, Harvey CJ, Bargmann G, Levin PS	2009	Diel activity patterns of sixgill sharks, *Hexanchus griseus*: the ups and downs of an apex predator	Animal Behaviour 78:525-536	Puget Sound	West Coast	Olympic Coast
Andrews KS, Williams GD, Levin PS	2010	Seasonal and Ontogenetic changes in movement patterns of sixgill sharks	PLoS one 5(9):e12549	Puget Sound, WA	West Coast	Olympic Coast
Arendt MD, Lucy JA, Munroe TA	2001	Seasonal occurrence and site-utilization patterns of adult tautog, *Tautoga onitis* (Labridae), at manmade and natural structures in lower Chesapeake Bay	Fish Bulletin 99:519-527	Chesapeake Bay - Cape Charles, VA	Southeast/Gulf	Monitor Stellwagen Bank
Auer NA	1999	Population characteristics and movements of lake sturgeon in the Sturgeon River and Lake Superior	Journal of Great Lakes Research 25(2):282-293	Sturgeon River near Lake Superior	Great Lakes	Thunder Bay
Barbour AB, Adams AJ, Lorenzen K	2014	Size-based, seasonal, and multidirectional movements of an estuarine fish species in a habitat mosaic	Marine Ecology Progress Series 507:263-276	Charlotte Harbor, FL	Southeast/Gulf	Florida Keys
Baumgartner MF, Mate BR	2003	Summertime foraging ecology of North Atlantic right whales	Marine Ecology Progress Series 264:123-135	Bay of Fundy and Roseway Basin, Nova Scotia	Northeast	Stellwagen Bank
Bellquist LF, Lowe CG, Caselle JE	2008	Fine-scale movement patterns, site fidelity, and habitat selection of ocean whitefish (*Caulolatilus Princeps*)	Fisheries Research 91(2):325-335	Catalina Island, CA	West Coast	Channel Islands

Bertelsen RD	**2013**	**Characterizing daily movements, nomadic movements, and reproductive migrations of *Panulirus argus* around the Western Sambo Ecological Reserve (Florida, USA) using acoustic telemetry**	**Fisheries Research 144:91-103**	**Western Sambo Ecological Reserve**	**Southeast/Gulf**	**Florida Keys**
Bertelsen RD, Hornbeck J	**2009**	**Using acoustic tagging to determine adult spiny lobster (*Panulirus argus*) movement patterns in the Western Sambo Ecological Reserve (Florida, United States)**	**New Zealand Journal of Marine and Freshwater Research 43(1):35-46**	**Western Sambo Ecological Reserve**	**Southeast/Gulf**	**Florida Keys**
Bishop MA, Reynolds BF, Powers SP	2010	An in situ, individual-based approach to quantify connectivity of lingcod.	PLoS ONE 5(12):e14267	Prince William Sound, AK	West Coast	Olympic Coast
Block BA, Booth DT, Carey FG	1992	Depth and temperature of the blue marlin, *Makaira nigricans*, observed by acoustic telemetry	Marine Biology 114:175-183	Hawaii	Pacific	Northwestern Hawaiian Islands (NWHI) MNM
Bradbury C, Green JM, Bruce-Lockhart M	1995	Home ranges of female cunner, Tautogolabrus adspersus (Labridae), as determined by acoustic telemetry.	Canadian Journal of Zoology 73:1268-1279	Newfoundland	Northeast	Stellwagen Bank
Brill R, Lutcavage M, Metzger G, Bushnell P, Arendt M, Lucy J, Watson C, Foley D	2002	Horizontal and vertical movements of juvenile bluefin tuna (*Thunnus thynnus*), in relation to oceanographic conditions of the western North Atlantic, determined with ultrasonic telemetry	Fishery Bulletin 100:155-167	northwestern Atlantic Ocean	Northeast	Stellwagen Bank
Brill RW, Block BA, Boggs CH, Bigelow KA, Freund EV, Marcinek DJ	1999	Horizontal movements and depth distribution of large adult yellowin tuna (*Thunnus albacares*) near the Hawaiian Islands, recorded using ultrasonic telemetry: implications for the physiological ecology of pelagic fishes	Marine Biology 133:395-408	Hawaiian Islands	Pacific	NWHI-MNM
Brill RW, Holts DB, Chang RKC, Sullivan S, Dewar H, Carey FG	1993	Vertical and horizontal movements of striped marlin (*Tetrapturus-audax*) near the Hawaiian-islands, determined by ultrasonic telemetry, with simultaneous measurement of oceanic currents	Marine Biology 117:567–574	Hawaii	Pacific	NWHI-MNM
Brown H, Benfield MC, Keenan SF, Powers SP	2010	Movement patterns and home ranges of a pelagic carangid fish, *Caranx crysos*, around a petroleum platform complex	Marine Ecology Progress Series 403:205-218	50 km south of Louisiana	Southeast/Gulf	Flower Garden Banks
Bunt CM, Cooke SJ, McKinley RS	2000	Assessment of the Dunnville Fishway for passage of walleyes from Lake Erie to the Grand River, Ontario	Journal of Great Lakes Research 26(4):482-488	Lake Erie	Great Lakes	Thunder Bay

Campos BR, Fish MA, Jones G, Riley RW, Allen PJ, Klimley PA, Cech JJ, Kelly JT	**2009**	**Environmental Biology of Fishes 82:123-131**	**Environmental Biology of Fishes 85:3-13**	**Tomales Bay, CA**	**West Coast**	**Greater Farallones**
Carey FG, Scharold JV	1990	Movements of blue sharks (*Prionace glauca*) in depth and course	Marine Biology 106:329-342	Georges Bank & Cape Hatteras	Northeast	Stellwagen Bank, Gray's Reef
Carlisle AB, Starr RM	**2009**	**Habitat use, residency, and seasonal distribution of female leopard sharks *Triakis semifasciata* in Elkhorn Slough, California**	**Marine Ecology Progress Series 380:213-228**	**Elkhorn Slough, CA**	**West Coast**	**Monterey Bay**
Carlson JK, Heupel MR, Bethea DM, Hollensead LD	2008	Coastal habitat use and residency of juvenile Atlantic sharpnose sharks (*Rhizoprionodon terraenovae*)	Estuaries and Coasts 31:931-940	Crooked Island Sound, FL	Southeast/Gulf	Flower Garden Banks, Florida Keys
Caroll C, Fangman S, McFall F, Kendall M, Ogburn M	**2010**	**Using acoustic telemetry to track snapper and grouper species in particular areas of Gray's Reef National Marine Sanctuary**	**39th Benthic Ecology Meeting (10 March 2010), & American Fisheries Society 141st Annual Meeting**	**Gray's Reef**	**Southeast/Gulf**	**Gray's Reef**
Cartamil D, Wegner NC, Kacev D, Ben-aderet N, Kohin S, Graham JB	2010	Movement patterns and nursery habitat of juvenile thresher sharks *Alopias vulpinus* in the Southern California Bight	Marine Ecology Progress Series 404:249-258	Southern California Bight	West Coast	Channel Islands
Cartamil DP, Lowe CG	2004	Diel movement patterns of the ocean sunfish *Mola mola* off southern California.	Marine Ecology Progress Series 266:245-253	Catalina Island, CA	West Coast	Channel Islands
Cartamil DP, Vaudo JJ, Lowe CG, Wetherbee BM, Holland KN	2003	Diel movement patterns of the Hawaiian stingray, *Dasyatis lata*: implications for ecological interactions between sympatric elasmobranch species	Marine Biology 142:841-847	Kaneohe Bay, Oahu, Hawaii	Pacific	NWHI-MNM
Caswell NM, Peterson DL, Manny BA, Kennedy GW	2004	Spawning by lake sturgeon (*Acipenser fulvescens*) in the Detroit River	Journal of Applied Ichthyology 17(5): 234-239	Detroit River	Great Lakes	Thunder Bay
Clark ME, Wolcott TG, Wolcott DL, Hines AH	1999	Intraspecific interference among foraging blue crabs *Callinectes sapidus*: interactive effects of predator density and prey patch distribution	Marine Ecology Progress Series 178:69-78	Chesapeake Bay	Northeast	Monitor Stellwagen Bank
Collins AB, Heupel MR, Motta PJ	2007	Residence and movement patterns of cownose rays *Rhinoptera bonasus* within a south-west Florida estuary	Journal of Fish Biology 71(4):1159-1178	Pine Island Sound, Florida	Southeast/Gulf	Florida Keys
Collins AB, Heupel MR, Motta PJ	2008	Spatial distribution and long-term movement patterns of cownose rays *Rhinoptera bonasus* within an estuarine river	Estuaries and Coasts 31:1174-1183	Southwest Florida	Southeast/Gulf	Florida Keys
Comeau LA, Campana SE, Castonguay M	2002	Automated monitoring of a large-scale cod (*Gadus morhua*) migration in the open sea	Canadian Journal of Fisheries & Aquatic Sciences 59:1845-1850	Laurentian Channel off eastern Canada	Northeast	Stellwagen Bank

Cooke SJ, Bunt CM, Schreer JF	2004	Understanding fish behavior, distribution, and survival in thermal effluents using fixed telemetry arrays: a case study of smallmouth bass in a discharge canal during winter	Environmental Management 33(1):140-150	Lake Erie	Great Lakes	Thunder Bay
Cooke SJ, Bunt CM, Schreer JF	2003	Nesting activity, parental care behavior, and reproductive success of smallmouth bass, *Micropterus dolomieu*, in an unstable thermal environment	Journal of Thermal Biology 28(6-7):445-456	Lake Erie	Great Lakes	Thunder Bay
Cooke SJ, McKinley RS	1999	Winter residency and activity patterns of channel catfish, *Ictalurus punctatus* (Rafinesque), and common carp, *Cyprinus Carpio* L., in a thermal discharge canal	Fisheries Management and Ecology 6:515-526	Lake Erie	Great Lakes	Thunder Bay
Cooke SJ, Schreer JF	2003	Environmental monitoring using physiological telemetry: a case study examining common carp responses to thermal pollution in a coal-fired generating station effluent	Water, Air, and Soil Pollution 142:113-136	Lake Erie	Great Lakes	Thunder Bay
Dawson CL, Starr RM	**2009**	**Movements of subadult prickly sharks *Echinorhinus cookei* in the Monterey Canyon**	**Marine Ecology Progress Series 386:253-262**	**Monterey Canyon**	**West Coast**	**Monterey Bay**
Dizon AE, Balazs GH	**1982**	**Radio telemetry of Hawaiian green turtles at their breeding colony**	**Marine Fisheries Review 44.5:13-20.**	**French Frigate Shoals, Hawaiian archipelago**	**Pacific**	**NWHI-MNM**
Drymon JM, Ajemian MJ, Power SP	2014	Distribution and dynamic habitat use of young bull sharks *Carcharhinus leucas* in a highly stratified Northern Gulf of Mexico Estuary	PLoS One 9(5):e97124	Mobile Bay, AL	Southeast/Gulf	Flower Garden Banks
Economakis AE, Lobel PS	1998	Aggregation behavior of the gray reef shark, Carcharhinus amblyrhynchos, at Johnston Atoll, central Pacific Ocean	Environmental Biology of Fishes 51(2):129-139	Johnston Atoll	Pacific	NWHI-MNM
Fabrizio MC, Manderson JP, Pessutti JP	2014	Home range and seasonal movements of Black Sea Bass (*Centropristis striata*) during their inshore residency at a reef in the mid-Atlantic Bight	Fishery Bulletin 112(1):82-97	off the coast of New Jersey	Southeast/Gulf	Stellwagen Bank
Farmer NA, Ault JS	**2014**	**Modeling Coral Reef Fish Home Range Movements in Dry Tortugas, Florida**	**Scientific World Journal 2014, Article ID 629791**	**Dry Tortugas, FL**	**Southeast/Gulf**	**Florida Keys**
Farmer NA, Ault JS	**2011**	**Grouper and snapper movements and habitat use in Dry Tortugas, Florida**	**Marine Ecology Progress Series 433:169-183**	**Dry Tortugas, FL**	**Southeast/Gulf**	**Florida Keys**
Freedman R, Whitcraft CR, Lowe CG	2015	Connectivity and movements of juvenile predatory fishes between discrete restored estuaries in southern California	Marine Ecology Progress Series 524:191-201	Southern California	West Coast	Channel Islands

Friday MJ	2008	The migratory and reproductive response of spawning lake sturgeon to controlled flows over Kakabeka Falls on the Kaministiquia River	Upper Great Lakes Management Unit – Lake Superior. Technical Report 2008 - 01	Lake Superior	Great Lakes	Thunder Bay
Friday MJ	2013	The migratory and reproductive response of spawning lake sturgeon to controlled flows over Kakabeka Falls on the Kaministiquia River, 2011	Upper Great Lakes Management Unit – Lake Superior. Technical Report 148	Lake Superior	Great Lakes	Thunder Bay
Furey NB, Dance MA, Rooker JR	2013	Fine-scale movements and habitat use of juvenile southern flounder *Paralichthys lethostigma* in an estuarine seascape	Journal of Fish Biology 82:1469-1483	Christmas Bay, Gulf of Mexico	Southeast/Gulf	Flower Garden Banks
Gahagan BI, Fox DA, Secor DH	2015	Partial migration of striped bass: revisiting the contingent hypothesis	Marine Ecology Progress Series 525:185-197	Hudson River, NY	Southeast/Gulf	Stellwagen Bank
Gerig B, Moerke A, Greil R, Koproski S	2011	Movement patterns and habitat characteristics of Lake Sturgeon (*Acipenser fulvescens*) in the St. Marys River, Michigan, 2007–2008	Journal of Great Lakes Research 37(2):54-60	St. Mary's River, MI	Great Lakes	Thunder Bay
Goldman KJ, Anderson SD	**1999**	**Space utilization and swimming depth of white sharks, *Carcharodon carcharias*, at the South Farallon Islands, central California**	**Environmental Biology of Fishes 56:351-364**	**South Farallon Islands**	**West Coast**	**Greater Farallones**
Goldstein JS, Waston WH	2015	Seasonal movements of American lobsters in southern Gulf of Maine coastal waters: patterns, environmental triggers, and implications for larval release	Marine Ecology Progress Series 524:197-211	New Hampshire	Northeast	Stellwagen Bank
Green KM, Greenley AP, Starr RM	**2014**	**Movements of blue rockfish (*Sebastes mystinus*) off Central California with comparisons to similar species**	**PLoS ONE 9(6):e98976**	**Carmel Bay, CA**	**West Coast**	**Monterey Bay**
Green KM, Starr RM	**2011**	**Movements of small adult black rockfish: implications for the design of MPAs**	**Marine Ecology Progress Series 14:219-230**	**Carmel Bay, CA**	**West Coast**	**Monterey Bay**
Greenley AP	**2009**	**Movements of lingcod (*Ophiodon elongatus*) tagged in Carmel Bay, California**	**Master's thesis: Moss Landing Marine Laboratories SJSU**	**Carmel Bay, CA**	**West Coast**	**Monterey Bay**
Gurshin CWD, Szedlmayer ST	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	northeast Gulf of Mexico - waters off AL	Southeast/Gulf	Flower Garden Banks
Halfyard EA, Gibson AJF, Ruzzante DE, Stokesbury MJW, Whoriskey FG	2012	Estuarine survival and migratory behaviour of Atlantic salmon *Salmo salar* smolts	Journal of Fish Biology 81:1626-1645	Southern Upland, Nova Scotia	Northeast	Stellwagen Bank
Hannah RW, Rankin PS	2011	Site fidelity and movement of eight species of Pacific rockfish at a high-relief rocky reef on the Oregon coast	North American Journal of Fisheries Management 31:483-494	Oregon	West Coast	Olympic Coast

Harden LA, Williard AS	2012	Using spatial and behavioral data to evaluate the seasonal bycatch risk of diamondback terrapins *Malaclemys terrapin* in crab pots	Marine Ecology Progress Series 467:207-217	southeastern North Carolina	Southeast/Gulf	Gray's Reef
Hart KM, Sartain AR, Fujisaki I, Pratt HL, Morley D, Feeley MW	**2012**	**Home range, habitat use, and migrations of hawksbill turtles tracked from Dry Tortugas National Park, Florida, USA**	**Marine Ecology Progress Series 457:193-207**	**Dry Tortugas National Park, FL**	**Southeast/Gulf**	**Florida Keys**
Hayden TA, Holbrook CM, Fielder DG, Vandergoot CS, Bergstedt RA, Dettmers JM, Krueger CC, Cooke SJ	**2014**	**Acoustic Telemetry Reveals Large-scale Migration Patterns of Walleye in Lake Huron**	**PloS One 9(12):e114833**	**Lake Huron**	**Great Lakes**	**Thunder Bay**
Haynes JM, Keleher CJ	1986	Movements of Pacific Salmon in Lake Ontario in spring and summer: evidence for wide dispersal	Journal of Freshwater Ecology 3(3):289-297	Lake Ontario	Great Lakes	Thunder Bay
Haynes JM, Nettles DC, Parnell KM, Voiland MP, Olson RA, Winter JD	1986	Movements of rainbow steelhead trout (*Salmo gairdneri*) in Lake Ontario and a hypothesis for the influence of spring thermal structure	Journal of Great Lakes Research 12(4):304-313	Lake Ontario	Great Lakes	Thunder Bay
Heupel MR	2006	Residency and movement patterns of bonnethead sharks, *Sphyrna tiburo*, in a large Florida estuary	Environmental Biology of Fishes 76(1):47-67	Pine Island Sound, FL	Southeast/Gulf	Florida Keys
Heupel MR, Hueter RE	2002	Importance of prey density in relation to the movement patterns of juvenile blacktip sharks (*Carcharhinus limbatus*)	Marine and Freshwater Research 53:543-550	Terra Ceia Bay, FL	Southeast/Gulf	Florida Keys
Heupel MR, Hueter RE	2001	Use of automated acoustic telemetry system to passively track juvenile blacktip shark movements	in: Sibert J, Nielsen JL (eds) Electronic tagging and tracking in marine fisheries. Kluwer Academic Publishers, Dordrecht, p 217-236	Terra Ceia Bay, FL	Southeast/Gulf	Florida Keys
Heupel MR, Simpfendorfer CA	2008	Movement and distribution of young bull sharks *Carcharhinus leucas* in a variable estuarine environment	Aquatic Biology 1:277-289	Southwest Florida	Southeast/Gulf	Florida Keys
Heupel MR, Simpfendorfer CA	2005	Quantitative analysis of aggregation behavior in juvenile blacktip sharks	Marine Biology 147:1239-1249	Terra Ceia Bay, FL	Southeast/Gulf	Florida Keys
Heupel MR, Simpfendorfer CA	2002	Estimation of mortality of juvenile blacktip sharks, *Carcharhinus limbatus*, within a nursery area using telemetry data	Canadian Journal of Fisheries & Aquatic Sciences 59:624-632	Terra Ceia Bay, FL	Southeast/Gulf	Florida Keys
Heupel MR, Simpfendorfer CA, and Hueter RE	2004	Estimation of shark home ranges using passive monitoring techniques	Environmental Biology of Fishes 71(2):135-142	Terra Ceia Bay, FL	Southeast/Gulf	Florida Keys
Heupel MR, Simpfendorfer CA, Hueter RE	2003	Running before the storm: blacktip sharks respond to falling barometric pressure associated with Tropical Storm Gabrielle	Journal of Fish Biology 63:1357-1363	Terra Ceia Bay, FL	Southeast/Gulf	Florida Keys

Hight BV, Lowe CG	2007	Elevated body temperatures of adult female leopard sharks, *Triakis semifasciata*, while aggregating in shallow nearshore embayments: Evidence for behavioral thermoregulation	Journal of Experimental Marine Biology and Ecology 352:114–128	Catalina Island, CA	West Coast	Channel Islands
Holbrook CM, Johnson NS, Steibel JP, Twohey MB, Binder TR, Krueger CC, Jones ML	2014	Estimating reach-specific fish movement probabilities in rivers with a Bayesian state-space model: application to sea lamprey passage and capture at dams	Canadian Journal of Fisheries and Aquatic Sciences 71(11):1713-1729	Cheboygan River, a tributary of Lake Huron	Great Lakes	Thunder Bay
Holland K, Brill R, Chang RKC	1990	Horizontal and vertical movements of Pacific blue marlin captured and released using sportfishing gear.	Fish Bulletin 88:397–402	Hawaii	Pacific	NWHI-MNM
Holland K, Brill R, Chang RKC	1990	Horizontal and vertical movements of yellowfin and bigeye tuna associated with fish aggregating devices.	Fish Bulletin 88:493-507	Hawaii	Pacific	NWHI-MNM
Holland KM, Lowe CG, Wetherbee BM	1996	Movements and dispersal patterns of blue trevally (*Caranx melampygus*) in a fisheries conservation zone	Fisheries Research 25:279-292	Kaneohe Bay, Oahu, HI	Pacific	NWHI-MNM
Holland KM, Peterson JD, Lowe CG, Wetherbee BM	1993	Movements, distribution and growth rates of the white goatfish *Mulloides flavolineatus* in a fisheries conservation zone	Bulletin of Marine Science 52(3):982-992	Oahu, HI	Pacific	NWHI-MNM
Holland KN, Lowe CG, Peterson JD, Gill A	1992	Tracking coastal sharks with small boats: hammerhead shark pups as a case study	Australian Journal of Marine and Freshwater Research 43:61-6	Kaneohe Bay, Oahu, HI	Pacific	NWHI-MNM
Holland KN, Wetherbee BM, Lowe CG, Meyer CG	1999	Movements of tiger sharks (*Galeocerdo cuvier*) in coastal Hawaiian waters	Marine Biology 134:665-673	Oahu, HI	Pacific	NWHI-MNM
Holland KN, Wetherbee BM, Peterson JD, Lowe CG	1993	Movements and distribution of hammerhead shark pups on their natal grounds	Copeia 1993(2):495–502	Kaneohe Bay, Oahu, HI	Pacific	NWHI-MNM
Holtgren JM, Auer NA	2004	Movement and habitat of juvenile lake sturgeon (*Acipenser fulvescens*) in the Sturgeon River/Portage Lake system, Michigan	Journal of Freshwater Ecology 19(3):419-432	Portage Lake	Great Lakes	Thunder Bay
Holts DB and Bedford DW	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	Southern California	West Coast	Channel Islands
Hondorp DW, Holbrook CM, Krueger CC	2015	Effects of acoustic tag implantation on lake sturgeon *Acipenser fulvescens*: lack of evidence for changes in behavior	Animal Biotelemetry (2015) 3:44	St. Clair River	Great Lakes	Thunder Bay
Huff DD, Lindley ST, Rankin PS, Mora EA	2011	Green sturgeon physical habitat use in the coastal Pacific Ocean.	PLoS one 6(9):e25156	Oregon	West Coast	Olympic Coast

Huish MT & Benedict C	1978	Sonic tracking of dusky sharks in the Cape Fear River, North Carolina	Journal of the Mitchell Society 93:21-26	Cape Fear River, North Carolina	Northeast	Gray's Reef, Monitor
Humston R, Ault JS, Larkin MF, Luo Jiangang	**2005**	**Movements and site fidelity of the bonefish *Albula vulpes* in the northern Florida Keys determined by acoustic telemetry**	**Marine Ecology Progress Series 291:237-248**	**northern Florida Keys**	**Southeast/Gulf**	**Florida Keys**
Jorgenson SJ, Kaplan DM, Klimley AP, Morgan SG, O'Farrell MR, Botsford LW	**2006**	**Limited movement in blue rockfish *Sebastes mystinus*: internal structure of home range**	**Marine Ecology Progress Series 327:157-170**	**Fort Ross, CA**	**West Coast**	**Cordell Bank**
Jorgenson SJ, Reeb CA, Chapple TK, Anderson S, Perle C, Van Sommeran SR, Fritz-Cope C, Brown AC, Klimley AP, Block BA	**2010**	**Philopatry and migration of Pacific white sharks**	**Proceedings of the Royal Society B 2009**	**California, Hawaii**	**West Coast**	**West Coast, NWHI-MNM**
Kelso JRM	1976	Movement of yellow perch (*Perca flavescens*) and white sucker (*Catostomus commersoni*) in a nearshore great lakes habitat subject to a thermal discharge	Journal of the Fisheries Research Board of Canada 33(1):42-53	Lake Erie	Great Lakes	Thunder Bay
Kelso JRM	1974	Influence of a thermal effluent on movement of brown bullhead (*Ictalurus nebulosus*) as determined by ultrasonic tracking	Journal of the Fisheries Research Board of Canada 31(9):1507-1513	Lake Ontario	Great Lakes	Thunder Bay
Kelso JRM, Gardner WM	1999	Emigration, upstream movement, and habitat use by sterile and fertile sea lampreys in three Lake Superior tributaries	North American Journal of Fisheries Management 20(1):144-153	Lake Superior	Great Lakes	Thunder Bay
Kelso JRM, Gardner WM	2001	Interactions among fertile male, female, and sterile male sea lampreys during spawning in the Carp River, Lake Superior	North American Journal of Fisheries Management 21(4):904-910	Lake Superior	Great Lakes	Thunder Bay
Kelso JRM, Kwain WH	1984	The post-spawning movement and diel activity of rainbow trout*, Salmo gairdneri,* as determined by ultrasonic tracking in Batchawana Bay, Lake Superior, Canada	Canadian Field-Naturalist 98:320-330	Lake Superior	Great Lakes	Thunder Bay
Kessel ST, Chapman DD, Franks BR, Gedamke T, Gruber SH, Newman JM, White ER, Perkins ER	2014	Predictable temperature-regulated residency, movement and migration in a large, highly mobile marine predator (*Negaprion brevirostris*)	Marine Ecology Progress Series 514:175-190	southeast Florida	Southeast/Gulf	Gray's Reef Florida Keys
Klimley AP, Beavers SC, Curtis TH, Jorgenson SJ	2002	Movements and swimming behavior of three species of sharks in La Jolla Canyon, California	Environmental Biology of Fishes 63:117-135	La Jolla Canyon	West Coast	Channel Islands
Kneebone J, Chisholm J, Skomal G	2012	Seasonal residency, habitat use, and site fidelity of juvenile sand tiger sharks *Carcharias taurus* in a Massachusetts estuary	Marine Ecology Progress Series 471:166-186	Plymouth, Kingston, Duxbury Bay, MA	Northeast	Stellwagen Bank

Kneebone J, Chisholm J, Skomal G	2014	Movement patterns of juvenile sand tigers (*Carcharias taurus)* along the east coast of the USA	Marine Biology 161:1149-1163	tagged in Plymouth, MA & RI. Tracked through central Florida	Northeast	Stellwagen Bank
Kraus RT, Secor DH, Wingate RL	2015	Testing the thermal-niche oxygen-squeeze hypothesis for estuarine striped bass		Chesapeake Bay	Northeast	Stellwagen Bank
Lamont MM, Fujisaki I, Stephens BS, Hackett C	2015	Home range and habitat use of juvenile green turtles (*Chelonia mydas*) in the northern Gulf of Mexico	Animal Biotelemetry (2015) 3:53	St. Joseph Bay, FL	Southeast/Gulf	Florida Keys, Flower Garden Banks
Le Boeuf BJ, Costa DP, Huntley AC, Feldkamp SD	**1988**	**Continuous, deep diving in female northern elephant seals, *Mirounga angustirostris***	**Canadian Journal of Zoology 66:446-458**	**Año Nuevo, California**	**West Coast**	**Monterey Bay**
Le Boeuf BJ, Crocker DE, Blackwell SB, Morris PA, Thorson PH	**1993**	**Sex differences in the diving and foraging behavior of northern elephant seals.**	**In: Boyd IL (ed) Recent advances in marine mammal science. Symp Zool Soc Lond 66:149–178**	**Año Nuevo, California**	**West Coast**	**Monterey Bay**
Lee JSF, Berejikian BA, Rust MB, Massee K, Wright T, Brakensiek K, Steltzner S, Blankenship HL	2011	Movements of hatchery-reared lingcod released on rocky reefs in Puget Sound	Environmental Biology of Fishes 92(4):437-445	Puget Sound, WA	West Coast	Olympic Coast
Lee JSF, Tezak EP, Berejikian BA	2013	Telemetry tag effects on juvenile lingcod *Ophiodon elongates* movement: a laboratory and field study	Journal of Fish Biology 82:1848-1857	Puget Sound, WA	West Coast	Olympic Coast
Lindholm J, Auster PJ, Knight A	**2007**	**Site fidelity and movement of adult Atlantic cod *Gadus morhua* at deep boulder reefs in the western Gulf of Maine, USA**	**Marine Ecology Progress Series 327:157-170**	**Gulf of Maine**	**Northeast**	**Stellwagen Bank**
Lindholm J, Auster PJ, Knight A	**2003**	**Site Utilization by Atlantic Cod (*Gadus Morhua*) in off-shore gravel habitat as determined by acoustic telemetry: implications for the design of marine protected areas**	**Marine Technology Society Journal 37(1):27**	**Stellwagen Bank**	**Northeast**	**Stellwagen Bank**
Lindholm J, Fangman S, Kaufman L, Miller S	**2010**	**In situ tagging and tracking of coral reef fishes from the Aquarius Undersea Laboratory**	**Marine Technology Society Journal**	**Conch Reef Research Only Area**	**Southeast/Gulf**	**Florida Keys**
Lindholm J, Kaufman L, Miller S, Wagschal, Newville M	**2005**	**Movement of yellowtail snapper (*Ocyurus Chrysurus* Block 1790) and black grouper (*Mycteroperca Bonaci* Poey 1860) in the Northern Florida Keys National Marine Sanctuary as determined by acoustic telemetry**	**NOAA Technical Memorandum - Marine Sanctuary Division (MSD), issue MSD054 , page 25**	**Conch Reef Research Only Area**	**Southeast/Gulf**	**Florida Keys**

Lindholm J, Knight A, Domeier M.	**2010**	**Gender-mediated patterns in the movement of California sheephead in the Northern Channel Islands (Eastern Pacific)**	**California Fish and Game 96(1):53-68**	**Anacapa Island**	**West Coast**	**Channel Islands**
Lindholm J, Knight A, Kaufman L, Miller S	**2006**	**A pilot study of hogfish (*Lachnolaimus maximus* Walbaum 1792) movement in the Conch Reef Research Only Area (Northern Florida Keys National Marine Sanctuary)**	**Marine Sanctuaries Conservation Series NMSP 06-06**	**Conch Reef**	**Southeast/Gulf**	**Florida Keys**
Lindholm J, Knight A, Kaufman L, Miller S	**2006**	**Site fidelity and movement of the parrotfishes *Scarus coeruleus* and *Scarus taeniopterus* at Conch Reef (northern Florida Keys)**	**Caribbean Journal of Science 42(1):138-144**	**Conch Reef**	**Southeast/Gulf**	**Florida Keys**
Lindley ST, ML Moser, DL Erickson, M Belchik, DW Welch, EL Rechisky, JT Kelly, J Heublein, AP Klimley	**2008**	**Marine migration of North American green sturgeon**	**Transactions of the American Fisheries Society 137(1):182-194**	**West Coast: Southeast Alaska to Monterey Bay**	**West Coast**	**within Monterey Bay; near Olympic Coast, Greater Farallones**
Lord K	2007	Movements and habitat use of juvenile lake sturgeon in the north channel of the St. Clair River	M.S. Thesis University of Michigan	St. Clair River	Great Lakes	Thunder Bay
Lowe CG, Anthony KM, Jarvis ET, Bellquist LF, Love MS	2009	Site fidelity and movement patterns of groundfish associated with offshore petroleum platforms in the Santa Barbara Channel	Marine and Coastal Fisheries: Dynamics, Management, and Ecosystem Science 1:71–89	Santa Barbara Channel	West Coast	Channel Islands
Lowe CG, Topping DT, Cartamil DP, Papastamatiou YP	2003	Movement patterns, home range, and habitat utilization of adult kelp bass *Paralabrax clathratus* in a temperate no-take marine reserve	Marine Ecology Progress Series 256:205-216	Catalina Island, CA	West Coast	Channel Islands
Lowe CG, Wetherbee BM, Meyer CG	**2006**	**Using acoustic telemetry monitoring techniques to quantify movement patterns and site fidelity of sharks and giant trevally around French Frigate Shoals and Midway Atoll**	**Atoll Res Bull 543:281–303**	**NWHI**	**Pacific**	**NWHI-MNM**
Lutcavage ME, Brill RW, Skomal GB, Chase BC, Goldstein JL, Tutein J	**2000**	**Tracking adult North Atlantic bluefin tuna (*Thunnus thynnus*) in the northwestern Atlantic using ultrasonic telemetry**	**Marine Biology 137:347-358**	**Gulf of Maine**	**Northeast**	**Stellwagen Bank**
MacLean NG, Teleki GC, Polak J	1982	Ultrasonic telemetry studies of fish activity near the Nanticoke Thermal Generating Station	Journal of Great Lakes Research 8(3):495-504	Lake Erie	Great Lakes	Thunder Bay
Mason TJ, Lowe CG	2010	Home range, habitat use, and site fidelity of barred sand bass within a southern California marine protected area	Fisheries Research 106:93–101	Catalina Island, CA	West Coast	Channel Islands

Matern SA, Cech JJ, Hopkins TE	**2000**	**Diel movements of bat rays, *Myliobatis californica*, in Tomales Bay, California: evidence for behavioral thermoregulation**	**Environmental Biology of Fishes 58:173-182**	**Tomales Bay, CA**	**West Coast**	**Greater Farallones**
Mathies NM, Ogburn MB, McFall G, Fangman S	**2014**	**Environmental interference factors affecting detection range in acoustic telemetry studies using fixed receiver arrays**	**Marine Ecology Progress Series 495:27-38**	**Gray's Reef NMS**	**Southeast/Gulf**	**Gray's Reef**
Matthews	1992	A telemetric study of the home ranges and homing routes of lingcod *Ophiodon elongatus* on shallow rocky reefs off Vancouver Island, British Columbia	Fishery Bulletin 90:784-790	Vancouver Island, BC	West Coast	Olympic Coast
McKinley RS, Griffiths JS, Kowalyk HE, McKenna GR, Cooke SJ	2000	Reproductive Activity and Summer Residency Patterns of Smallmouth Bass, *Micropterus dolomieu*, in a Thermal Discharge Canal on Lake Erie	Journal of Freshwater Ecology 15(3):307-316	Lake Erie	Great Lakes	Thunder Bay
Meckley TD, Wagner CM, Gurarie E	2014	Coastal movements of migrating sea lamprey (*Petromyzon marinus*) in response to a partial pheromone added to river water: implications for management of invasive populations	Canadian Journal of Fisheries and Aquatic Sciences 71(4):533-544	Lake Huron near outlet of Black Mallard River	Great Lakes	Thunder Bay
Medved RJ, Marshall JA	1983	Short-term movements of young sandbar sharks*, Carcharhinus plumbeus* (Pisces, Carcharhinidae)	Bulletin of Marine Science 33:87–93	Chincoteague Bay, Virginia	Southeast/Gulf	Monitor, Stellwagen Bank
Melnychuk MC, Walters CJ, Christensen V, Bothwell ML, Welch DW	2012	Effects of solar ultraviolet radiation exposure on early ocean survival and fry-to-smolt growth of juvenile salmon	Marine Ecology Progress Series 457:251-264	southern British Columbia	West Coast	Olympic Coast
Meyer CG, Clark TB, Papastamatiou YP, Whitney NM, Holland KM	2009	Long-term movement patterns of tiger sharks *Galeocerdo cuvier* in Hawaii	Marine Ecology Progress Series 381:223-235	main Hawaiian islands	Pacific	NWHI-MNM
Meyer CG, Holland KN	2005	Movement patterns, home range size and habitat utilization of the bluespine unicornfish, *Naso unicornis* (Acanthuridae) in a Hawaiian marine reserve	Environmental Biology of Fishes 73:201-210	Oahu, HI	Pacific	NWHI-MNM
Meyer CG, Holland KN, Papastamatiou YP	**2007**	**Seasonal and diel movements of giant trevally *Caranx ignobilis* at remote Hawaiian atolls: implications for the design of Marine Protected Areas**	**Marine Ecology Progress Series 333:13-25**	**5 atolls in NWHI-MNM**	**Pacific**	**NWHI-MNM**
Meyer CG, Holland KN, Wetherbee BM, Lowe, CG	2000	Movement patterns, habitat utilization, home range size, and site fidelity of whitesaddle goatfish, *Parupeneus porphyreus*, in a marine reserve.	Environmental Biology of Fishes 59(3):235-242	Kaneohe Bay, Oahu, Hawaii	Pacific	NWHI-MNM

Meyer CG, Papastamatiou YP, Clark TB	2010	Differential movement patterns and site fidelity among trophic groups of reef fishes in a Hawaiian marine protected area	Marine Biology 157:1499-1511	Kealakekua Bay MPA, HI	Pacific	NWHI-MNM
Meyer CG, Papastamatiou YP, Holland KM	**2010**	**A multiple instrument approach to quantifying the movement patterns and habitat use of tiger (*Galeocerdo cuvier*) and Galapagos sharks (*Carcharhinus galapagensis)* at French Frigate Shoals, Hawaii**	**Marine Biolgy 157:1857-1868**	**French Frigate Shoals, Hawaiian archipelago**	**Pacific**	**NWHI-MNM**
Meyer CG, Papastamatiou YP, Holland KM	**2007**	**Seasonal, diel, and tidal movements of green jobfish (*Aprion virescens*, Lutjanidae) at remote Hawaiian atolls: implications for marine protected area design**	**Marine Biology 157:2133-2143**	**NWHI-MNM**	**Pacific**	**NWHI-MNM**
Moore ME, Berejikian BA, Goetz FA, Berger AG, Hodgson SS, Connor EJ, Quinn TP	2015	Multi-population analysis of Puget Sound steelhead survival and migration behavior	Marine Ecology Progress Series 537:217-232	Puget Sound	West Coast	Olympic Coast
Mucha JM, Mackereth RW	2008	Habitat use and movement patterns of brook trout in Nipigon Bay, Lake Superior	Transactions of the American Fisheries Society 137(4):1203-1212	Lake Superior	Great Lakes	Thunder Bay
Murchie KJ, Smokorowski KE	2004	Relative activity of brook trout and walleyes in response to flow in a regulated river	North American Journal of Fisheries Management 24:1050-0157	Magpie River, Ontario	Great Lakes	Thunder Bay
Nelson, D.R., J.N. McKibben, W.R. Strong, Jr., C.G. Lowe, J.A. Sisneros, D.M. Schroeder & R.J. Lavenberg.	1997	An acoustic tracking of a megamouth shark, *Megachasma pelagios*: a crepuscular vertical migrator	Environmental Biology of Fishes 49:389-399	Southern California	West Coast	Channel Islands
Nettles DC, Haynes JM, Olson RA, Winter JD	1987	Seasonal movements and habitats of brown trout (*Salmo trutta*) in southcentral Lake Ontario	Journal of Great Lakes Research 13(2):168-177	Lake Ontario	Great Lakes	Thunder Bay
Nosal AP, Caillat A, Kisfaludy EK, Royer MA, Wegner NC	2014	Aggregation behavior and seasonal philopatry in male and female leopard sharks *Triakis semifasciata* along the open coast of southern California, USA	Marine Ecology Progress Series 499:157-175	Southern California (San Clemente, CA to Baja)	West Coast	Channel Islands
Nosal AP, Cartamil DC, Long JW, Lurhmann M, Wegner NC, Graham JB	2013	Demography and movement patterns of leopard sharks (*Triakis semifasciata*) aggregating near the head of a submarine canyon along the open coast of southern California, USA	Environmental Biology of Fishes 96:865-878	Southern California	West Coast	Channel Islands
Papastamatiou YP, Itano DG, Dale JJ, Meyer CG, Holland KM	2010	Site fidelity and movements of sharks associated with ocean-farming cages in Hawaii	Marine and Freshwater Research 61:1366-1375	Oahu & Kona Coast, HW	Pacific	NWHI-MNM

Papastamatiou YP, Lowe CG, Caselle JE, Friedlander AM	2009	Scale-dependent effects of habitat on movements and path structure of reef sharks at a predator-dominated atoll	Ecology 90(4):996-1008	Palmyra Atoll National Wildlife Refuge	Pacific	American Samoa NWHI-MNM
Papastamatiou YP, Meyer CG, Carvalho F, Dale JJ, Hutchinson MR, Holland KM	**2013**	**Telemetry and random-walk models reveal complex patterns of partial migration in a large marine predator**	**Ecology 94(1):2595-2606**	**Hawaiian islands**	**Pacific**	**NWHI-MNM**
Parker SJ, Rankin PS, Olson JM, Hannah RW, Malvitch JS	2008	Patterns in vertical movements of black rockfish	Aquatic Biology 2:57-65	Newport, OR	West Coast	Olympic Coast
Pearcy WG	1992	Movements of acoustically-tagged yellowtail rockfish *Sebastes flavidus* on Heceta bank, Oregon	Fishery Bulletin 90:726-735	Heceta Bank, OR	West Coast	Olympic Coast
Rechisky EL, Wetherbee BM	2003	Short-term movements of juvenile sandbar sharks*, Carcharhinus plumbeus*, on their nursery grounds in Delaware Bay.	Environmental Biology of Fishes 68:113-128	Delaware Bay	Southeast/Gulf	Monitor Stellwagen Bank
Reyier EA, Franks BR, Chapman DD, Scheidt DM, Stolen ED, Gruber SH	2014	Regional-Scale Migrations and Habitat Use of Juvenile Lemon Sharks (*Negaprion brevirostris*) in the US South Atlantic	PLoS ONE 9(2):e88470	Cape Canaveral, FL	Southeast/Gulf	Gray's Reef
Reynolds BF, Powers SP, Bishop MA	2010	Application of acoustic telemetry to assess residency and movements of rockfish and lingcod at created and natural habitats in Prince William Sound.	PLoS ONE 5:1–8	Prince William Sound, AK	West Coast	Olympic Coast
RIley SC, Binder TR, Wattrus NJ, Faust MD, Janssen J, Menzies J, Marsden JE, Ebener MP, Bronte CR, He JX, Tucker TR, Hansen MJ,Thompson HT, Muir AM, Krueger CC	**2014**	**Lake trout in northern Lake Huron spawn on submerged drumlins**	**Journal of Great Lakes Research 40:415-420**	**Lake Huron**	**Great Lakes**	**Thunder Bay**
Robert M, Dagorn L, Filmalter JD, Deneubourg JL, Itano D, Holland K	2013	Intra-individual behavioral variability displayed by tuna at fish aggregating devices (FADs)	Marine Ecology Progress Series 484:239-247	Oahu, HI	Pacific	NWHI-MNM
Ross ST, Slack WT, Heise RJ, Dugo MA, Rogillio H, Bowen BR, Mickle P, Heard RW	2009	Estuarine and Coastal Habitat Use of Gulf Sturgeon (*Acipenser oxyrinchus desotoi*) in the North-Central Gulf of Mexico	Estuaries and Coasts 32:360-374	north-central Gulf of Mexico	Southeast/Gulf	Flower Garden Banks
Sackett DK, Able KW, Grothues TM	2008	Habitat dynamics of summer flounder *Paralichthys dentatus* within a shallow USA estuary, based on multiple approaches using acoustic telemetry	Marine Ecology Progress Series 364:199-212	Mullica River-Great Bay estuary, NJ	Northeast	Stellwagen Bank
Sackett DK, Able KW, Grothues TM	2007	Dynamics of summer flounder, *Paralichthys dentatus,* seasonal migrations based on ultrasonic telemetry	Estuarine, Coastal and Shelf Science 74:119-130	Mullica River-Great Bay estuary, NJ	Northeast	Stellwagen Bank

Savitz J, Treat L	2007	Movements and site fidelity of black bass in three harbors along the Illinois shoreline of Lake Michigan	Journal of Freshwater Ecology 22(2):267-269	Lake Michigan	Great Lakes	Thunder Bay
Schreer JK, Cooke SJ	2002	Behavioral and physiological responses of Smallmouth Bass to a dynamic thermal environment	American Fisheries Society Symposium 31:191-203	Lake Erie	Great Lakes	Thunder Bay
Sepulveda CA, Kohin S, Chan C, Vetter R, Graham JB	2004	Movement patterns, depth preferences, and stomach temperatures of free-swimming juvenile mako sharks*, Isurus oxyrinchus*, in the Southern California Bight.	Marine Biology 145:191-199	Southern California	West Coast	Channel Island
Smith JM, Fresh KL, Kagley AN, Quinn TP	2015	Ultrasonic telemetry reveals seasonal variation in depth distribution and diel vertical migrations of sub-adult Chinook and coho salmon in Puget Sound	Marine Ecology Progress Series 532:227-242	Puget Sound	West Coast	Olympic Coast
Standora EA, Nelson DR	1977	A telemetric study of the behavior of free-swimming angel sharks Squatina californica.	Bulletin of Southern California Academy of Sciences 76:193–201.	Catalina Island, CA	West Coast	Channel Islands
Starr RM, Heine JN, Felton JM, Cailliet GM	**2002**	**Movements of bocaccio and greenspotted rockfishes in a Monterey submarine canyon: implications for the design of marine reserves**	**Fisheries Bulletin 100:324–337.**	**Monterey Bay**	**West Coast**	**Monterey Bay**
Starr RM, O'Connell V, Ralston S	2004	Movements of lingcod (*Ophiodon elongatus*) in southeast Alaska: potential for increased conservation and yield from marine reserves	Canadian Journal of Fisheries & Aquatic Sciences 61:1083-1094	Southeast Alaska	West Coast	Olympic Coast
Starr RM, O'Connell V, Ralston S, Breaker L	2005	Use of acoustic tags to estimate natural mortality, spillover, and movements of lingcod (*Ophiodon elongates*) in a marine reserve	Marine Technology Society Journal 39(1):19	Southeast Alaska	West Coast	Olympic Coast
Szedlmayer ST	1997	Ultrasonic telemetry of red snapper, *Lutjanus campechanus*, at artificial reef sites in the northeast Gulf of Mexico	Copeia 1997(4):846-850	Mobile Bay, AL	Southeast/Gulf	Flower Garden Banks
Szedlmayer, ST, Able, KW,	1993	Ultrasonic telemetry of age-0 summer flounder, *Paralichthys dentatus,* movements in a southern New Jersey estuary.	Copeia 1993(3): 728-736	New Jersey	Northeast	Stellwagen Bank
Teo SLH, Sandstrom PT, Chapman ED, Null RE, Brown K, Klimley AP, Block BA	2013	Archival and acoustic tags reveal the post-spawning migrations, diving behavior, and thermal habitat of hatchery-origin Sacramento River steelhead kelts (*Oncorhynchus mykiss*)	Environmental Biology of Fishes 96:175-187	Sacramento River & Delta, SF Bay estuary	West Coast	Cordell Bank, Gulf of the Farallones, Monterey Bay

Thompson AL	2009	Walleye habitat use, spawning behavior, and egg deposition in Sandusky Bay, Lake Erie	Master's thesis: Ohio State University	Sandusky Bay, Lake Erie	Great Lakes	Thunder Bay
Tolimieri N, Andrews K, Williams G, Katz S, Levin PS	2009	Home range size and patterns of space use by lingcod, copper rockfish and quillback rockfish in relation to diel and tidal cycles	Marine Ecology Progress Series 380:229-243	Puget Sound	West Coast	Olympic Coast
Topping D, Lowe C, Caselle J	2006	Site fidelity and seasonal movement patterns of adult California sheephead *Semicossyphus pulcher* (Labridae): an acoustic monitoring study	Marine Ecology Progress Series 326:257–267.	Catalina Island, CA	West Coast	Channel Islands
Topping DT, Lowe CG, Caselle JE	2005	Home range and habitat utilization of adult California sheephead, *Semicossyphus pulcher* (Labridae), in a temperate no-take marine reserve	Marine Biology 147: 301-311	Catalina Island, CA	West Coast	Channel Islands
Topping DT, Szedlmayer ST	2011	Site fidelity, residence time and movements of red snapper *Lutjanus campechanus* estimated with long-term acoustic monitoring	Marine Ecology Progress Series 437:183-200	northeastern Gulf of Mexico	Southeast/Gulf	Flower Garden Banks
Tricas TC, Taylor LR, Naftel G	**1981**	**Diel behavior of the tiger shark, *Galeocerdo cuvier*, at French Frigate Shoals, Hawaiian Islands.**	**Copeia 1981(4):904-908**	**French Frigate Shoals, Hawaiian archipelago**	**Pacific**	**NWHI-MNM**
Turnure JT, Grothues TM, Able KW	2015	Seasonal residency of adult weakfish (*Cynoscion regalis*) in a small temperate estuary based on acoustic telemetry: a local perspective of a coast wide phenomenon	Environmental Biology of Fishes 98:1207-1221	Mullica River-Great Bay estuary, NJ	Northeast	Stellwagen Bank
Ubeda AJ, Simpfendorfer CA, Heupel MR	2007	Movements of bonnetheads, *Sphyrna tiburo*, as a response to salinity change in a Florida estuary	Environmental Biology of Fishes 84:293-303	Pine Island Sound, Charlotte Harbor, FL	Southeast/Gulf	Florida Keys
Vaudo JJ, Lowe CG	2006	Movement patterns of the round stingray *Urobatis halleri* (Cooper) near a thermal outfall	Journal of Fish Biology 68:1756-1766	Seal Beach, CA	West Coast	Channel Islands
Vrieze LA, Bergstedt RA, Sorensen PW	2011	Olfactory-mediated stream-finding behavior of migratory adult sea lamprey (*Petromyzon marinus*)	Canadian Journal of Fisheries and Aquatic Sciences 68(3):523-533	Lake Huron	Great Lakes	Thunder Bay
Wenger MN, Lichorate RM, Winter JD	1985	Fall movements and behaviour of radio-tagged brown trout and rainbow trout in eastern Lake Erie in 1979 and 1980	New York Fish and Game Journal 32(2):176-188	Lake Erie	Great Lakes	Thunder Bay
Wetherbee BM, Holland KN, Meyer CG, Lowe CG	2004	Use of a marine reserve in Kaneohe Bay, Hawaii by the giant trevally, *Caranx ignobilis*	Fisheries Research 67:253-263	Kaneohe Bay, Oahu, Hawaii	Pacific	NWHI-MNM
Wetherbee BM, Rechisky EL, Pratt HL, McCandless CT	2001	Use of Telemetry in Fisheries Management: Juvenile Sandbar Sharks in Delaware Bay	in: Sibert J, Nielsen JL (eds) Electronic tagging and tracking in marine fisheries. Kluwer Academic Publishers, Dordrecht, p 249–262	Delaware Bay	Southeast/Gulf	Gray's Reef

Williams GD, Andrews KS, Katz SL, Moser ML, Tolimieri N, Farrer DA, Levin PA	2012	Scale and pattern of broadnose sevengill shark *Notorynchus cepedianus* movement in estuarine embayments	Journal of Fish Biology 80:1380-1400	Willapa Bay and Grays Harbor, WA	West Coast	Olympic Coast
Winger PD, McCallum BR, Walsh SJ, Brown JA	2002	Taking the bait: in situ voluntary ingestion of acoustic transmitters by Atlantic cod (*Gadus morhua*)	Hydrobiologia 483:287-292	Newfoundland	Northeast	Stellwagen Bank
Winger, P. D. & S. J. Walsh,	2001	Tagging of Atlantic cod (*Gadus morhua*) with intragastric transmitters: effects of forced insertion and voluntary ingestion on retention, food consumption and survival	Journal of Applied Ichthyology 17(5): 234-239	Trinity Bay, Newfoundland	Northeast	Stellwagen Bank
Workman RD, Hayes DB, Coon TG	2002	A model of steelhead movement in relation to water temperature in two Lake Michigan tributaries	Transactions of the American Fisheries Society 131(3):463-475	Lake Michigan	Great Lakes	Thunder Bay
Yamanaka KL, Richards LJ	1993	Movements of transplanted lingcod, *Ophiodon elongatus*, determined by ultrasonic telemetry	Fishery Bulletin 91:582-587	Vancouver Island, BC	West Coast	Olympic Coast
Yeiser BG, Heupel MR, Simpfendorfer CA	2008	Occurrence, home range and movement patterns of juvenile bull (*Carcharhinus leucas*) and lemon (*Negaprion brevirostris*) sharks within a Florida estuary.	Marine and Freshwater Research 59:489-501	Pine Island Sound, Charlotte Harbor, FL	Southeast/Gulf	Florida Keys

The complete literature review, including specific fields related to the types of studies conducted area are available electronically in an Excel spreadsheet.

Analysis of Published Literature

Following the literature review, we next analyzed the distribution of articles per region to reveal patterns in each region over time, with a specific focus on two categories of acoustic studies, a) projects historically conducted within a specific spatial footprint and b) projects conducted within specific Sanctuaries within each region.

In each region, the total number of studies conducted outnumbered the subset of those studies that were conducted within the Sanctuaries boundaries of the region.

Region – Pacific

There were a total of 28 telemetry studies identified in the Pacific region. Figure 1 below depicts those studies over time, both within the entire region (upper) and within Sanctuary waters (n=8, lower). All but one of the studies were conducted in the vicinity of Papahānaumokuākea MNM or Hawaiian Islands Humpback Whale NMS. The eight studies conducted within sanctuary waters were in Papahānaumokuākea MNM. Tiger shark (*Galeocerdo cuvier*) projects produced four of these studies.

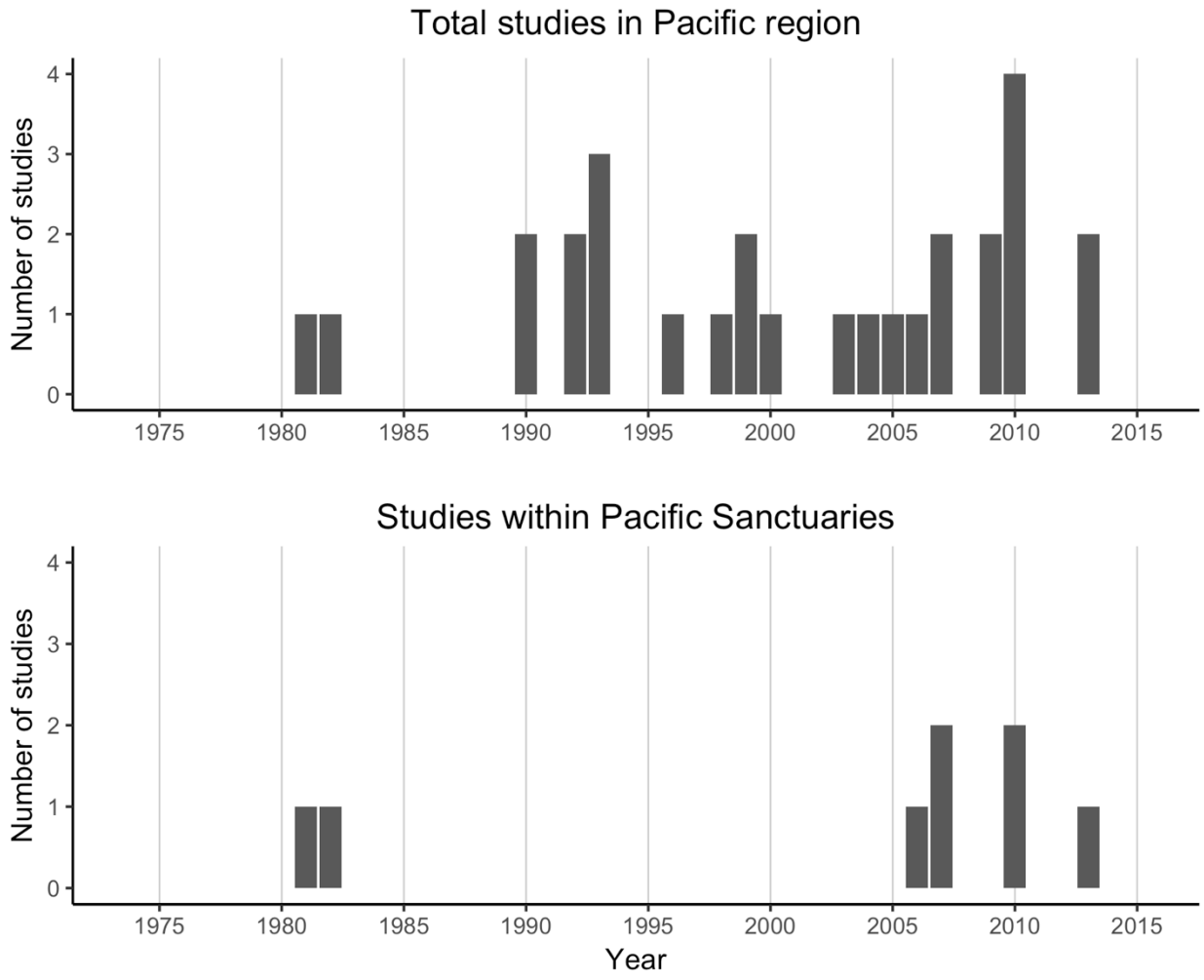


Figure 1. Telemetry studies in the Pacific Region

Region – West Coast

There were a total of 57 telemetry studies identified in the West Coast region. Figure 2 below depicts those studies over time, both within the entire region (upper) and within Sanctuary waters (n=16, lower). Over half (n=9) of these within-sanctuary studies occurred within Monterey Bay NMS, and included elephant seals (*Mirounga angustirostris*), two shark species (*Triakis semifasciata* and *Echinorhinus cookie*), and several species of rockfish (*Sebastes spp.*). All four of the studies within Greater Farallones NMS were conducted on elasmobranchs.

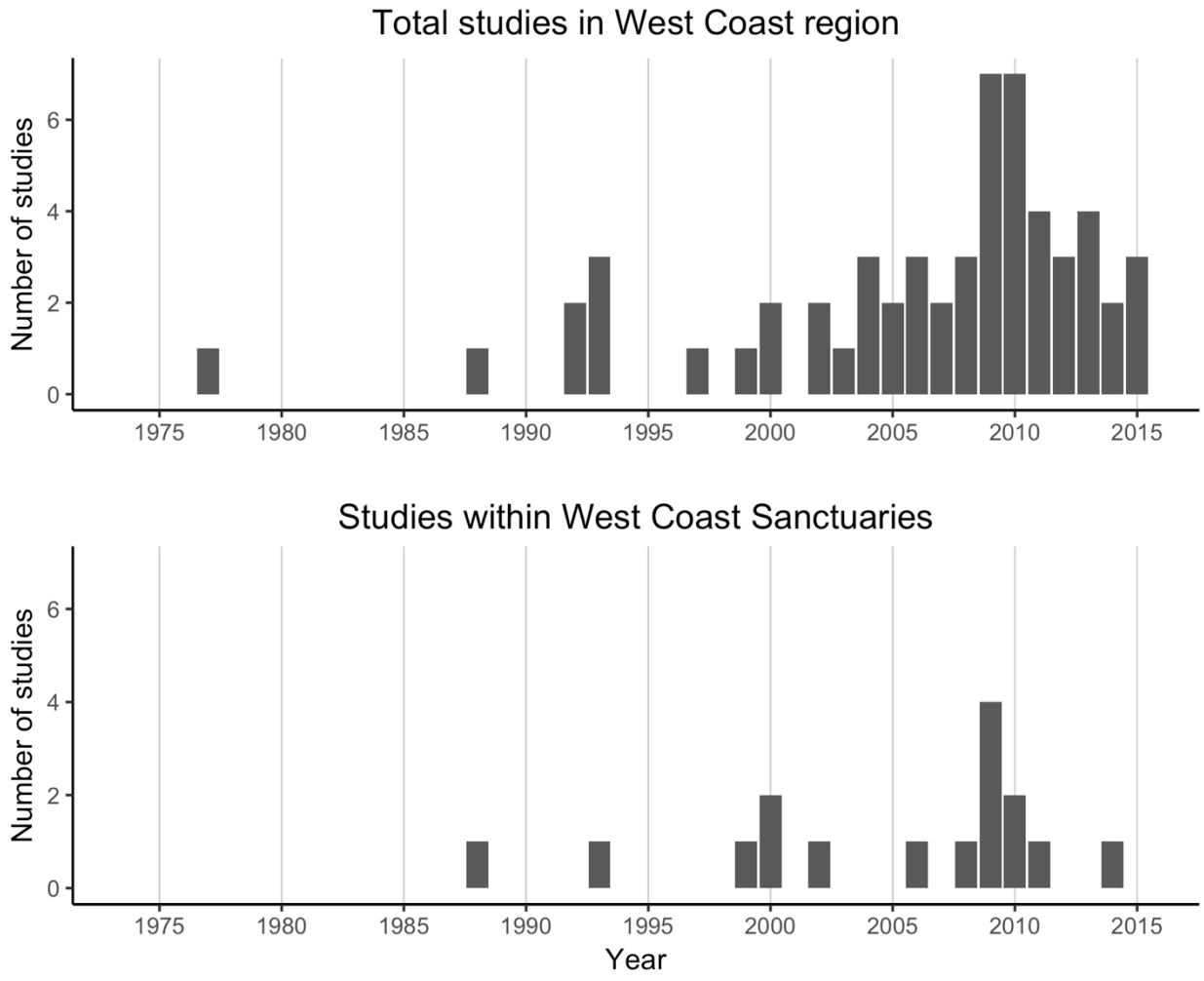


Figure 2. Telemetry studies in the West Coast Region

Region – Gulf and Southeast

There were a total of 45 telemetry studies identified in the Gulf and Southeast region. Figure 3 below depicts those studies over time, both within the entire region (upper) and within Sanctuary waters (n=12, lower). Ten of the studies were conducted within Florida Keys NMS, and included projects on hawksbill turtles (*Eretmochelys imbricata*), spiny lobster (*Panulirus argus*), and several species of bony fish. The other two studies within sanctuaries were conducted in Gray's Reef NMS.

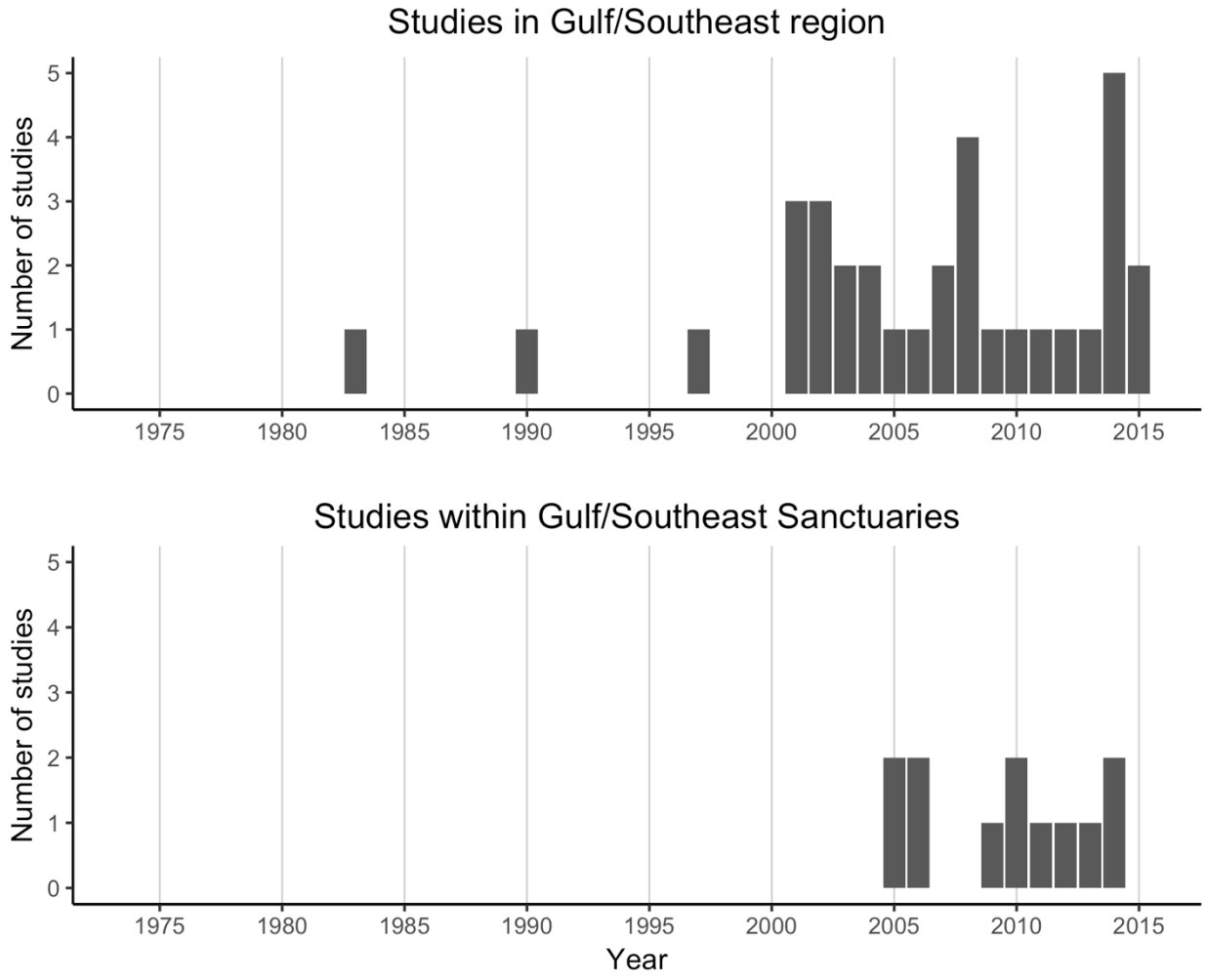


Figure 3. Telemetry studies in the Gulf and Southeast Region

Region – Northeast

There was a total of 24 telemetry studies identified in the Northeast region. Figure 4 below depicts those studies over time, both within the entire region (upper) and within Sanctuary waters (n=3, lower). All three studies occurred within Stellwagen Bank NMS; two projects tracked Atlantic cod (*Gadus morhua*) and one tracked bluefin tuna (*Thunnus thynnus*).

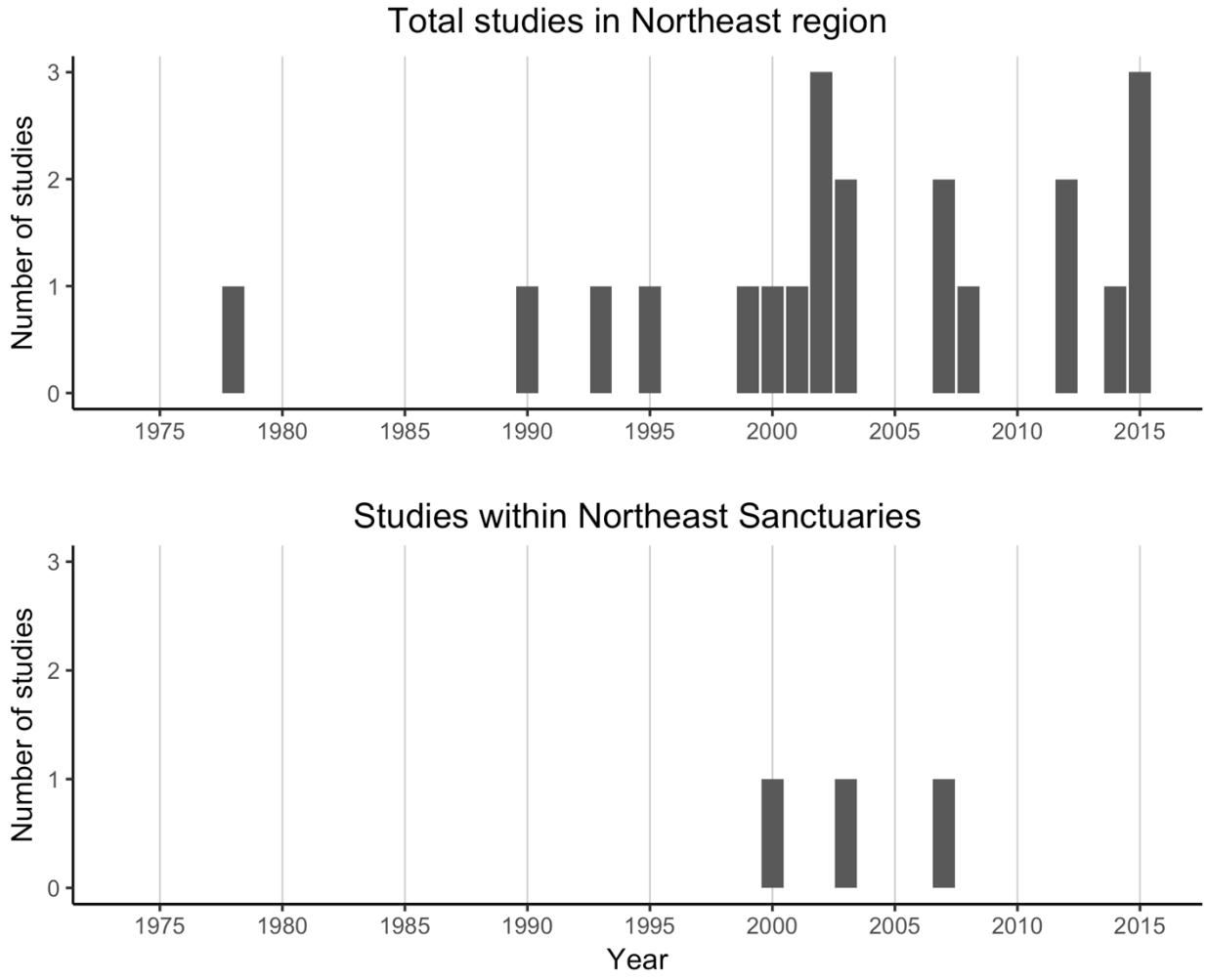


Figure 4. Telemetry studies in the Northeast Region

Region – Great Lakes

There was a total of 35 telemetry studies identified in the Great Lakes region. Figure 5 below depicts those studies over time, both within the entire region (upper) and within Sanctuary waters (n=2, lower).

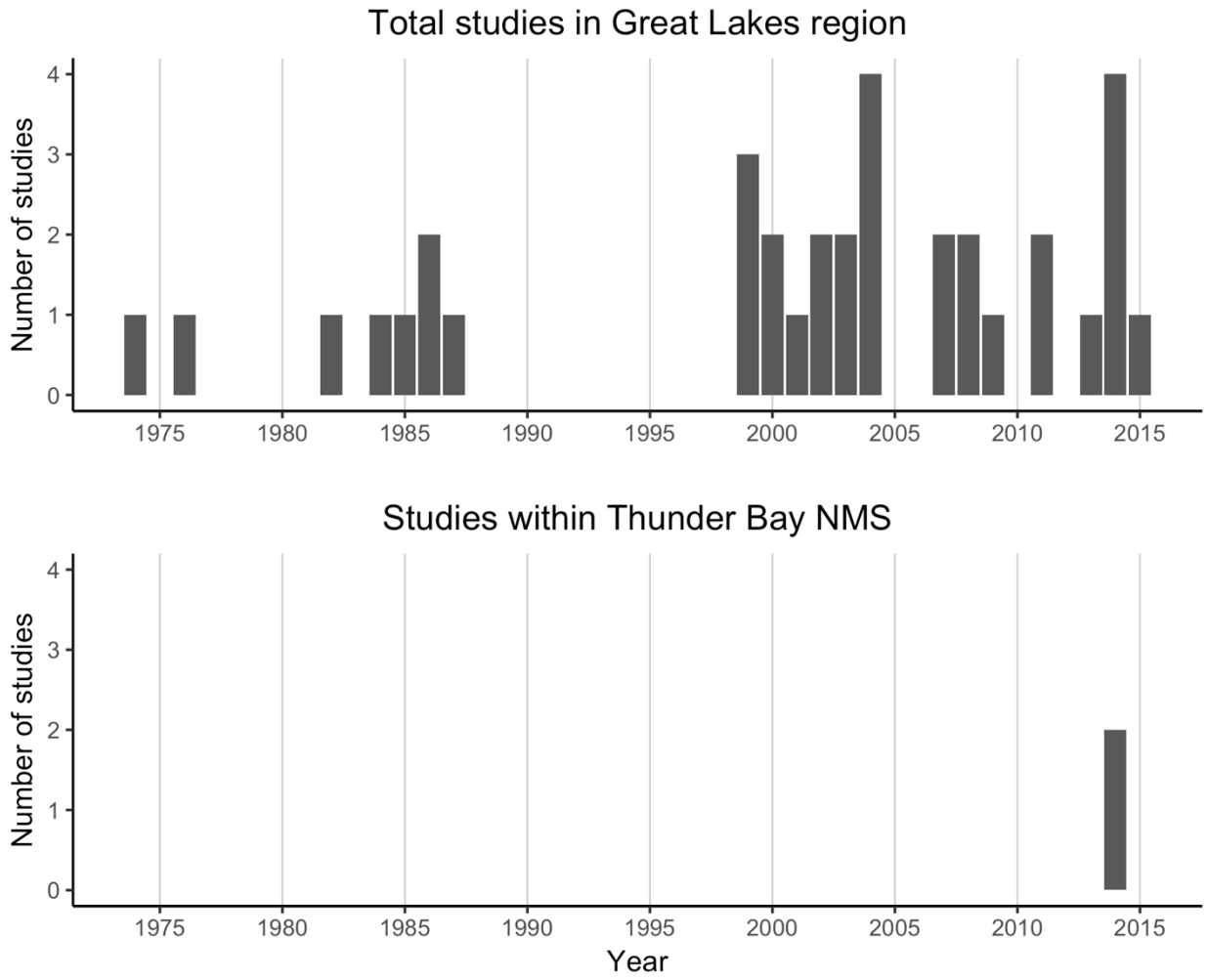


Figure 5. Telemetry studies in the Great Lakes Region

Management Questions/Issues to address with acoustic telemetry

The utility of movement data for meeting ONMS science and natural resource management objectives is considerable from a variety of different perspectives. It is important to note that telemetry will generally well-suited to answer questions of where, when, and how far? But it is less well-suited to answering questions about why those movements happen. To help provide some context for any such discussions moving forward, below we offer some examples of guiding questions that telemetry can answer. It is also important to note that over the course of this project we encountered a variety of on-going or recently-completed projects that were not yet published and were therefore not included in our literature review. We provide several examples below that derive from those projects.

a) Regional scale questions – Telemetry can help address the movement of fishes and key invertebrates **between** Sanctuaries and surrounding waters. Potential applications of this type of information will include potential boundary extensions (e.g., Flower Garden Banks NMS) and/or adjustments (e.g., recent expansions of CBNMS and GFNMS) as well as management linkages with other federal (e.g., National Marine Fisheries Service) and state jurisdictions (e.g., various state fish and wildlife divisions).

Primary question: Do any organisms move from within a Sanctuary to surrounding areas?

Related questions: If so, how frequent is any movement of organisms from within a Sanctuary to surrounding areas? If so, how distant from a Sanctuary's boundaries is any movement?

The answer to the first question appears to be yes for many, if not all, of the Sanctuaries. An interesting example comes from on-going work (Domeier et al., unpublished) with Giant Seabass (*Stereolepis gigas*). Giant Seabass, once known to form spawning aggregations throughout California's Channel Islands, have since been impacted considerably by fishing (both recreational and commercial) activities. A project using acoustic telemetry tagged multiple individuals to determine whether or not aggregations still formed in the islands. Results demonstrated regular movements of tagged fish between Anacapa and Santa Cruz Islands, but also out to Santa Barbara Island and down to Catalina Island (well outside of the Sanctuary

boundaries). With respect to *frequency*, movements were seasonal (over the course of five years), and in each case the fish resumed "normal" behavior after arriving at each island. With respect to *distance*, one fish was recorded as swimming 80+ miles from Catalina to Anacapa in less than 24 hrs. It is also interesting to note that the tagged fish, though demonstrating large total ambits, spent up to 20% of the study period within the relatively small state marine reserves and state marine conservation areas within the boundaries of the CINMS (California Department of Fish and Game et al., 2008).

Other related questions: What if any connections exist between Sanctuaries w/in a region (e.g., four CA sites) or between regions (e.g., SBNMS and GRNMS, or GRNMS and FGBNMS)?

A review of movement data from the Tagging of Pacific Predators (TOPP) project (http://www.gtopp.org/) suggests that white sharks (*Carcharodon carcharias*) provide a clear connection between Sanctuaries in northern California, with individual sharks moving from the MBNMS to the FKNMS and CBNMS. While satellite transmitters provide the majority of the data for this project, multiple sharks are also tagged with coded acoustic transmitters for tracking finer-scale movements. Another example of regional connectivity comes from the Greys Reef National Marine Sanctuary, where acoustic transmitters for a variety of species tagged to the north and south of the Sanctuary have been recorded as transient visitors to the Sanctuary.

b) Sanctuary-scale questions- Movement patterns of fishes and key invertebrates **within** Sanctuaries. Potential applications of these data include more effective management of key species; better education and outreach associated with Sanctuary ecosystems; management linkages with other federal and state jurisdictions.

Primary Question: What is the residence time of relevant organisms within a Sanctuary?

Related Question: What are the patterns in movements of targeted animals within boundaries?

A review of the literature included in Table 1 indicates that acoustic telemetry is frequently used to answer questions of residence time and movement patterns. However, due to the relatively small size of most acoustic receiver arrays relative to the boundaries of the Sanctuaries, most projects address issues of residence times and movement patterns at smaller spatial scales (e.g., fidelity to particular reef features or particular marine protected areas).

c) Fine-scale questions – Nearly all of the projects found in Table 1 address fine scale questions.

Primary question: How do animals move relative to key features (geological and/or biogenic) within Sanctuaries (e.g., boulder reefs in SBNMS, live-bottom reefs in GRNMS, coral reefs in FKNMS and FGBNMS)?

Infographics Per Region

Anticipating different approaches to communicating with broader communities and/or the general public, we experimented with the development of “infographics” for two of the regions to highlight the breadth and depth of acoustic telemetry research in a region, as well as some of the more interesting stories to result from published literature. It is likely that these graphics will require modification to meet the ONMS design guidelines prior to any distribution.

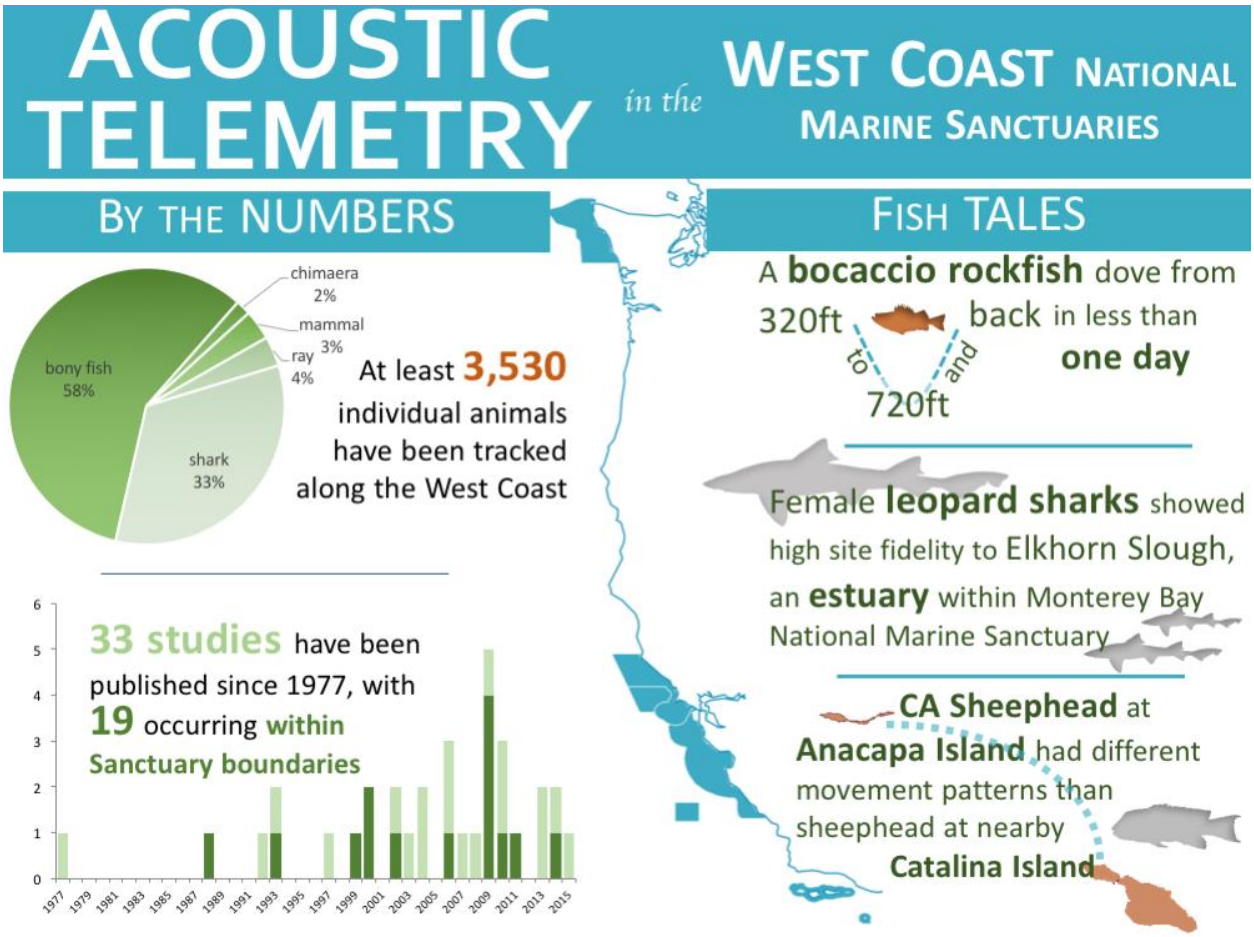


Figure 6. First draft of the West Coast animal telemetry infographic.

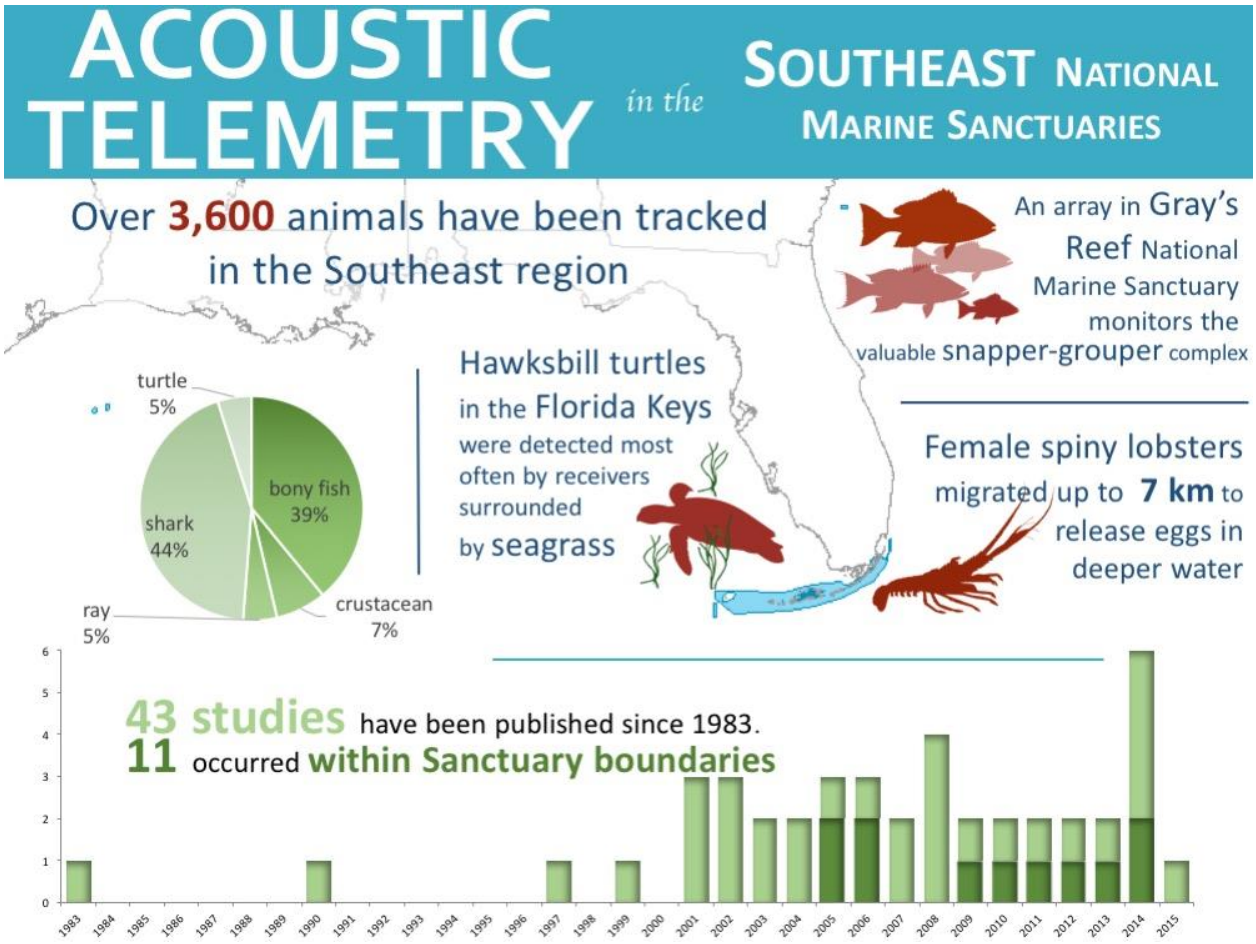


Figure 7. First draft of the Southeast animal telemetry infographic.

Selected On-line Telemetry Resources

Animal Telemetry Network - https://ioos.noaa.gov/project/atn/

Hydra - http://hydra3.sound-data.com/researchers/

Pacific Ocean Shelf Tracking Project (POST) - http://www.coml.org/projects/pacific-ocean-shelf-tracking-project-post

Tagging of Pelagic Predators (TOPP) - http://www.gtopp.org/

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