IMPACTS OF SEISMIC AIRGUN NOISE ON FISH AND MARINE INVERTEBRATES

1. What are seismic surveys?

Seismic airgun blasting is a process that the oil and gas industry uses to identify and map oil and gas deposits under the seafloor. A typical seismic airgun survey involves a vessel traveling in successive parallel lines while towing one or multiple airgun arrays. Seismic airguns release pressurized air bubbles to create powerful sound waves that travel through the water column and seafloor[1] and provide information on the geologic formations more than 6 miles below the seafloor.[2] These sound waves travel as echoes back to the sea surface, where they are captured by hydrophones.[3]

2. Why is seismic airgun blasting a problem?

Airgun pulses are loud, repetitive, explosive sounds and are the second largest source of noise energy in the oceans, behind military explosives.[4] Loud blasts are repeated every 10-12 seconds for days, weeks, or months at a time. Noise from seismic airguns can travel over large distances because of its low pressure and high amplitude.[5] The sea surface area covered by the largest towed seismic array is 21 times larger than the National Mall in Washington, D.C.,[6] and seismic airgun blasts are so powerful they can be heard up to 2,500 miles from the source under some propagation conditions.[7] As the sound waves from the individual blasts move away from the sound source, they merge into continuous low frequency noise pollution that drowns out other sounds in the ocean.

3. Seismic noise can have significant and wide-ranging impacts on fish and invertebrates, including species that are commercially important.

a. The biological impacts of impulsive noise from seismic airgun blasting

Causes severe physical injury and mortality. Research into the impacts of exposure to pile driving (which generates similar acute, high-intensity, low-frequency sound as seismic operations) has shown substantial damage to the internal organs of fish, including the swim bladder, liver, kidney, and gonads.[8,9,10,11,12] For marine invertebrates, exposure to near-field low-frequency sound may cause anatomical damage. Strikingly, zooplankton abundance was found to decline by up to 50% (in 58% of the species examined) up to three quarters of a mile from a single airgun source (volume: 150 cubic inches) in 24 hours following exposure; krill larvae were completely wiped out.[13] Both immediate and post-exposure mortality of copepods has also been observed close (within 10 m) of the seismic source.[14] Pronounced sensory organ ("statocyst") and internal organ damage was observed in seven stranded giant squid after nearby seismic surveys.[15] Exposure of scallops to seismic signals was found to significantly increase mortality, particularly over long periods of time.[16,17]

Damages the hearing and sensory abilities of fish and marine invertebrates. For fish, the high-intensity of airgun emissions may damage hair cells and cause changes in associated hearing capabilities. Exposure to repeated emissions of a single airgun caused extensive damage to the sensory hair cells in the inner ear of the caged pink snapper; the damage was so severe that no repair or replacement of hair cells was observed for up to 58 days after exposure.[18] Rock lobsters were found to experience severe statocyst damage that resulted in reflex impairment (demonstrated by the ability of a lobster to right itself); these effects persisted for up to 365 days post exposure and did not improve following moulting.[19,20] Significant statocyst damage was also observed in the spiny lobster and persisted for an entire year following exposure to seismic airgun blasts.[21] It was hypothesized that the devastating impacts of a single seismic airgun on zooplankton was, at least in part, due to severe statocyst damage.[22]

Impedes development of early life history stages. Early life history stages of some groups of fish and invertebrates can be more susceptible to the impacts of underwater noise than older life stages.[23] Repeated exposure to nearby seismic sound caused slower development rates in the larvae of crabs[24] and scallops.[25] Lesions on the sensory cells of squid and cuttlefish appeared 48 hours following noise exposure in adults, whereas the same degree of damage was observed immediately after exposure in hatchlings.[26] Seismic activity has also been anecdotally implicated in larval recruitment declines.[27]

***Induces stress that physically damages marine invertebrates and compromises fish health*.** Experimental seismic noise has been shown to affect primary stress hormones (adrenaline and cortisol) in Atlantic salmon[28] and European seabass and Atlantic cod have shown elevated ventilation rates, indicating heightened stress, in response to seismic surveys;[29,30,31] elevated stress hormones and chemicals have also been recorded in sea bass following airgun exposure.[32] Invertebrates may exhibit common immune suppression and compromised ability to maintain homeostasis, with similar responses observed in scallops and spiny lobsters up to 120 days post-exposure,[33,34] potentially affecting the long-term health of associated fisheries.[35]

Causes startle and alarm responses that interrupt other vital behaviors, such as feeding and reproduction. Airgun discharges elicit varying degrees of startle and alarm responses in fish, including escape responses and changes in schooling patterns, water column positions, and swim speeds.[36,37,38,39,40,41,42,43,44,45,46] During seismic surveying, reef-fish abundance declined by 78% during evening hours when fish habitat use is usually highest.[47] Startle and alarm responses have been observed in captive fish several kilometers from the sound source, with European sea bass and the lesser sand eel responding at distances up to 2.5 and 5 km from a seismic source, respectively.[48,49] Field studies suggest that airgun exposure can lead to schools of some fish species to move lower in the water column,[50,51] change their horizontal and vertical position in the water column more frequently,[52] increase swim speeds, change diel movements in the post-survey period,[53] or move away from the sound source.[54]Squid have been observed to shelter in the quiet area near the ocean surface.[55] Startle responses are also commonly observed in marine invertebrates; jetting and inking – behaviors typically induced by ambush predators – have been observed in squid,[56,57,58] scallops have shown a distinctive flinching response in response to airgun signals and persistent alterations in reflex behavior following exposure, [59,60] and oysters close their valves and stop feeding.[61]

Change predator avoidance behaviors that may reduce probability of survival. Airgun exposure may have population-level implications if predation rates increase due to sound-induced behavioral changes. Scallops, rock lobster, and spiny lobster were slower to right themselves after exposure to airguns, increasing their chance of mortality from predation.[62,63,64] Saithe, a species of marine fish, became more dispersed following exposure to seismic airgun noise, potentially increasing vulnerability to predators.[65] Some fish and invertebrates may become habituated to sound and show fewer responses over exposure trials;[66,67,68,69] however, habituation may also make individuals less sensitive to predatory cues and increase their vulnerability to predation.[70]

Affect catch and abundance of commercial important species. If an animal is affected by seismic sound, associated catch may also be affected.[71] For example, commercial trawl and longline catches of Atlantic cod have been shown to fall by 45% and 70%, respectively, five days after seismic surveys in the Barents Sea.[72] Similar reductions in catch rates (52% decrease in catch per unit effort relative to controls) have been demonstrated in the hook-and-line fishery for rockfish during seismic discharges off the California coast.[73] Impacts appear to be species-specific and depend on catch method. Commercial catch rates of 15 species harvested using two gear types following a seismic survey in Bass Strait, Australia, were found to be higher for some species and lower for others.[74]

b. The biological impacts of continuous low frequency noise pollution produced by seismic surveys

***Damages the hearing and sensory abilities of fish and marine invertebrates*.** Continuous noise physically damages hair cells in fish ears[75,76] and the sensory receptors of marine invertebrates, including octopus, squid, and cuttlefish, that are responsible for their balance and position (known as "statocysts").[77,78,79] This damage can lead to permanent or temporary hearing loss in both groups.[80,81,82,83,84,85,86] Young individuals appear to be most sensitive; three species of cephalopod hatchlings showed more severe lesions in less time (almost immediately after sound exposure) than adults.[87] Even temporary loss of hearing or sensory capability can compromise an individual's chance of survival and the important role that they play in the larger marine ecosystem.

***Induces stress that physically damages marine invertebrates and compromises fish health*.** When exposed to continuous noise, marine invertebrates, including prawns and mussels, produce stress chemicals that degrade their DNA, alter gene expression, damage proteins, elicit an immune response, and impair vital functions such as oxygen consumption and filtration rate.[88,89] Fish, including seahorses, exhibit increases in ventilation and metabolic rate[90,91,92,93,94,95] and release stress chemicals, such as cortisol, [96,97,98,99] following noise exposure. Noise-induced cortisol exposure can compromise the long-term health of the individual.[100]

***Masks ('drowns out') important biological sounds essential to survival*.** Many fish communicate using frequency ranges that overlap least with the natural background noise of the ocean.[101,102,103] Similarly, the sensory systems of marine invertebrates are attuned to natural background noise conditions. Continuous noise pollution raises the background noise level and reduces the distance over which individuals of a species can communicate with one another,[104,105,106,107] which can have negative consequences for survival and reproduction. In addition, call rates and call complexity of fish assemblages were found to be significantly higher in low-noise environments relative to environments exposed to regulate regular motor boat noise, indicating community-level effects.[108]

***Reduces reproductive success, potentially jeopardizing the long-term sustainability of fish populations*.** Noise can mask courtship vocalizations necessary for successful mating[109,110] and can also disrupt social behaviors such as nest-digging, antipredator defense, and other social interactions necessary to successfully rear young.[111] Gobies and damselfish spend less time caring for their nests under noisy conditions,[112] female common goby spawning decisions are delayed by a reduced ability to assess male acoustic signals resulting in decreased spawning probability,[113] and common goby males exposed to noise had significantly fewer egg clutches and eggs hatched earlier than under ambient conditions.[114] Nesting success of the oyster toadfish was significantly lower in areas where their mating calls were masked.[115,116] Exposure to noise during spawning resulted in a significant reduction in total egg production and fertilization rates, which reduced the total production of viable embryos by over 50%.[117] Startle responses and faster yolk sac consumption have been observed in newly hatched Atlantic cod, which then grew to a smaller size than hatchlings not exposed to noise; this demonstrates that noise can impact survival related measures during development.[118]

***Interrupts feeding behaviors and induces other species-specific effects that may increase the risk of starvation, reducing reproduction, and alter community structure*.** Increased noise has been found to lead to significantly less foraging activity in fish, as individuals are startled,[119,120,121,122] take shelter,[123,124,125] or undertake an escape response.[126] Seahorses abandon habitat when exposed to transient motor boat noise.[127] The common cockle also suspends feeding and buries deeper into the sand in response to noise.[128] Disturbance from noise can force fish to feed at night when prey availability is also lowest,[129] which also results in an altered and likely sub-optimal diet composition.[130] In cases where fish and crabs are still able to locate prey, noise results in an increase in food handling errors and a reduced ability to discriminate between food and non-food items, consistent with a shift in attention.[131,132,133,134] Interruption of natural behaviors may, over the long-term, disrupt important ecosystem processes, such as the nutrient cycling carried out by sediment-dwelling invertebrates.[135]

***Increases risk of predation of fish and marine invertebrates, reducing survival and reproduction, and altering community structure*.** Response time to predators was significantly slower and the type of anti-predator behavior more variable in hermit crabs[136] and Ambon damselfish[137] exposed to noise. European eels were 50% less likely and 25% slower to show a startle response to an 'ambush' predator, and were caught more than twice as quickly by a 'pursuit' predator;[138] eels in poor condition were more likely to exhibit these behaviors than healthy individuals.[139] Shore crabs exhibit a 'freeze' response to noise, making them more vulnerable to predation from natural predators.[140] Noise can increase the foraging success of predatory species less affected by noise; for example, more than twice as many prey were consumed by the dusky dottyback in field experiments when motorboats were passing compared to ambient conditions.[141]

***Compromises the orientation of fish larvae with potential ecosystem-level affects*.** Most settlement stage fish move towards the component of coral reef noise that is produced by marine invertebrates, as a means to orient towards suitable settlement habitat.[142] The number of settlement stage coral reef fish larvae that moved towards a recording of natural coral reef with boat noise added was found to be 13% less than the natural sound alone. In addition, 44% moved away from the noise playback compared to only 8% during the natural reef playback.[143] Overall, fewer fish settled to reefs with added boat noise compared to reef noise alone.[144] Coral reefs with man-made noise showed an increased diversity of species and increased abundance of certain taxa of juvenile reef fish.[145] In the lab, settlement-stage larvae (~20 days old) exposed to man-made noise developed an attraction to that noise rather than the natural noise of the reef, whereas wild-caught larvae showed an attraction to reef noise and responded adversely to man-made noise.[146] Noise pollution can therefore affect the natural behavior of reef fish at a critical stage in their life history, and can disrupt the community composition of natural ecosystems.[147]

---

[1] "Seismic Surveys at Sea: The contributions of airguns to ocean noise," Backgrounder: Acoustic Ecology Institute, 2004.
[2] National Research Council. "Ocean Noise and Marine Mammals," Washington, DC: The National Academies Press. 2003.
[3] "Seismic Surveys at Sea: The contributions of airguns to ocean noise," Backgrounder: Acoustic Ecology Institute, 2004.
[4] Badelt, B., "The Inventor of the Seismic Air Gun Is Trying to Supplant His Controversial Creation," Hakai Magazine, 2015.
[5] A. Thode, K. H. Kim, C. R. Greene Jr., and E. Roth, "Long range transmission loss of broadband seismic pulses in the Arctic under ice-free conditions," *The Journal of the Acoustical Society of America*, vol. 128, no. 4, pp. EL181-EL187, 2010.
[6] M. Schuler, "MV Sanco Sword Tows Record-Setting Seismic Streamer Spread," *gCaptain*, 2015. Available at: http://gcaptain.com/mv-sanco-sword-tows-record-setting-seismic-streamer-spread/#.VoGysZfHIYA
[7] S. L. Nieukirk, D. K. Mellinger, S. E. Moore, K. Klinck, R. P. Dziak, and J. Goslin, "Sounds from airguns and fins whales recorded in the mid-Atlantic Ocean, 1999-2009." *The Journal of the Acoustical Society of America*, vol. 131, no. 2, pp. 1102-1112.
[8] B. M. Casper, A. N. Popper, F. Matthews, T. J., Carlson, and M. B. Halvorsen, "Recovery of barotrauma injuries in Chinook salmon, *Oncorhynchus tshawytscha,* from exposure to pile driving sound," *PLoS ONE*, vol. 7, p. e39593, 2012.
[9] M. B. Halvorsen, B. M. Casper, C. M. Woodley, T. J. Carlson, and A. N. Popper, "Threshold for onset of injury in Chinook salmon from exposure to impulsive pile driving sounds," *PLoS ONE*, vol. 7, p. e38968, 2012.
[10] B. M. Casper, M. B. Halvorsen, F. Matthews, T. J. Carlson, and A. N. Popper, "Recovery of barotrauma injuries resulting from exposure to pile driving sound in two sizes of hybrid striped bass," *PLoS ONE*, vol. 7, p. e73844, 2013.
[11] M. B. Halvorsen, D. G. Zeddies, D. Chicoine, and A. N. Popper, "Effects of low-frequency naval sonar exposure on three species of fish," *Journal of the Acoustical Society of America*, vol. 134, pp. EL205-EL210, 2013.
[12] M. B. Halvorsen, B. M. Casper, T. J. Carlson, and A. N. Popper, "Barotrauma injury onset relative to number of impulses and sound exposure level," Presentation at Oceanoise2017 Conference, Vilanova i la Geltrú, Barcelona, Spain, 8-12 May, 2017.
[13] R. D. McCauley, R. D. Day, K. M. Swadling, Q. P. Fitzgibbon, R. A. Watson, and J. A. Semmens, "Widely used marine seismic survey air gun operations negatively impact zooplankton," *Nature Ecology & Evolution,* vol. 1, Article no. 0195, 2017.
[14] D. M. Fields, N. O. Handegard, J. Dalen, C. Eichner, K. Malde, Ø. Karlsen, A. B. Skiftesvik, C. M. F. Durif, and H. I. Browman, "Airgun blasts used in marine seismic surveys have limited effects on mortality, and no sublethal effects on behavior or gene expression, in the copepod *Calanus finmarchicus*," *ICES Journal of Marine Science*, fsz126, 2019.
[15] Á. Guerra, Á. F. González, and F. Rocha, "A review of the records of giant squid in the north-eastern Atlantic and severe injuries in *Architeuthis dux* stranded after acoustic explorations," *ICES CM*, vol. 200, p. 29, 2004.
[16] R. D. Day, R. McCauley, Q. P. Fitzgibbon, and J. M. Semmens, "Assessing the impact of marine seismic surveys on Southeast Australian scallop and lobster fisheries," FRDC Report 2012/008, University of Tasmania, Hobart, 2016a.
[17] R. D. Day, R. D. McCauley, Q. P. Fitzgibbon, K. Hartmann, and J. M. Semmens, "Exposure to seismic air gun signals causes physiological harm and alters behavior in the scallop *Pecten fumatus*," *PNAS*, vol. 114, pp. E8537-E8546, 2017.
[18] R. D. McCauley, J. Fewtrell, and A. N. Popper, "High intensity anthropogenic sound damages fish ears," *Journal of the Acoustical Society of America*, vol. 113, pp. 638-642, 2003.
[19] R. D. Day, R. D. McCauley, Q. P. Fitzgibbon, K. Hartmaan, and J. M. Semmens, "Seismic airguns damage rock lobster mechanosensory organs and impair righting reflex," *PRSB: Biological Sciences*, published online 14 July, 2019.
[20] R. D. Day, R. McCauley, Q. P. Fitzgibbon, and J. M. Semmens, "Assessing the impact of marine seismic surveys on Southeast Australian scallop and lobster fisheries," FRDC Report 2012/008, University of Tasmania, Hobart, 2016a.
[21] J. Semmens, R. D. Day, Q. P. Fitzgibbon, K. Hartmann, and C. J. Simon, "Are seismic surveys putting bivalve and spiny lobster fisheries at risk," Presentation at Oceanoise2017 Conference, Vilanova i la Geltrú, Barcelona, Spain, 8-12 May, 2017.
[22] R. D. McCauley, R. D. Day, K. M. Swadling, Q. P. Fitzgibbon, R. A. Watson, and J. A. Semmens, "Widely used marine seismic survey air gun operations negatively impact zooplankton," *Nature Ecology & Evolution,* vol. 1, Article no. 0195, 2017.
[23] A. G. Carroll, R. Przeslawski, A. Duncan, M. Gunning, and B. Bruce, "A critical review of the potential impacts of marine seismic surveys on fish and invertebrates," *Marine Pollution Bulletin*, vol. 114, no. 1, pp. 9-24, 2017.

[24] J. R. Christian, A. Mathieu, D. H. Thompson, D. White, and R. A. Buchanan, "Effect of seismic energy on snow crab (*Chionoecetes opilio*)," Environmental Funds Project No. 158, Fisheries and Oceans Canada, Calgary, 2003.
[25] N. Aguilar de Soto, N. Delorme, J. Atkins, S. Howard, J. Williams, and M. Johnson, "Anthropogenic noise causes body malformations and delays development in marine larvae," *Scientific Reports*, vol. 3, 2013.
[26] M. Solé, M. Lenoir, J. M. Fortuño, M. van der Schaar, and M. André, "Sensitivity to sound of cephalopod hatchlings," Presentation at Oceanoise2017 Conference, Vilanova i la Geltrú, Barcelona, Spain, 8-12 May, 2017.
[27] http://www.abc.net.au/site-archive/rural/tas/content/2012/08/s3576796.htm
[28] A. Sverdrup, E. Kjellsby, P. Krüger, R. Fløysand, F. Knudsen, P. Enger, G. Serck-Hanssen, and K. Helle, "Effects of experimental seismic shock on vasoactivity of arteries, integrity of the vascular endothelium and on primary stress hormones of the Atlantic salmon," *Journal of Fish Biology*, vol. 45, pp. 973-995, 1994.
[29] A. N. Radford, L. Lèbre, G. Lecaillon, S. L. Nedelec, and S. D. Simpson, "Repeated exposure reduces the response to impulsive noise in European seabass," *Global Change Biology*, vol. 22, pp. 3349-3360, 2016.
[30] I. Spiga, N. Aldred, and G. S. Caldwell, "Anthropogenic noise compromises the anti-predator behaviour of the European seabass, *Dicentrarchus labrax* (L.)," *Marine Pollution Bulletin*, vol. 122, pp. 297-305.
[31] J. G. Davidsen, H. Dong, M. Linné, M. H. Andersson, A. Piper, A. Piper, T. S. Prystay, E. B. Hvam, E. B. Thorstad, F. Whoriskey, S. J. Cooke, A.D. Sjursen, L. Rønning, T.C. Netland, and A. D. Hawkins, "Effects of sound exposure from a seismic airgun on heart rate, acceleration and depth use in free-swimming Atlantic cod and saithe," *Conservation Physiology*, vol. 7, art. coz020, 2019.
[32] A. Santulli, A. Modica, C. Messina, L. Ceffa, A. Curatolo, G. Rivas, G. Fabi, and V. D'Amelio, "Biochemical responses of European sea bass (*Dicentrarchus labrax* L) to the stress induced by offshore experimental seismic prospecting," *Marine Pollution Bulletin*, vol. 38, pp.1105-1114, 1999.
[33] Q. P. Fitzgibbon, R. D. Day, R. D. McCauley, C. J. Simon, and J. M. Semmens, "The impact of seismic air gun exposure on the haemolymph physiology and nutritional condition of the spiny lobster," *Marine Pollution Bulletin*, In press.
[34] R. D. Day, R. D. McCauley, Q. P. Fitzgibbon, K. Hartmann, and J. M. Semmens, "Exposure to seismic air gun signals causes physiological harm and alters behavior in the scallop *Pecten fumatus*," *PNAS*, vol. 114, pp. E8537-E8546, 2017.
[35] J. Semmens, R. D. Day, Q. P. Fitzgibbon, K. Hartmann, and C. J. Simon, "Are seismic surveys putting bivalve and spiny lobster fisheries at risk," Presentation at Oceanoise2017 Conference, Vilanova i la Geltrú, Barcelona, Spain, 8-12 May, 2017.
[36] W. H. Pearson, J. R. Skalski, and C. I. Malme, "Effects of sounds from a geophysical survey device on behavior of captive rockfish (*Sebastes* spp.)," *Canadian Journal of Fisheries and Aquatic Science*, vol. 49, pp. 1343-1356, 1992.
[37] A. Santulli, A. Modica, C. Messina, L. Ceffa, A. Curatolo, G. Rivas, G. Fabi, and V. D'Amelio, "Biochemical responses of European sea bass (*Dicentrarchus labrax* L) to the stress induced by offshore experimental seismic prospecting,"*Marine Pollution Bulletin*, vol. 38, pp.1105-1114, 1999.
[38] C. S. Wardle, T. J. Carter, G. G. Urquhart, A. D. F. Johnstone, A. M. Ziolkowski, G. Hampson, and D. Mackie, "Effects of seismic air guns on marine fish," *Continental Shelf Research*, vol. 21, pp. 1005-1027, 2001.
[39] A. Hassel, T. Knutsen, J. Dalen, K. Skaar, S. Løkkeborg, O. A. Misund, Ø. Østensen, M. Fonn, and E. K. Haugland, "Influence of seismic shooting on the lesser sandeel (*Ammodytes marinus*)," *ICES Journal of Marine Science*, vol. 61, pp. 1165-1173, 2004.
[40] W. A. Boeger, M. R. Pie, A. Ostrensky, and M. F. Cardoso, "The effect of exposure to seismic prospecting on coral reef fishes," *Brazilian Journal of Oceanography*, vol. 54, pp. 235-239, 2006.
[41] J. L. Fewtrell and R. D. McCauley, "Impact of air gun noise on the behavior of marine fish and squid," *Marine Pollution Bulletin*, vol. 64, pp. 984-993, 2012.
[42] R. Hansen, L. D. Silve, H. E. Karlsen, and N. O. Handegaard, "Playback of seismic airgun signals and infrasound elicit evasive swimming responses in the Atlantic mackerel (*Scomber scombrus*)," Presentation at Oceanoise2017 Conference, Vilanova i la Geltrú, Barcelona, Spain, 8-12 May, 2017.
[43] T. N. Forland, R. H. Hansen, H. E. Karlsen, P. H. Kvadsheim, M. Andersson, M. Linné, E. Grimsbí, and L. D. Silve, "Behavior of penned Atlantic mackerel exposed to increasing levels of seismic argun pulses," Presentation at Oceanoise2017 Conference, Vilanova i la Geltrú, Barcelona, Spain, 8-12 May, 2017.
[44] B. Bruce, R. Bradford, S. Foster, K. Lee, M. Lansdell, S. Cooper, and R. Przeslawski, "Quantifying fish behaviour and commercial catch rates in relation to a marine seismic survey," *Marine Environmental Research*, vol. 140, pp. 18-30, 2019.
[45] J. G. Davidsen, H. Dong, M. Linné, M. H. Andersson, A. Piper, A. Piper, T. S. Prystay, E. B. Hvam, E. B. Thorstad, F. Whoriskey, S. J. Cooke, A.D. Sjursen, L. Rønning, T.C. Netland, and A. D. Hawkins, "Effects of sound exposure from a seismic airgun on heart rate, acceleration and depth use in free-swimming Atlantic cod and saithe," *Conservation Physiology*, vol. 7, art. coz020, 2019.
[46] J. M. Rivera, D. C. Glover, P. M. Kocovsky, J. E. Garvey, M. P. Gaikowski, N. R. Jensen, and R. F. Adams, "Water guns affect abundance and behavior of bigheaded carp and native fish differently," *Biological Invasions*, vol. 20, pp. 1243-1255, 2018.
[47] A. B. Paxton, J. C. Taylor, D P. Nowacek, J. Dale, E. Cole, C. M. Voss, and C. H. Peterson. "Seismic survey noise disrupted fish use of a temperate reef," *Marine Policy,* vol. 78, pp. 68-73.
[48] A. Santulli, A. Modica, C. Messina, L. Ceffa, A. Curatolo, G. Rivas, G. Fabi, and V. D'Amelio, "Biochemical responses of European sea bass (*Dicentrarchus labrax* L) to the stress induced by offshore experimental seismic prospecting,"*Marine Pollution Bulletin*, vol. 38, pp.1105-1114, 1999.

[49] A. Hassel, T. Knutsen, J. Dalen, K. Skaar, S. Løkkeborg, O. A. Misund, Ø. Østensen, M. Fonn, and E. K. Haugland, "Influence of seismic shooting on the lesser sandeel (*Ammodytes marinus*)," *ICES Journal of Marine Science*, vol. 61, pp. 1165-1173, 2004.
[50] C. Chapman and A. Hawkins, "The importance of sound in fish behavior in relation to capture by trawls," FAO Fisheries and Aquaculture Report, vol. 62, no. 3, pp. 717-718, 1969.
[51] A. Slotte, K. Hansen, J. Dalen, and E. Ona, "Acoustic mapping of pelagic fish distribution and abundance in relation to a seismic shooting area off the Norwegian west coast," *Fisheries Research*, vol. 67, pp. 143-150, 2004.
[52] J. G. Davidsen, H. Dong, M. Linné, M. H. Andersson, A. Piper, A. Piper, T. S. Prystay, E. B. Hvam, E. B. Thorstad, F. Whoriskey, S. J. Cooke, A.D. Sjursen, L. Rønning, T.C. Netland, and A. D. Hawkins, "Effects of sound exposure from a seismic airgun on heart rate, acceleration and depth use in free-swimming Atlantic cod and saithe," *Conservation Physiology*, vol. 7, art. coz020, 2019.
[53] B. Bruce, R. Bradford, S. Foster, K. Lee, M. Lansdell, S. Cooper, and R. Przeslawski, "Quantifying fish behaviour and commercial catch rates in relation to a marine seismic survey," *Marine Environmental Research*, vol. 140, pp. 18-30, 2019.
[54] J. M. Rivera, D. C. Glover, P. M. Kocovsky, J. E. Garvey, M. P. Gaikowski, N. R. Jensen, and R. F. Adams, "Water guns affect abundance and behavior of bigheaded carp and native fish differently," *Biological Invasions*, vol. 20, pp. 1243-1255, 2018.
[55] McCauley et al. 2000
[56] J. L. Fewtrell and R. D. McCauley, "Impact of air gun noise on the behavior of marine fish and squid," *Marine Pollution Bulletin*, vol. 64, pp. 984-993, 2012.
[57] J. E. Samson, T. A. Mooney, S. W. S. Gussekloo, and R. T. Hanlon, "Graded behavioral responses and habituation to sound in the common cuttlefish *Sepia officinalis,*" *Journal of Experimental Biology*, vol. 217, pp. 4347-4355, 2014.
[58] T. A. Mooney, J. E. Samson, A. D. Schlunk, S. Zacarias, "Loudness-dependent behavioural responses and habituation to sound by the longfin squid (*Doryteuthis pealeii*)," *Journal of Comparative Physiology A*, vol. 202, no. 7, pp. 489-501, 2016.
[59] R. D. Day, R. McCauley, Q. P. Fitzgibbon, and J. M. Semmens, "Assessing the impact of marine seismic surveys on Southeast Australian scallop and lobster fisheries," FRDC Report 2012/008, University of Tasmania, Hobart, 2016a.
[60] R. D. Day, R. D. McCauley, Q. P. Fitzgibbon, K. Hartmann, and J. M. Semmens, "Exposure to seismic air gun signals causes physiological harm and alters behavior in the scallop *Pecten fumatus*," *PNAS*, vol. 114, pp. E8537-E8546, 2017.
[61] M. Charifi, M. Sow, P. Ciret, S. Benomar, and J-C. Massabuau, "The sense of hearing in the Pacific oyster, *Magallana gigas*," *PLoS ONE*, vol. 12, pp. e0185353, 2017.
[62] R. D. Day, R. McCauley, Q. P. Fitzgibbon, and J. M. Semmens, "Assessing the impact of marine seismic surveys on Southeast Australian scallop and lobster fisheries," FRDC Report 2012/008, University of Tasmania, Hobart, 2016a.
[63] R. D. Day, R. D. McCauley, Q. P. Fitzgibbon, K. Hartmann, and J. M. Semmens, "Exposure to seismic air gun signals causes physiological harm and alters behavior in the scallop *Pecten fumatus*," *PNAS*, vol. 114, pp. E8537-E8546, 2017.
[64] J. Semmens, R. D. Day, Q. P. Fitzgibbon, K. Hartmann, and C. J. Simon, "Are seismic surveys putting bivalve and spiny lobster fisheries at risk," Presentation at Oceanoise2017 Conference, Vilanova i la Geltrú, Barcelona, Spain, 8-12 May, 2017.
[65] J. G. Davidsen, H. Dong, M. Linné, M. H. Andersson, A. Piper, A. Piper, T. S. Prystay, E. B. Hvam, E. B. Thorstad, F. Whoriskey, S. J. Cooke, A.D. Sjursen, L. Rønning, T.C. Netland, and A. D. Hawkins, "Effects of sound exposure from a seismic airgun on heart rate, acceleration and depth use in free-swimming Atlantic cod and saithe," *Conservation Physiology*, vol. 7, art. coz020, 2019.
[66] J. L. Fewtrell and R. D. McCauley, "Impact of air gun noise on the behavior of marine fish and squid," *Marine Pollution Bulletin*, vol. 64, pp. 984-993, 2012.
[67] J. E. Samson, T. A. Mooney, S. W. S. Gussekloo, and R. T. Hanlon, "Graded behavioral responses and habituation to sound in the common cuttlefish *Sepia officinalis,*" *Journal of Experimental Biology*, vol. 217, pp. 4347-4355, 2014.
[68] T. A. Mooney, J. E. Samson, A. D. Schlunk, S. Zacarias, "Loudness-dependent behavioural responses and habituation to sound by the longfin squid (*Doryteuthis pealeii*)," *Journal of Comparative Physiology A*, vol. 202, no. 7, pp. 489-501, 2016.
[69] J. G. Davidsen, H. Dong, M. Linné, M. H. Andersson, A. Piper, A. Piper, T. S. Prystay, E. B. Hvam, E. B. Thorstad, F. Whoriskey, S. J. Cooke, A.D. Sjursen, L. Rønning, T.C. Netland, and A. D. Hawkins, "Effects of sound exposure from a seismic airgun on heart rate, acceleration and depth use in free-swimming Atlantic cod and saithe," *Conservation Physiology*, vol. 7, art. coz020, 2019.
[70] I. Spiga, N. Aldred, and G. S. Caldwell, "Anthropogenic noise compromises the anti-predator behaviour of the European seabass, *Dicentrarchus labrax* (L.)," *Marine Pollution Bulletin*, vol. 122, pp. 297-305.
[71] A. G. Carroll, R. Przeslawski, A. Duncan, M. Gunning, and B. Bruce, "A critical review of the potential impacts of marine seismic surveys on fish and invertebrates," *Marine Pollution Bulletin*, vol. 114, no. 1, pp. 9-24, 2017.
[72] A. Engås, S. Løkkeborg, E. Ona, and A. V. Soldal, "Effects of seismic shooting and vessel-generated noise on fish behavior and catch rates," *Bioacoustics*, vol. 12, pp. 313-316, 1996.
[73] J. R. Skalski, W. H. Pearson, and C. J. Malme, "Effects of sounds from a geophysical survey device on catch-per-unit-effort in a hook-and-line fishery for rockfish (*Sebastes* spp.)," *Canadian Journal of Fisheries and Aquatic Science*, vol. 49, pp. 1357-1365, 1992.
[74] B. Bruce, R. Bradford, S. Foster, K. Lee, M. Lansdell, S. Cooper, and R. Przeslawski, "Quantifying fish behaviour and commercial catch rates in relation to a marine seismic survey," *Marine Environmental Research*, vol. 140, pp. 18-30, 2019.
[75] M. E. Smith, J. B. Schuck, R. R. Gilley, and B. D. Rogers, "Structural and functional effects of acoustic exposure in goldfish: evidence for tonotopy in the teleost saccule," *BMC neuroscience*, vol. 12, no. 19, p. doi:10.1186/1471-2202-12-19, 2011.

[76] M. F. Mickle, C. M. Harris, O. P. Love, and D. M. Higgins, "Behavioral and morphological changes in fish exposed to ecologically relevant boat noise," *Canadian Journal of Fisheries and Aquatic Sciences*, submitted 25 November, 2018.
[77] M. Solé, M. Lenoir, M. Durfort, M. López-Bejar, A. Lombarte, and M. André, "Ultrastructural Damage of Loligo vulgaris and Illex coindetii statocysts after Low Frequency Sound Exposure," *PLoS ONE*, vol. 8, no. 10, pp. 1–12, 2013a.
[78] M. Solé, M. Lenoir, M. Durfort, M. López-Bejar, A. Lombarte, M. Van Der Schaar, and M. André, "Does exposure to noise from human activities compromise sensory information from cephalopod statocysts?," *Deep-Sea Research Part II: Topical Studies in Oceanography*, vol. 95, pp. 160–181, 2013b.
[79] M. Solan, C. Hauton, J. A. Godbold, C. L. Wood, T. G. Leighton, and P. White, "Anthropogenic sources of underwater sound can modify how sediment-dwelling invertebrates mediate ecosystem properties," *Scientific Reports*, vol. 6, no. 1, p. 20540, 2016.
[80] A. J. Belanger, I. Bobeica, and D. M. Higgs, "The effect of stimulus type and background noise on hearing abilities of the round goby Neogobius melanostomus," *Journal of Fish Biology*, vol. 77, no. 7, pp. 1488–1504, 2010.
[81] M. Gutscher, L. E. Wysocki, and F. Ladich, "Effects of Aquarium and Pond Noise on Hearing Sensitivity in an Otophysine Fish," *Bioacoustics*, vol. 20, no. 2, pp. 117–136, 2011.
[82] M. Liu, Q. W. Wei, H. Du, Z. Y. Fu, and Q. C. Chen, "Ship noise-induced temporary hearing threshold shift in the Chinese sucker Myxocyprinus asiaticus (Bleeker, 1864)," *Journal of Applied Ichthyology*, vol. 29, no. 6, pp. 1416–1422, 2013.
[83] A. R. Scholik and H. Y. Yan, "Effects of boat engine noise on the auditory sensitivity of the fathead minnow, Pimephales promelas," *Environmental Biology of Fishes*, vol. 63, no. 2, pp. 203–209, 2002.
[84] A. R. Scholik and H. Y. Yan, "The effects of noise on the auditory sensitivity of the bluegill sunfish, Lepomis macrochirus," *Comparative Biochemistry and Physiology Part A*, vol. 133, pp. 43–52, 2002.
[85] M. E. Smith, "Noise-induced stress response and hearing loss in goldfish (Carassius auratus)," *Journal of Experimental Biology*, vol. 207, no. 3, pp. 427–435, 2004.
[86] M. E. Smith, J. B. Schuck, R. R. Gilley, and B. D. Rogers, "Structural and functional effects of acoustic exposure in goldfish: evidence for tonotopy in the teleost saccule," *BMC neuroscience*, vol. 12, no. 19, p. doi:10.1186/1471-2202-12-19, 2011.
[87] Solé, M; Lenoir, M; Fortuño, JM; van der Schaar, M; André, M, "Sensitivity of sound to cephalopod hatchlings," Presentation at Oceanoise2017 Conference, Vilanova i la Geltrú, Barcelona, Spain, 8-12 May, 2017.
[88] F. Filiciotto, M. Vazzana, M. Celi, V. Maccarrone, M. Ceraulo, G. Buffa, V. Arizza, G. de Vincenzi, R. Grammauta, S. Mazzola, and G. Buscaino, "Underwater noise from boats: Measurement of its influence on the behaviour and biochemistry of the common prawn (Palaemon serratus, Pennant 1777)," *Journal of Experimental Marine Biology and Ecology*, vol. 478, pp. 24–33, 2016.
[89] M. A. Wale, R. A. Briers, M. G. J. Hartl, D. Bryson, and K. Diele, "From DNA to ecological performance: Effects of anthropogenic noise on a reef-building mussel," *Science of the Total Environment*, vol. 289, 2019.

[90] R. Bruintjes, J. Purser, K. A. Everley, S. Mangan, S. D. Simpson, and A. N. Radford, "Rapid recovery following short-term acoustic disturbance in two fish species," *Royal Society open science*, vol. 3, p. 150686, 2016.
[91] J. Purser, R. Bruintjes, S. D. Simpson, and A. N. Radford, "Condition-dependent physiological and behavioural responses to anthropogenic noise," *Physiology and Behavior*, vol. 155, pp. 157–161, 2016.
[92] S. L. Nedelec, S. C. Mills, D. Lecchini, B. Nedelec, S. D. Simpson, and A. N. Radford, "Repeated exposure to noise increases tolerance in a coral reef fish," *Environmental Pollution*, vol. 216, pp. 428–436, 2016.
[93] S. D. Simpson, J. Purser, and A. N. Radford, "Anthropogenic noise compromises antipredator behaviour in European eels," *Global Change Biology*, vol. 21, no. 2, pp. 586–593, 2015.
[94] R. Bruintjes and A. N. Radford, "Context-dependent impacts of anthropogenic noise on individual and social behaviour in a cooperatively breeding fish," *Animal Behaviour*, vol. 85, no. 6, pp. 1343–1349, 2013.
[95] J. Palma, M. Magalhaes, M. Correia, and J. P. Andrade, "Effects of anthropogenic noise as a source of acoustic stress on wild populations of *Hippocampus guttulatus* in the Ria Formose, south Portugal," *Aquatic Conservation*, vol. 29, pp. 751-759, 2019.
[96] R. Bruintjes, J. Purser, K. A. Everley, S. Mangan, S. D. Simpson, and A. N. Radford, "Rapid recovery following short-term acoustic disturbance in two fish species," *Royal Society open science*, vol. 3, p. 150686, 2016.
[97] J. A. Crovo, M. T. Mendon, D. E. Holt, and C. E. Johnston, "Stress and auditory responses of the otophysan fish, Cyprinella venusta, to road traffic noise," *PLoS ONE*, vol. 10, no. 9, pp. 3–11, 2015.
[98] R. Sierra-Flores, T. Atack, H. Migaud, and A. Davie, "Stress response to anthropogenic noise in Atlantic cod Gadus morhua L.," *Aquacultural Engineering*, vol. 67, pp. 67–76, 2015.
[99] T. Wysocki and L. Gavin, "Paternal involvement in the management of pediatric chronic diseases: Associations with adherence, quality of life, and health status," *Journal of Pediatric Psychology*, vol. 31, no. 5, pp. 501–511, 2006.
[100] M. Spreng, "Possible health effects of noise induced cortisol increase," *Noise and Health*, vol. 2, no. 7, pp. 59-63, 2000.
[101] A. Codarin, L. E. Wysocki, F. Ladich, and M. Picciulin, "Effects of ambient and boat noise on hearing and communication in three fish species living in a marine protected area (Miramare, Italy)," *Marine Pollution Bulletin*, vol. 58, no. 12, pp. 1880–1887, 2009.

[102] P. Speares, D. Holt, and C. Johnston, "The relationship between ambient noise and dominant frequency of vocalizations in two species of darters (Percidae: Etheostoma)," *Environmental Biology of Fishes*, vol. 90, no. 1, pp. 103–110, 2011.
[103] D. E. Holt and C. E. Johnston, "Traffic noise masks acoustic signals of freshwater stream fish," *Biological Conservation*, vol. 187, pp. 27–33, 2015.
[104] A. Codarin, L. E. Wysocki, F. Ladich, and M. Picciulin, "Effects of ambient and boat noise on hearing and communication in three fish species living in a marine protected area (Miramare, Italy)," *Marine Pollution Bulletin*, vol. 58, no. 12, pp. 1880–1887, 2009.
[105] P. Speares, D. Holt, and C. Johnston, "The relationship between ambient noise and dominant frequency of vocalizations in two species of darters (Percidae: Etheostoma)," *Environmental Biology of Fishes*, vol. 90, no. 1, pp. 103–110, 2011.
[106] D. E. Holt and C. E. Johnston, "Traffic noise masks acoustic signals of freshwater stream fish," *Biological Conservation*, vol. 187, pp. 27–33, 2015.
[107] P. J. Fonseca, C. M. Amorim, and D. Alves, "Boat noise reduces acoustic active space in the Lusitanian toadfish *Halobatrachus didactylus*," Presentation at the 4th International Conference on the Effects of Noise on Aquatic Life, Dublin, Ireland, 10-15 July, 2016.
[108] Correa, J. M. G., J-T. B. Sempere, F. Juanes, R. Rountree, J. F. Ruiz, and J. Ramis, "Recreational boat traffic effects on fish assemblages: First evidence of detrimental consequences at regulated mooring zone in sensitive marine areas detected by passive acoustics," *Ocean & Coastal Management*, vol. 168, pp. 22-34, 2019.
[109] R. Bruintjes and A. N. Radford, "Context-dependent impacts of anthropogenic noise on individual and social behaviour in a cooperatively breeding fish," *Animal Behaviour*, vol. 85, no. 6, pp. 1343–1349, 2013.
[110] R. O. Vasconcelos, M. C. P. Amorim, and F. Ladich, "Effects of ship noise on the detectability of communication signals in the Lusitanian toadfish," *Journal of Experimental Biology*, vol. 210, no. 12, pp. 2104–2112, 2007.
[111] R. Bruintjes and A. N. Radford, "Context-dependent impacts of anthropogenic noise on individual and social behaviour in a cooperatively breeding fish," *Animal Behaviour*, vol. 85, no. 6, pp. 1343–1349, 2013.
[112] M. Picciulin, L. Sebastianutto, A. Codarin, A. Farina, and E. A. Ferrero, "In situ behavioural responses to boat noise exposure of Gobius cruentatus (Gmelin, 1789; fam. Gobiidae) and Chromis (Linnaeus, 1758; fam. Pomacentridae) living in a Marine Protected Area," *Journal of Experimental Marine Biology and Ecology*, vol. 386, no. 1–2, pp. 125–132, 2010.
[113] E-L. Blom, C. Kvarnemo, I. Dekla, S. Schold, M. H. Andersson, O. Svensson, and M. C. P. Amorim, "Continuous but not intermittent noise has a negative impact on mating success in a marine fish with paternal care," *Scientific Reports*, vol. 9, art. 5494, 2019.
[114] E-L. Blom, S. Schöld, L. Kvarnemo, O. Svensson, and C. Amorim, "Silence is golden, at least for a common goby male who wants to mate," Presentation at the 4th International Conference on the Effects of Noise on Aquatic Life, Dublin, Ireland, 10-15 July, 2016.
[115] C. S. Krahforst, M. W. Sprague, M. Rose, M. Heater, M. L. Fine, and J. J. Luczkovich, "Impact of vessel noise on fish communication, reproduction, and larval development," Presentation at the 4th International Conference on the Effects of Noise on Aquatic Life, Dublin, Ireland, 10-15 July, 2016.
[116] J. J. Luczokovich, C. S. Krahforst, H. Hoppe, and M. W. Sprague, "Does vessel noise affect oyster toadfish calling rates?" pp. 647-653, In: A. N. Popper and A. Hawkins (eds.), "The effects of noise on aquatic life II," Advances in Experimental Medicine and Biology, vol. 875, 2013.
[117] R. Sierra-Flores, T. Atack, H. Migaud, and A. Davie, "Stress response to anthropogenic noise in Atlantic cod Gadus morhua L.," *Aquacultural Engineering*, vol. 67, pp. 67–76, 2015.
[118] S. L. Nedelec, S. D. Simpson, E. L. Morley, B. Nedelec, and A. N. Radford, "Impacts of regular and random noise on the behaviour, growth and development of larval Atlantic cod (Gadus morhua)," *Proceedings of the Royal Society of London B: Biological Sciences*, vol. 282, no. 1817, pp. 1–7, 2015.
[119] J. Purser and A. N. Radford, "Acoustic noise induces attention shifts and reduces foraging performance in three-spined sticklebacks (Gasterosteus aculeatus)," *PLoS ONE*, vol. 6, no. 2, 2011.
[120] S. S. Sabet, Y. Y. Neo, and H. Slabbekoorn, "The effect of temporal variation in sound exposure on swimming and foraging behaviour of captive zebrafish," *Animal Behaviour*, vol. 107, pp. 49–60, 2015.
[121] I. K. Voellmy, J. Purser, D. Flynn, P. Kennedy, S. D. Simpson, and A. N. Radford, "Acoustic noise reduces foraging success in two sympatric fish species via different mechanisms," *Animal Behaviour*, vol. 89, pp. 191–198, 2014a.
[122] M. I. McCormick, E. P. Fakan, S. L. Nedelec, and B. J. M. Allan, "Effects of boat noise on fish fast-start escape response depend on engine type," *Scientific Reports*, vol. 9, art. 6554, 2019.
[123] K. E. McLaughlin and H. P. Kunc, "Changes in the acoustic environment alter the foraging and sheltering behaviour of the cichlid Amititlania nigrofasciata," *Behavioural Processes*, vol. 116, pp. 75–79, 2015.
[124] N. L. Payne, D. E. van der Meulen, I. M. Suthers, C. A. Gray, and M. D. Taylor, "Foraging intensity of wild mulloway Argyrosomus japonicus decreases with increasing anthropogenic disturbance," *Marine Biology*, vol. 162, no. 3, pp. 539–546, 2015.
[125] M. F. Mickle, C. M. Harris, O. P. Love, and D. M. Higgins, "Behavioral and morphological changes in fish exposed to ecologically relevant boat noise," *Canadian Journal of Fisheries and Aquatic Sciences*, submitted 25 November, 2018.

[126] C. Bracciali, D. Campobello, C. Giacoma, and G. Sarà, "Effects of nautical traffic and noise on foraging patterns of Mediterranean Damselfish (Chromis chromis)," *PLoS ONE*, vol. 7, no. 7, 2012.
[127] J. Palma, M. Magalhaes, M. Correia, and J. P. Andrade, "Effects of anthropogenic noise as a source of acoustic stress on wild populations of *Hippocampus guttulatus* in the Ria Formose, south Portugal," *Aquatic Conservation*, vol. 29, pp. 751-759, 2019.
[128] D. Dijkstra and R. Kastelein, "Acoustic dose-behavioral response relationship in a bivalve mollusk, the common cockle (*Cerastoderma edule*)," Presentation at the 4th International Conference on the Effects of Noise on Aquatic Life, Dublin, Ireland, 10-15 July, 2016.
[129] C. Bracciali, D. Campobello, C. Giacoma, and G. Sarà, "Effects of nautical traffic and noise on foraging patterns of Mediterranean Damselfish (Chromis chromis)," *PLoS ONE*, vol. 7, no. 7, 2012.
[130] N. L. Payne, D. E. van der Meulen, I. M. Suthers, C. A. Gray, and M. D. Taylor, "Foraging intensity of wild mulloway Argyrosomus japonicus decreases with increasing anthropogenic disturbance," *Marine Biology*, vol. 162, no. 3, pp. 539–546, 2015.
[131] J. Purser and A. N. Radford, "Acoustic noise induces attention shifts and reduces foraging performance in three-spined sticklebacks (gasterosteus aculeatus)," *PLoS ONE*, vol. 6, no. 2, 2011.
[132] S. S. Sabet, Y. Y. Neo, and H. Slabbekoorn, "The effect of temporal variation in sound exposure on swimming and foraging behaviour of captive zebrafish," *Animal Behaviour*, vol. 107, pp. 49–60, 2015.
[133] I. K. Voellmy, J. Purser, D. Flynn, P. Kennedy, S. D. Simpson, and A. N. Radford, "Acoustic noise reduces foraging success in two sympatric fish species via different mechanisms," *Animal Behaviour*, vol. 89, pp. 191–198, 2014.
[134] M. A. Wale, S. D. Simpson, and A. N. Radford, "Noise negatively affects foraging and antipredator behaviour in shore crabs," *Animal Behaviour*, vol. 86, no. 1, pp. 111–118, 2013.
[135] M. Solan, C. Hauton, J. A. Godbold, C. L. Wood, T. G. Leighton, and P. White, "Anthropogenic sources of underwater sound can modify how sediment-dwelling invertebrates mediate ecosystem properties," *Scientific Reports*, vol. 6, no. 1, p. 20540, 2016.
[136] A. E. Nousek-McGregor, F. Tee, and L. Mei, "The Effects of Noise on Aquatic Life II," vol. 875, pp. 767–774, 2016.
[137] S. D. Simpson, A. N. Radford, S. L. Nedelec, M. C. O. Ferrari, D. P. Chivers, M. I. McCormick, and M. G. Meekan, "Anthropogenic noise increases fish mortality by predation," *Nature Communications*, vol. 7, p. 10544, 2016.
[138] S. D. Simpson, J. Purser, and A. N. Radford, "Anthropogenic noise compromises antipredator behaviour in European eels," *Global Change Biology*, vol. 21, no. 2, pp. 586–593, 2015.
[139] J. Purser, R. Bruintjes, S. D. Simpson, and A. N. Radford, "Condition-dependent physiological and behavioural responses to anthropogenic noise," *Physiology and Behavior*, vol. 155, pp. 157–161, 2016.
[140] M. A. Wale, S. D. Simpson, and A. N. Radford, "Noise negatively affects foraging and antipredator behaviour in shore crabs," *Animal Behaviour*, vol. 86, no. 1, pp. 111–118, 2013.
[141] I. K. Voellmy, J. Purser, S. D. Simpson, and A. N. Radford, "Increased noise levels have different impacts on the anti-predator behaviour of two sympatric fish species," *PLoS ONE*, vol. 9, no. 7, pp. 1–8, 2014.
[142] S. D. Simpson, M. G. Meekan, A. Jeffs, J. C. Montgomery, and R. D. McCauley, "Settlement-stage coral reef fish prefer the higher-frequency invertebrate-generated audible component of reef noise," *Animal Behaviour*, vol. 75, no. 6, pp. 1861–1868, 2008.
[143] S. H. Holles, S. D. Simpson, A. N. Radford, L. Berten, and D. Lecchini, "Boat noise disrupts orientation behaviour in a coral reef fish," *Marine Ecology Progress Series*, vol. 485, pp. 295–300, 2013.
[144] S. D. Simpson, A. N. Radford, M. C. O. Ferarri, D. P. Chivers, M. I. McCormick, and M. G. Meekan, "Small-boat noise impacts natural settlement behavior of coral reef fish larvae" pp. 1041-1048, In: A. N. Popper and A. Hawkins (eds.), "The effects of noise on aquatic life II," Advances in Experimental Medicine and Biology, vol. 875, 2013.
[145] S. D. Simpson, A. Jeffs, J. C. Montgomery, R. D. McCauley, and M. G. Meekan, "Nocturnal relocation of adult and juvenile coral reef fishes in response to reef noise," *Coral Reefs*, vol. 27, no. 1, pp. 97–104, 2008.
[146] S. D. Simpson, M. G. Meekan, N. J. Larsen, R. D. McCauley, and A. Jeffs, "Behavioral plasticity in larval reef fish: Orientation is influenced by recent acoustic experiences," *Behavioral Ecology*, vol. 21, no. 5, pp. 1098–1105, 2010.
[147] S. D. Simpson, M. G. Meekan, A. Jeffs, J. C. Montgomery, and R. D. McCauley, "Settlement-stage coral reef fish prefer the higher-frequency invertebrate-generated audible component of reef noise," *Animal Behaviour*, vol. 75, no. 6, pp. 1861–1868, 2008.