

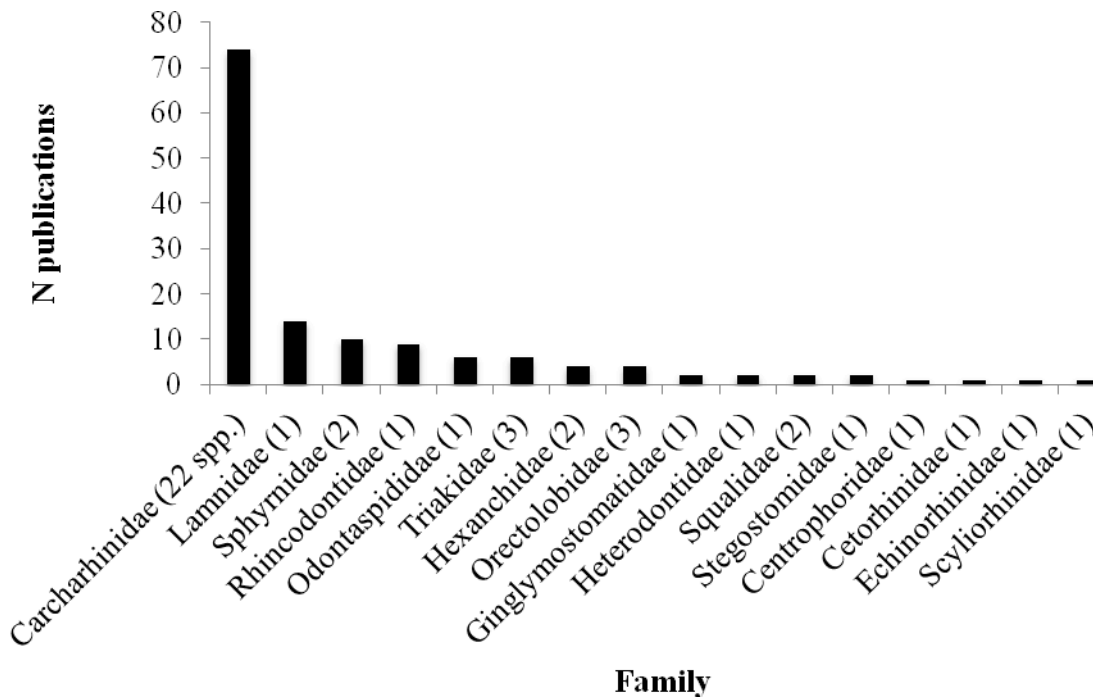
The following supplement accompanies the article

## A review of batoid philopatry, with implications for future research and population management

Kathryn I. Flowers\*, Matthew J. Ajemian, Kim Bassos-Hull, Kevin A. Feldheim, Robert E. Hueter, Yannis P. Papastamatiou, Demian D. Chapman\*

\*Corresponding author: katie.flowers.90@gmail.com

*Marine Ecology Progress Series 562: 251–261 (2016)*



**Fig S1.** Number of philopatry publications per shark family (16 of 34 families represented). The number of species (spp.) represented in each family is reported beside the family name.

**Table S1.** Evidence for philopatry in sharks reviewed through 7 December 2015. Criteria for study inclusion are found in Chapman *et al.* 2015. R: residency, SR: seasonal residency, SF: site fidelity, RP: regional philopatry, NP: natal philopatry.

<b>Species</b>	<b>Type</b>	<b>Reference</b>
<i>Carcharhinus acronotus</i>	RP	Portnoy <i>et al.</i> 2014
<i>Carcharhinus albimarginatus</i>	R	Barnett <i>et al.</i> 2012
<i>Carcharhinus albimarginatus</i>	R	Espinoza <i>et al.</i> 2015a
<i>Carcharhinus amblyrhynchos</i>	R	Barnett <i>et al.</i> 2012
<i>Carcharhinus amblyrhynchos</i>	R	Espinoza <i>et al.</i> 2015b
<i>Carcharhinus amblyrhynchos</i>	R	Espinoza <i>et al.</i> 2015a
<i>Carcharhinus amblyrhynchos</i>	R	Field <i>et al.</i> 2011
<i>Carcharhinus amblyrhynchos</i>	R	Speed <i>et al.</i> 2016
<i>Carcharhinus amblyrhynchos</i>	R	Vianna <i>et al.</i> 2013
<i>Carcharhinus amboinensis</i>	R	Knip <i>et al.</i> 2011
<i>Carcharhinus amboinensis</i>	RP	Tillett <i>et al.</i> 2012
<i>Carcharhinus cautus</i>	R	Escalle <i>et al.</i> 2015
<i>Carcharhinus falciformis</i>	SF	Clarke <i>et al.</i> 2011
<i>Carcharhinus falciformis</i>	RP	Clarke <i>et al.</i> 2015
<i>Carcharhinus fitzroyensis</i>	R	Munroe <i>et al.</i> 2015a
<i>Carcharhinus galapagensis</i>	R	Lowe <i>et al.</i> 2006
<i>Carcharhinus leucas</i>	SF	Brunnschweiler & Baensch 2011
<i>Carcharhinus leucas</i>	SR-SF	Brunnschweiler & Barnett 2013
<i>Carcharhinus leucas</i>	R	Daly <i>et al.</i> 2014
<i>Carcharhinus leucas</i>	SR-SF	Espinoza <i>et al.</i> 2015a
<i>Carcharhinus leucas</i>	R	Heupel & Simpfendorfer 2008
<i>Carcharhinus leucas</i>	R	Heupel <i>et al.</i> 2010
<i>Carcharhinus leucas</i>	SR-SF	Heupel <i>et al.</i> 2015
<i>Carcharhinus leucas</i>	SR-SF	Lea <i>et al.</i> 2015a
<i>Carcharhinus leucas</i>	R	Matic & Heithaus 2015
<i>Carcharhinus leucas</i>	R	Werry <i>et al.</i> 2012
<i>Carcharhinus limbatus</i>	R	DeAngelis <i>et al.</i> 2008
<i>Carcharhinus limbatus</i>	SR-SF	Heupel & Simpfendorfer 2002
<i>Carcharhinus limbatus</i>	RP	Keeney <i>et al.</i> 2003, 2005
<i>Carcharhinus limbatus</i>	R	Legare <i>et al.</i> 2015
<i>Carcharhinus longimanus</i>	SR-SF	Howey-Jordan <i>et al.</i> 2013
<i>Carcharhinus longimanus</i>	SR-SF	Madigan <i>et al.</i> 2015
<i>Carcharhinus melanopterus</i>	SF-NP	Mourier & Planes 2013
<i>Carcharhinus melanopterus</i>	R	Papastamatiou <i>et al.</i> 2009
<i>Carcharhinus melanopterus</i>	R	Papastamatiou <i>et al.</i> 2010
<i>Carcharhinus melanopterus</i>	R	Speed <i>et al.</i> 2016
<i>Carcharhinus melanopterus</i>	RP	Vignaud <i>et al.</i> 2014
<i>Carcharhinus perezi</i>	R	Bond <i>et al.</i> 2012
<i>Carcharhinus perezi</i>	SR-SF	Brooks <i>et al.</i> 2013
<i>Carcharhinus perezi</i>	R	Garla <i>et al.</i> 2006
<i>Carcharhinus plumbeus</i>	SR-SF	Conrath & Musick 2010
<i>Carcharhinus plumbeus</i>	SR-SF	Papastamatiou <i>et al.</i> 2011
<i>Carcharhinus sorrah</i>	R	Knip <i>et al.</i> 2012a
<i>Carcharhinus sorrah</i>	R	Knip <i>et al.</i> 2012b
<i>Carcharias taurus</i>	SR-SF	Bansemmer & Bennett 2011
<i>Carcharias taurus</i>	SR-SF	Bansemmer & Bennett 2009
<i>Carcharias taurus</i>	SR-SF	Barker & Williamson 2010
<i>Carcharias taurus</i>	SR-SF	Kneebone <i>et al.</i> 2014
<i>Carcharias taurus</i>	R	Smale <i>et al.</i> 2015
<i>Carcharias taurus</i>	SR-SF	Teter <i>et al.</i> 2015

<b>Species</b>	<b>Type</b>	<b>Reference</b>
<i>Carcharodon carcharias</i>	SR-SF	Anderson <i>et al.</i> 2011
<i>Carcharodon carcharias</i>	SR	Bonfil & O'Brien 2015
<i>Carcharodon carcharias</i>	SF	Bonfil <i>et al.</i> 2005
<i>Carcharodon carcharias</i>	SR-SF	Bruce & Bradford 2012
<i>Carcharodon carcharias</i>	SR-SF	Domeier & Nasby-Lucas 2007
<i>Carcharodon carcharias</i>	SR-SF	Domeier & Nasby-Lucas 2008
<i>Carcharodon carcharias</i>	SR-SF	Domeier & Nasby-Lucas 2013
<i>Carcharodon carcharias</i>	SR-SF	Duffy <i>et al.</i> 2012
<i>Carcharodon carcharias</i>	SR	Francis <i>et al.</i> 2015
<i>Carcharodon carcharias</i>	SR-SF-RP	Jorgensen <i>et al.</i> 2010
<i>Carcharodon carcharias</i>	R-SF	Kock <i>et al.</i> 2013
<i>Carcharodon carcharias</i>	RP	Oñate-González <i>et al.</i> 2015
<i>Carcharodon carcharias</i>	RP	Pardini <i>et al.</i> 2001
<i>Carcharodon carcharias</i>	SR-SF	Robbins <i>et al.</i> 2015
<i>Centrophorus zeehaani</i>	R-SR	Daley <i>et al.</i> 2015
<i>Cetorhinus maximus</i>	SR-SF	Hoogenboom <i>et al.</i> 2015
<i>Echinorhinus cookei</i>	R	Dawson & Starr 2009
<i>Galeocerdo cuvier</i>	R-SR	Ferreira <i>et al.</i> 2015
<i>Galeocerdo cuvier</i>	SF	Heithaus 2001
<i>Galeocerdo cuvier</i>	SR-SF	Holmes <i>et al.</i> 2014
<i>Galeocerdo cuvier</i>	SR-SF	Lea <i>et al.</i> 2015b
<i>Galeocerdo cuvier</i>	SF	Lowe <i>et al.</i> 2006
<i>Galeocerdo cuvier</i>	SF	Meyer <i>et al.</i> 2009
<i>Galeocerdo cuvier</i>	R-SF	Papastamatiou <i>et al.</i> 2013
<i>Galeocerdo cuvier</i>	SR-SF, R	Werry <i>et al.</i> 2014
<i>Galeorhinus galeus</i>	SR-SF	McAllister <i>et al.</i> 2015
<i>Ginglymostoma cirratum</i>	SF	Carrier <i>et al.</i> 2004
<i>Ginglymostoma cirratum</i>	R	Ferreira <i>et al.</i> 2013
<i>Glyphis glyphis</i>	NP	Feutry <i>et al.</i> 2014
<i>Heterodontus portjacksoni</i>	R	McLaughlin & O'Gower 1971
<i>Heterodontus portjacksoni</i>	SF	Powter & Gladstone 2009
<i>Hexanchus griseus</i>	R-SR-SF	Andrews <i>et al.</i> 2010
<i>Mustelus mustelus</i>	SR-SF	da Silva <i>et al.</i> 2013
<i>Negaprion acutidens</i>	SF	Clua <i>et al.</i> 2010
<i>Negaprion acutidens</i>	SF	Mourier <i>et al.</i> 2013
<i>Negaprion acutidens</i>	R	Speed <i>et al.</i> 2011
<i>Negaprion acutidens</i>	R	Speed <i>et al.</i> 2015
<i>Negaprion brevirostris</i>	RP	Ashe <i>et al.</i> 2015.
<i>Negaprion brevirostris</i>	R-SF	Chapman <i>et al.</i> 2009a
<i>Negaprion brevirostris</i>	R	DeAngelis <i>et al.</i> 2008
<i>Negaprion brevirostris</i>	SF	DiBattista <i>et al.</i> 2008
<i>Negaprion brevirostris</i>	SF	Feldheim <i>et al.</i> 2004
<i>Negaprion brevirostris</i>	NP	Feldheim <i>et al.</i> 2014
<i>Negaprion brevirostris</i>	SF	Feldheim <i>et al.</i> 2002
<i>Negaprion brevirostris</i>	R	Freitas <i>et al.</i> 2009
<i>Negaprion brevirostris</i>	SR-SF	Kessel <i>et al.</i> 2014
<i>Negaprion brevirostris</i>	R	Legare <i>et al.</i> 2015
<i>Negaprion brevirostris</i>	R	Murchie <i>et al.</i> 2010
<i>Negaprion brevirostris</i>	SR-SF	Reyier <i>et al.</i> 2014
<i>Notorhynchus cepedianus</i>	SR-SF	Abrantes & Barnett 2011
<i>Notorhynchus cepedianus</i>	SR-SF	Barnett <i>et al.</i> 2011
<i>Notorhynchus cepedianus</i>	SR-SF	Dudgeon <i>et al.</i> 2015
<i>Orectolobus ornatus</i>	RP	Corrigan <i>et al.</i> 2016
<i>Orectolobus halei</i>	RP	Corrigan <i>et al.</i> 2016

Species	Type	Reference
<i>Orectolobus halei</i>	R	Huveneers <i>et al.</i> 2006
<i>Orectolobus maculatus</i>	RP	Corrigan <i>et al.</i> 2016
<i>Prionace glauca</i>	SR-SF, R	Vandeperre <i>et al.</i> 2014
<i>Rhincodon typus</i>	SR	Araujo <i>et al.</i> 2014
<i>Rhincodon typus</i>	SR-SF	Berumen <i>et al.</i> 2014
<i>Rhincodon typus</i>	R	Cagua <i>et al.</i> 2015
<i>Rhincodon typus</i>	SF	Fox <i>et al.</i> 2013
<i>Rhincodon typus</i>	SF	Graham & Roberts 2007
<i>Rhincodon typus</i>	SF	Hearn <i>et al.</i> 2013
<i>Rhincodon typus</i>	SF	Holmberg <i>et al.</i> 2008
<i>Rhincodon typus</i>	SF	Hueter <i>et al.</i> 2013
<i>Rhincodon typus</i>	SF	Riley <i>et al.</i> 2010
<i>Rhizoprionodon taylori</i>	R	Munroe <i>et al.</i> 2015b
<i>Scyliorhinus canicula</i>	RP	Gubili <i>et al.</i> 2014
<i>Sphyrna lewini</i>	SR-SF	Bessudo <i>et al.</i> 2011
<i>Sphyrna lewini</i>	RP	Chapman <i>et al.</i> 2009b
<i>Sphyrna lewini</i>	RP	Daly-Engel <i>et al.</i> 2012
<i>Sphyrna lewini</i>	SR-SF	Hearn <i>et al.</i> 2010
<i>Sphyrna lewini</i>	SF	Hoyos-Padilla <i>et al.</i> 2014
<i>Sphyrna lewini</i>	R-SR	Ketchum <i>et al.</i> 2014
<i>Sphyrna tiburo</i>	SR-SF	Driggers <i>et al.</i> 2014
<i>Sphyrna tiburo</i>	RP	Escatel-Luna <i>et al.</i> 2015
<i>Sphyrna tiburo</i>	R	Heupel <i>et al.</i> 2006
<i>Sphyrna tiburo</i>	RP	Portnoy <i>et al.</i> 2015
<i>Squalus acanthias</i>	SR	Thorburn <i>et al.</i> 2015
<i>Squalus suckleyi</i>	SR-SF	Andrews & Harvey 2013
<i>Stegostoma fasciatum</i>	SF	Dudgeon <i>et al.</i> 2008
<i>Stegostoma fasciatum</i>	SR-SF	Dudgeon <i>et al.</i> 2013
<i>Triaenodon obesus</i>	R	Barnett <i>et al.</i> 2012
<i>Triaenodon obesus</i>	R	Speed <i>et al.</i> 2011
<i>Triakis semifasciata</i>	RP	Barker <i>et al.</i> 2015
<i>Triakis semifasciata</i>	SR-SF	Carlisle & Starr 2009
<i>Triakis semifasciata</i>	RP	Lewallen <i>et al.</i> 2007
<i>Triakis semifasciata</i>	SR-SF	Nosal <i>et al.</i> 2014

## REFERENCES (SHARKS).

- Abrantes KG, Barnett A (2011) Intrapopulation variations in diet and habitat use in a marine apex predator, the broadnose sevengill shark *Notorynchus cepedianus*. *Mar Ecol Prog Ser* 442: 133–148
- Anderson SD, Chapple TK, Jorgensen SJ, Klimley AP, Block BA (2011) Long-term individual identification and site fidelity of white sharks, *Carcharodon carcharias*, off California using dorsal fins. *Mar Biol* 158:1233–1237
- Andrews KS, Harvey CJ (2013) Ecosystem-level consequences of movement: seasonal variation in the trophic impact of a top predator. *Mar Ecol Prog Ser* 473:247–260
- Andrews KS, Williams GD, Levin PS (2010) Seasonal and ontogenetic changes in movement patterns of sixgill sharks. *PLOS ONE* 5:e12549
- Araujo G, Lucey A, Labaja J, So CL, Snow S, Ponzo A (2014) Population structure and residency patterns of whale sharks, *Rhincodon typus*, at a provisioning site in Cebu, Philippines. *PeerJ* 2:e543

- Ashe JL, Feldheim KA, Fields AT (2015) Local population structure and context-dependent isolation by distance in a large coastal shark. *Mar Ecol Prog Ser* 520:203–216
- Bansemmer CS, Bennett MB (2009) Reproductive periodicity, localised movements and behavioural segregation of pregnant *Carcharias taurus* at Wolf Rock, southeast Queensland, Australia. *Mar Ecol Prog Ser* 374:215–227
- Bansemmer CS, Bennett MB (2011) Sex-and maturity-based differences in movement and migration patterns of grey nurse shark, *Carcharias taurus*, along the eastern coast of Australia. *Mar Freshw Res* 62:596–606
- Barker SM, Williamson JE (2010) Collaborative photo-identification and monitoring of grey nurse sharks (*Carcharias taurus*) at key aggregation sites along the eastern coast of Australia. *Mar Freshw Res* 61:971–979
- Barker AM, Nosal AP, Lewallen EA, Burton RS (2015) Genetic structure of leopard shark (*Triakis semifasciata*) populations along the Pacific coast of North America. *J Exp Mar Biol Ecol* 472:151–157
- Barnett A, Abrantes KG, Stevens JD, Semmens JM (2011) Site fidelity and sex-specific migration in a mobile apex predator: implications for conservation and ecosystem dynamics. *Anim Behav* 81:1039–1048
- Barnett A, Abrantes KG, Seymour J, Fitzpatrick R (2012) Residency and spatial use by reef sharks of an isolated seamount and its implications for conservation. *PLOS ONE* 7:e36574
- Berumen ML, Braun CD, Cochran JE, Skomal GB, Thorrold SR (2014) Movement patterns of juvenile whale sharks tagged at an aggregation site in the Red Sea. *PLOS ONE* 9:e103536
- Bessudo S, Soler GA, Klimley AP, Ketchum JT, Hearn A, Arauz R (2011) Residency of the scalloped hammerhead shark (*Sphyrna lewini*) at Malpelo Island and evidence of migration to other islands in the Eastern Tropical Pacific. *Environ Biol Fishes* 91:165–176
- Bond ME, Babcock EA, Pikitch EK, Abercrombie DL, Lamb NF, Chapman DD (2012) Reef sharks exhibit site-fidelity and higher relative abundance in marine reserves on the Mesoamerican Barrier Reef. *PLOS ONE* 7:e32983
- Bonfil R, O'Brien S (2015) Strongly directional and differential swimming behavior of an adult female white shark, *Carcharodon carcharias* (Chondrichthyes: Lamnidae) from Guadalupe Island, Mexico. *Lat Am J Aquat Res* 43:267–273
- Bonfil R, Meyer M, Scholl MC, Johnson R and others (2005) Transoceanic migration, spatial dynamics, and population linkages of white sharks. *Science* 310:100–103
- Brooks EJ, Sims DW, Danylchuk AJ, Sloman KA (2013) Seasonal abundance, philopatry and demographic structure of Caribbean reef shark (*Carcharhinus perezii*) assemblages in the north-east Exuma Sound, The Bahamas. *Mar Biol* 160:2535–2546
- Bruce BD, Bradford RW (2012) Habitat use and spatial dynamics of juvenile white sharks, *Carcharodon carcharias*, in eastern Australia. In: *Global Perspectives on the Biology and Life History of the White Shark* (Domier ML ed.), 225-254 pp.
- Brunnschweiler JM, Baensch H (2011) Seasonal and long-term changes in relative abundance of bull sharks from a tourist shark feeding site in Fiji. *PLOS ONE* 6:e16597
- Brunnschweiler JM, Barnett A (2013) Opportunistic visitors: long-term behavioural response of bull sharks to food provisioning in Fiji. *PLOS ONE* 8:e58522

- Cagua EF, Cochran JE, Rohner CA, Prebble CE, Sinclair-Taylor TH, Pierce SJ, Berumen ML (2015) Acoustic telemetry reveals cryptic residency of whale sharks. *Biol Lett* 11:20150092
- Carlisle AB, Starr RM (2009) Habitat use, residency, and seasonal distribution of female leopard sharks *Triakis semifasciata* in Elkhorn Slough, California. *Mar Ecol Prog Ser* 380:213–228
- Carrier JC, Pratt HL Jr, Castro JI (2004) Elasmobranch reproduction. In: *Biology of sharks and their relatives*. (Carrier JC, Musick JA, Heithaus MR eds), 269-286.
- Chapman DD, Babcock EA, Gruber SH, DiBattista JD and others (2009a) Long-term natal site-fidelity by immature lemon sharks (*Negaprion brevirostris*) at a subtropical island. *Mol Ecol* 18:3500–3507
- Chapman DD, Pinhal D, Shivji MS (2009b) Tracking the fin trade: genetic stock identification in western Atlantic scalloped hammerhead sharks *Sphyrna lewini*. *Endang Species Res* 9:221–228
- Clarke C, Lea JS, Ormond RF (2011) Reef-use and residency patterns of a baited population of silky sharks, *Carcharhinus falciformis*, in the Red Sea. *Mar Freshw Res* 62:668–675
- Clarke CR, Karl SA, Horn RL, Bernard AM and others (2015) Global mitochondrial DNA phylogeography and population structure of the silky shark, *Carcharhinus falciformis*. *Mar Biol* 162:945–955
- Clua E, Buray N, Legendre P, Mourier J, Planes S (2010) Behavioural response of sicklefin lemon sharks *Negaprion acutidens* to underwater feeding for ecotourism purposes. *Mar Ecol Prog Ser* 414:257–266
- Conrath CL, Musick JA (2010) Residency, space use and movement patterns of juvenile sandbar sharks (*Carcharhinus plumbeus*) within a Virginia summer nursery area. *Mar Freshw Res* 61:223–235
- Corrigan S, Huveneers C, Stow A, Beheregaray LB (2016) A multi-locus comparative study of dispersal in three codistributed demersal sharks from eastern Australia. *Can J Fish Aquat Sci* 73:406–415
- da Silva C, Kerwath SE, Attwood CG, Thorstad EB, Cowley PD, Økland F, Wilke CG, Næsje TF (2013) Quantifying the degree of protection afforded by a no-take marine reserve on an exploited shark. *Afr Journ Mar Sci* 35:57-66.
- Daley RK, Williams A, Green M, Barker B, Brodie P (2015) Can marine reserves conserve vulnerable sharks in the deep sea? A case study of *Centrophorus zeehaani* (Centrophoridae), examined with acoustic telemetry. *Deep Sea Res P II* 115:127–136
- Daly R, Smale MJ, Cowley PD, Froneman PW (2014) Residency patterns and migration dynamics of adult bull sharks (*Carcharhinus leucas*) on the east coast of southern Africa. *PLOS ONE* 9:e109357
- Daly-Engel TS, Seraphin KD, Holland KN, Coffey JP, Nance HA, Toonen RJ, Bowen BW (2012) Global phylogeography with mixed-marker analysis reveals male-mediated dispersal in the endangered scalloped hammerhead shark (*Sphyrna lewini*). *PLOS ONE* 7:e29986
- Dawson CL, Starr RM (2009) Movements of subadult prickly sharks *Echinorhinus cookei* in the Monterey Canyon. *Mar Ecol Prog Ser* 386:253–262
- DeAngelis BM, McCandless CT, Kohler NE, Recksiek CW, Skomal GB (2008) First characterization of shark nursery habitat in the United States Virgin Islands: evidence of habitat partitioning by two shark species. *Mar Ecol Prog Ser* 358:257–271
- DiBattista JD, Feldheim KA, Thirbert-Plante X, Gruber SH, Hendry AP (2008) A genetic assessment of polyandry and breeding site fidelity in lemon sharks. *Mol Ecol* 17:3337–3351

- Domeier ML, Nasby-Lucas N (2007) Annual re-sightings of photographically identified white sharks (*Carcharodon carcharias*) at an eastern Pacific aggregation site (Guadalupe Island, Mexico). *Mar Biol* 150:977–984
- Domeier ML, Nasby-Lucas N (2008) Migration patterns of white sharks *Carcharodon carcharias* tagged at Guadalupe Island, Mexico, and identification of an eastern Pacific shared offshore foraging area. *Mar Ecol Prog Ser* 370:221–237
- Domeier ML, Nasby-Lucas N (2013) Two-year migration of adult female white sharks (*Carcharodon carcharias*) reveals widely separated nursery areas and conservation concerns. *Animal Biotelemetry* 1:2
- Driggers WB, Frazier BS, Adams DH, Ulrich GF, Jones CM, Hoffmayer ER, Campbell MD (2014) Site fidelity of migratory bonnethead sharks *Sphyrna tiburo* (L. 1758) to specific estuaries in South Carolina, USA. *J Exp Mar Biol Ecol* 459:61–69
- Dudgeon CL, Noad MJ, Lanyon JM (2008) Abundance and demography of a seasonal aggregation of zebra sharks *Stegostoma fasciatum*. *Mar Ecol Prog Ser* 368:269–281
- Dudgeon CL, Lanyon JM, Semmens JM (2013) Seasonality and site fidelity of the zebra shark, *Stegostoma fasciatum*, in southeast Queensland, Australia. *Anim Behav* 85:471–481
- Dudgeon CL, Pollock KH, Braccini JM, Semmens JM, Barnett A (2015) Integrating acoustic telemetry into mark–recapture models to improve the precision of apparent survival and abundance estimates. *Oecologia* 178:761–772
- Duffy CA, Francis MP, Manning MJ, Bonfil R (2012) Regional population connectivity, oceanic habitat, and return migration revealed by satellite tagging of white sharks, *Carcharodon carcharias*, at New Zealand aggregation sites. In: Global perspectives on the biology and life history of the white shark. (Domeier ML ed.), 301–318 pp.
- Escalle L, Speed CW, Meekan MG, White WT, Babcock RC, Pillans RD, Huveneers C (2015) Restricted movements and mangrove dependency of the nervous shark *Carcharhinus caudatus* in nearshore coastal waters. *J Fish Biol* 87:323–341
- Escatel-Luna E, Adams DH, Uribe-Alcocer M, Islas-Villanueva V, Díaz-Jaimes P (2015) Population genetic structure of the bonnethead shark, *Sphyrna tiburo*, from the western North Atlantic Ocean based on mtDNA sequences. *J Hered* 106:355–365
- Espinoza M, Lédée EJ, Simpfendorfer CA, Tobin AJ, Heupel MR (2015a) Contrasting movements and connectivity of reef-associated sharks using acoustic telemetry: implications for management. *Ecol Appl* 25:2101–2118
- Espinoza M, Heupel MR, Tobin AJ, Simpfendorfer CA (2015b) Residency patterns and movements of grey reef sharks (*Carcharhinus amblyrhynchos*) in semi-isolated coral reef habitats. *Mar Biol* 162:343–358
- Feldheim KA, Gruber SH, Ashley MV (2002) The breeding biology of lemon sharks at a tropical nursery lagoon. *Proc R Soc B* 269:1655–1661
- Feldheim KA, Gruber SH, Ashley MV (2004) Reconstruction of parental microsatellite genotypes reveals female polyandry and philopatry in the lemon shark, *Negaprion brevirostris*. *Evolution* 58:2332–2342
- Feldheim KA, Gruber SH, Dibattista JD, Babcock EA and others (2014) Two decades of genetic profiling yields first evidence of natal philopatry and long-term fidelity to parturition sites in sharks. *Mol Ecol* 23:110–117

- Ferreira LC, Afonso AS, Castilho PC, Hazin FH (2013) Habitat use of the nurse shark, *Ginglymostoma cirratum*, off Recife, Northeast Brazil: a combined survey with longline and acoustic telemetry. *Environ Biol Fishes* 96:735–745
- Ferreira LC, Thums M, Meeuwig JJ, Vianna GM, Stevens J, McAuley R, Meekan MG (2015) Crossing latitudes-long-distance tracking of an apex predator. *PLOS ONE* 10:e0116916
- Feutry P, Kyne PM, Pillans RD, Chen X, Naylor GJ, Grewe PM (2014) Mitogenomics of the Spertooth Shark challenges ten years of control region sequencing. *BMC Evol Biol* 14:232
- Field IC, Meekan MG, Speed CW, White W, Bradshaw CJ (2011) Quantifying movement patterns for shark conservation at remote coral atolls in the Indian Ocean. *Coral Reefs* 30:61–71
- Fox S, Foisy I, De La Parra Venegas R, Galván Pastoriza BE and others (2013) Population structure and residency of whale sharks *Rhincodon typus* at Utila, Bay Islands, Honduras. *J Fish Biol* 83:574–587
- Francis MP, Duffy C, Lyon W (2015) Spatial and temporal habitat use by white sharks (*Carcharodon carcharias*) at an aggregation site in southern New Zealand. *Mar Freshw Res* 66:900–918
- Freitas RH, Rosa RS, Wetherbee BM, Gruber SH (2009) Population size and survivorship for juvenile lemon sharks (*Negaprion brevirostris*) on their nursery grounds at a marine protected area in Brazil. *Neotrop Ichthyol* 7:205–212
- Garla RC, Chapman DD, Wetherbee BM, Shivji M (2006) Movement patterns of young Caribbean reef sharks, *Carcharhinus perezii*, at Fernando de Noronha Archipelago, Brazil: the potential of marine protected areas for conservation of a nursery ground. *Mar Biol* 149:189–199
- Graham RT, Roberts CM (2007) Assessing the size, growth rate and structure of a seasonal population of whale sharks (*Rhincodon typus* Smith 1828) using conventional tagging and photo identification. *Fish Res* 84:71–80
- Gubili C, Sims DW, Veríssimo A, Domenici P and others (2014) A tale of two seas: contrasting patterns of population structure in the small-spotted catshark across Europe. *R Soc Open Sci* 1:140175
- Hearn A, Ketchum J, Klimley AP, Espinoza E, Penaherrera C (2010) Hotspots within hotspots? Hammerhead shark movements around Wolf Island, Galapagos Marine Reserve. *Mar Biol* 157:1899–1915
- Hearn AR, Green JR, Espinoza E, Peñaherrera C, Acuña D, Klimley AP (2013) Simple criteria to determine detachment point of towed satellite tags provide first evidence of return migrations of whale sharks (*Rhincodon typus*) at the Galapagos Islands, Ecuador. *Animal Biotelemetry* 1:11
- Heithaus MR (2001) The biology of tiger sharks, *Galeocerdo cuvier*, in Shark Bay, Western Australia: sex ratio, size distribution, diet, and seasonal changes in catch rates. *Environ Biol Fishes* 61:25–36
- Heupel MR, Simpfendorfer CA (2002) Estimation of mortality of juvenile blacktip sharks, *Carcharhinus limbatus*, within a nursery area using telemetry data. *Can J Fish Aquat Sci* 59:624–632
- Heupel MR, Simpfendorfer CA (2008) Movement and distribution of young bull sharks *Carcharhinus leucas* in a variable estuarine environment. *Aquat Biol* 1:277–289
- Heupel MR, Simpfendorfer CA, Collins AB, Tyminski JP (2006) Residency and movement patterns of bonnethead sharks, *Sphyrna tiburo*, in a large Florida estuary. *Environ Biol Fishes* 76:47–67



- Heupel MR, Yeiser BG, Collins AB, Ortega L, Simpfendorfer CA (2010) Long-term presence and movement patterns of juvenile bull sharks, *Carcharhinus leucas*, in an estuarine river system. *Mar Freshw Res* 61:1–10
- Heupel MR, Simpfendorfer CA, Espinoza M, Smoothey AF, Tobin A, Peddemors V (2015) Conservation challenges of sharks with continental scale migrations. *Front Mar Sci* 2:12
- Holmberg J, Norman B, Arzoumanian Z (2008) Robust, comparable population metrics through collaborative photo-monitoring of whale sharks *Rhincodon typus*. *Ecol Appl* 18:222–233
- Holmes BJ, Pepperell JG, Griffiths SP, Jaine FR, Tibbetts IR, Bennett MB (2014) Tiger shark (*Galeocerdo cuvier*) movement patterns and habitat use determined by satellite tagging in eastern Australian waters. *Mar Biol* 161:2645–2658
- Hoogenboom JL, Wong SN, Ronconi RA, Koopman HN, Murison LD, Westgate AJ (2015) Environmental predictors and temporal patterns of basking shark (*Cetorhinus maximus*) occurrence in the lower Bay of Fundy, Canada. *J Exp Mar Biol Ecol* 465:24–32
- Howey-Jordan LA, Brooks EJ, Abercrombie DL, Jordan LK and others (2013) Complex movements, philopatry and expanded depth range of a severely threatened pelagic shark, the oceanic whitetip (*Carcharhinus longimanus*) in the Western North Atlantic. *PLOS ONE* 8:e56588
- Hoyos-Padilla EM, Ketchum JT, Klimley AP, Galván-Magaña F (2014) Ontogenetic migration of a female scalloped hammerhead shark *Sphyrna lewini* in the Gulf of California. *Animal Biotelemetry* 2:17
- Hueter RE, Tyminski JP, de la Parra R (2013) Horizontal movements, migration patterns, and population structure of whale sharks in the Gulf of Mexico and northwestern Caribbean Sea. *PLOS ONE* 8:e71883
- Huveneers C, Harcourt RG, Otway NM (2006) Observation of localised movements and residence times of the wobbegong shark *Orectolobus halei* at Fish Rock, NSW, Australia. *Cybium* 30:103–111
- Jorgensen SJ, Reeb CA, Chapple TK, Anderson S and others (2010) Philopatry and migration of Pacific white sharks. *Proc R Soc B* 277:679–688
- Keeney DB, Heupel M, Hueter RE, Heist EJ (2003) Genetic heterogeneity among blacktip sharks, *Carcharhinus limbatus*, continental nurseries along the U.S. Atlantic and Gulf of Mexico. *Mar Biol* 143:1039–1046
- Keeney DB, Heupel MR, Hueter RE, Heist EJ (2005) Microsatellite and mitochondrial DNA analyses of the genetic structure of blacktip shark (*Carcharhinus limbatus*) nurseries in the northwestern Atlantic, Gulf of Mexico & Caribbean Sea. *Mol Ecol* 14:1911–1923
- Kessel ST, Chapman DD, Franks BR, Gedamke T and others (2014) Predictable temperature-regulated residency, movement and migration in a large, highly mobile marine predator (*Negaprion brevirostris*). *Mar Ecol Prog Ser* 514:175–190
- Ketchum JT, Hearn A, Klimley AP, Peñaherrera C and others (2014) Inter-island movements of scalloped hammerhead sharks (*Sphyrna lewini*) and seasonal connectivity in a marine protected area of the eastern tropical Pacific. *Mar Biol* 161:939–951
- Kneebone J, Chisholm J, Skomal G (2014) Movement patterns of juvenile sand tigers (*Carcharias taurus*) along the east coast of the USA. *Mar Biol* 161:1149–1163
- Knip DM, Heupel MR, Simpfendorfer CA, Tobin AJ, Moloney J (2011) Ontogenetic shifts in movement and habitat use of juvenile pigeye sharks *Carcharhinus amboinensis* in a tropical nearshore region. *Mar Ecol Prog Ser* 425:233–246

- Knip DM, Heupel MR, Simpfendorfer CA (2012a) Habitat use and spatial segregation of adult spottail sharks *Carcharhinus sorrah* in tropical nearshore waters. *J Fish Biol* 80:767–784
- Knip DM, Heupel MR, Simpfendorfer CA (2012b) Evaluating marine protected areas for the conservation of tropical coastal sharks. *Biol Conserv* 148:200–209
- Kock A, O’Riain MJ, Mauff K, Meyer M, Kotze D, Griffiths C (2013) Residency, habitat use and sexual segregation of white sharks, *Carcharodon carcharias* in False Bay, South Africa. *PLOS ONE* 8:e55048
- Lea JS, Humphries NE, Clarke CR, Sims DW (2015a) To Madagascar and back: long-distance, return migration across open ocean by a pregnant female bull shark *Carcharhinus leucas*. *J Fish Biol* 87:1313–1321
- Lea JS, Wetherbee BM, Queiroz N, Burnie N and others (2015b) Repeated, long-distance migrations by a philopatric predator targeting highly contrasting ecosystems. *Sci Rep* 5:11202
- Legare B, Kneebone J, DeAngelis B, Skomal G (2015) The spatiotemporal dynamics of habitat use by blacktip (*Carcharhinus limbatus*) and lemon (*Negaprion brevirostris*) sharks in nurseries of St. John, United States Virgin Islands. *Mar Biol* 162:699–716
- Lewallen EA, Anderson TW, Bohonak AJ (2007) Genetic structure of leopard shark (*Triakis semifasciata*) populations in California waters. *Mar Biol* 152:599–609
- 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
- Madigan DJ, Brooks EJ, Bond ME, Gelsleichter J, Howey LA, Abercrombie DL, Chapman DD (2015) Diet shift and site-fidelity of oceanic whitetip sharks *Carcharhinus longimanus* along the Great Bahama Bank. *Mar Ecol Prog Ser* 529:185–197
- Matich P, Heithaus MR (2015) Individual variation in ontogenetic niche shifts in habitat use and movement patterns of a large estuarine predator (*Carcharhinus leucas*). *Oecologia* 178:347–359
- McAllister JD, Barnett A, Lyle JM, Semmens JM (2015) Examining the functional role of current area closures used for the conservation of an overexploited and highly mobile fishery species. *ICES J Mar Sci* 72:2234–2244
- McLaughlin RH, O’Gower AK (1971) Life history and underwater studies of a heterodont shark. *Ecol Monogr* 1971:271–289
- Meyer CG, Clark TB, Papastamatiou YP, Whitney NM, Holland KN (2009) Long-term movement patterns of tiger sharks *Galeocerdo cuvier* in Hawaii. *Mar Ecol Prog Ser* 381:223–235
- Mourier J, Planes S (2013) Direct genetic evidence for reproductive philopatry and associated fine-scale migrations in female blacktip reef sharks (*Carcharhinus melanopterus*) in French Polynesia. *Mol Ecol* 22:201–214
- Mourier J, Buray N, Schultz JK, Clua E, Planes S (2013) Genetic network and breeding patterns of a sicklefin lemon shark (*Negaprion acutidens*) population in the Society Islands, French Polynesia. *PLOS ONE* 8:e73899
- Munroe SE, Simpfendorfer CA, Moloney J, Heupel MR (2015a) Nearshore movement ecology of a medium-bodied shark, the creek whaler *Carcharhinus fitzroyensis*. *Animal Biotelemetry* 3:10
- Munroe SE, Heupel MR, Fisk AT, Logan M, Simpfendorfer CA (2015b) Regional movement patterns of a small-bodied shark revealed by stable isotope analysis. *J Fish Biol* 86:1567–1586

- Murchie KJ, Schwager E, Cooke SJ, Danylchuk AJ and others (2010) Spatial ecology of juvenile lemon sharks (*Negaprion brevirostris*) in tidal creeks and coastal waters of Eleuthera, The Bahamas. *Environ Biol Fishes* 89:95–104
- 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. *Mar Ecol Prog Ser* 499:157–175
- Oñate-González EC, Rocha-Olivares A, Saavedra-Sotelo NC, Sosa-Nishizaki O (2015) Mitochondrial genetic structure and matrilineal origin of white sharks, *Carcharodon carcharias*, in the Northeastern Pacific: implications for their conservation. *J Hered* 106:347–354
- 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* 90:996–1008
- Papastamatiou YP, Friedlander AM, Caselle JE, Lowe CG (2010) Long-term movement patterns and trophic ecology of blacktip reef sharks (*Carcharhinus melanopterus*) at Palmyra Atoll. *J Exp Mar Biol Ecol* 386:94–102
- Papastamatiou YP, Itano DG, Dale JJ, Meyer CG, Holland KN (2010) Site fidelity and movements of sharks associated with ocean-farming cages in Hawaii. *Mar Freshw Res* 61:1366–1375
- Papastamatiou YP, Meyer CG, Carvalho F, Dale JJ, Hutchinson MR, Holland KN (2013) Telemetry and random-walk models reveal complex patterns of partial migration in a large marine predator. *Ecology* 94:2595–2606
- Pardini AT, Jones CS, Noble LR, Kreiser B and others (2001) Sex-biased dispersal of great white sharks. *Nature* 412:139–140
- Portnoy DS, Hollenbeck CM, Belcher CN, Driggers WB and others (2014) Contemporary population structure and post-glacial genetic demography in a migratory marine species, the blacknose shark, *Carcharhinus acronotus*. *Mol Ecol* 23:5480–5495
- Portnoy DS, Puritz JB, Hollenbeck CM, Gelsleichter J, Chapman DD, Gold JR (2015) Selection and sex-biased dispersal in a coastal shark: the influence of philopatry on adaptive variation. *Mol Ecol* 24:5877–5885
- Powter DM, Gladstone W (2009) Habitat-mediated use of space by juvenile and mating adult Port Jackson sharks, *Heterodontus portusjacksoni*, in eastern Australia. *Pac Sci* 63:1–14
- 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:e88470
- Riley M, Hale M, Harman A, Rees R (2010) Analysis of whale shark *Rhincondon typus* aggregations near South Ari Atoll, Maldives Archipelago. *Aquat Biol* 8:145–150
- Robbins RL, Enarson M, Bradford RW, Robbins WD, Fox AG (2015) Residency and local connectivity of white sharks at Liguanea Island: a second aggregation site in South Australia? *The Open Fish Sci J* 8:23–29
- Smale MJ, Dicken ML, Booth AJ (2015) Seasonality, behaviour and philopatry of spotted ragged?tooth sharks *Carcharias taurus* in Eastern Cape nursery areas, South Africa. *Afr J Mar Sci* 37:219–231
- Speed CW, Meekan MG, Field IC, McMahon CR and others (2011) Spatial and temporal movement patterns of a multi-species coastal reef shark aggregation. *Mar Ecol Prog Ser* 429:261–275

- Speed CW, Meekan MG, Field IC, McMahon CR and others (2016) Reef shark movements relative to a coastal marine protected area. *Regional Studies in Marine Science* 3:58–66
- Teter SM, Wetherbee BM, Fox DA, Lam CH, Kiefer DA, Shivji M (2015) Migratory patterns and habitat use of the sand tiger shark (*Carcharias taurus*) in the western North Atlantic. *Mar Freshw Res* 66:158–169
- Thorburn J, Neat F, Bailey DM, Noble LR, Jones CS (2015) Winter residency and site association in the critically endangered North east Atlantic Spurdog (*Squalus acanthias*). *Mar Ecol Prog Ser* 526:113–124
- Tillett BJ, Meekan MG, Broderick D, Field IC, Cliff G, Ovenden JR (2012) Pleistocene isolation, secondary introgression and restricted contemporary gene flow in the pig-eye shark, *Carcharhinus amboinensis*, across northern Australia. *Conserv Genet* 13:99–115
- Vandeperre F, Aires-da-Silva A, Fontes J, Santos M, Santos RS, Afonso P (2014) Movements of blue sharks (*Prionace glauca*) across their life history. *PLOS ONE* 9:e103538
- Vianna GM, Meekan MG, Meeuwig JJ, Speed CW (2013) Environmental influences on patterns of vertical movement and site fidelity of grey reef sharks (*Carcharhinus amblyrhynchos*) at aggregation sites. *PLOS ONE* 8:e60331
- Vignaud TM, Mourier J, Maynard JA, Leblois R, Spaet JLY, Clua E, Neglia V, Planes S (2014) Blacktip reef sharks, *Carcharhinus melanopterus*, have high genetic structure and varying demographic histories in their Indo-Pacific range. *Mol Ecol* 23:5193–5207
- Werry JM, Lee SY, Lemckert CJ, Otway NM (2012) Natural or artificial? Habitat-use by the bull shark, *Carcharhinus leucas*. *PLOS ONE* 7:e49796
- Werry JM, Planes S, Berumen ML, Lee KA, Braun CD, Clua E (2014) Reef-fidelity and migration of tiger sharks, *Galeocerdo cuvier*, across the Coral Sea. *PLOS ONE* 9:e83249