



November 15, 2019

Mr. Dan Virobik  
ionGeoventures GXT, Inc.  
2105 City West Blvd., Suite 900  
Houston, TX, 77042-2837  
dan.virobik@iongeo.com

Re: Request of Supplemental Coordination; GXT, Inc., 2D Seismic Survey, Atlantic Ocean,  
SC Coastal Zone Consistency ID # CZC-15-0144

Dear Mr. Virobik:

Subsequent to the May 22, 2015 issuance of the Conditional Coastal Zone Consistency Determination to ionGeoventures GXT, Inc. (GXT) associated with its federal permit application for Geological and Geophysical (G&G) seismic survey activities, South Carolina Department of Health and Environmental Control (DHEC or the Department) has obtained new relevant scientific information. This body of information is cause for the Department to believe that the reasonably foreseeable coastal effects of your proposed activity on the State's coastal resources and uses are substantially different than those initially described in your original Consistency Certification and considered by DHEC in its decision-making process.

Federal regulation 15 CFR 930.66(a) requires that "applicants shall further coordinate with the State agency and prepare a supplemental consistency certification if the proposed activity will affect any coastal use or resource substantially different than originally described." The regulations state that substantially different coastal effects are reasonably foreseeable if "(2) There are significant new circumstances or information relevant to the proposed activity and the proposed activity's effect on any coastal use or resource." Based on the new studies and information described below, DHEC believes that the activity you have proposed will have coastal effects that are substantially different than those originally described and may severely impact the biological and economic value of South Carolina's commercial and recreational fisheries and pose a significant risk to threatened and endangered sea turtle species. These effects, as described below, would contravene South Carolina's enforceable policies and federally-approved Coastal Zone Management Program. In accordance with 15 CFR 930.66, DHEC requires that you submit supplemental Consistency Certification.

### **Consistency Determination History and Scope of Coastal Zone Consistency Review**

In March 2014, BOEM published a Programmatic Environmental Impact Statement (PEIS) to evaluate potential significant environmental effects of multiple geological and geophysical (G&G) activities on the

Atlantic Outer Continental Shelf (OCS), pursuant to the National Environmental Policy Act (NEPA). Bureau of Ocean Energy Management (BOEM) issued this PEIS to describe and evaluate the potential environmental impacts of G&G survey activities in Federal waters of the Mid- and South Atlantic OCS and adjacent state waters. The PEIS examines G&G survey activities for three program areas (oil and gas, renewable energy, and marine minerals) for the period between 2012 and 2020. The PEIS evaluates impacts to Atlantic resources that could occur as a result of G&G activities, and identifies mitigation and monitoring measures to avoid, reduce, or minimize impacts.

Federal actions are subject to consistency review by DHEC if the proposed activity would have reasonably foreseeable effects on coastal uses or resources within the Coastal Zone. Federal actions may also undergo consistency review based on the geographic location of the proposed activity and whether the activity is listed in the SC CZMP as having coastal effects on state resources or uses. In order to review listed federal permit activities outside of the State waters, DHEC must either have a geographic location description (GLD) approved by NOAA or request to review the listed activity if it is presumed to have foreseeable effects on state resources. Similarly, DHEC may also request review of unlisted federal license and permit activities if foreseeable coastal effects on state resources are determined.

On August 13, 2014, DHEC was briefed by BOEM on pending federal permit applications for G&G seismic surveying activities, including the application submitted by GXT. On August 25, 2014, DHEC submitted documentation and requested approval from the NOAA Office for Coastal Management (NOAA OCM) to review federal permit applications for seismic surveying as an unlisted activity request (UAR). In order to grant a state request to review an unlisted activity, NOAA OCM must find that the state has shown that there are reasonably foreseeable effects to uses or resources of the coastal zone of the state. On November 18, 2014, NOAA OCM concluded that South Carolina had demonstrated that seismic surveys occurring in specific areas in the federal waters offshore of the state may have reasonable and foreseeable effects on coastal uses (commercial and recreational fishing) and coastal resources (sea turtle nesting). Accordingly, DHEC's review of GXT's federal permit application for consistency with the enforceable policies of the SC CZMP is limited to the evaluation of potential effects to these two specific resource categories, utilizing the enforceable policies within SCCZMP Document including Chapter III, Guidelines for Evaluation of All Projects, Policies 1, 5, 7, 9 and 10; Chapter III, Wildlife and Fisheries Management, Section VII, Policy 1; and Chapter IV, Priority of Uses for Geographic Areas of Particular Concern, Section A (8), Threatened or Endangered Species Habitat.

On February 17, 2015, ion Geventures GXT, Inc. (GXT) submitted a Consistency Certification to DHEC for a proposed geophysical and geological (G&G) 2D seismic survey in the Atlantic Ocean offshore of the Mid and South Atlantic coast. The proposed survey transects extend from 20 kilometers (10) nautical miles (nmi) out to 600 kilometers (324) nautical miles offshore of South Carolina and represents 7% of the total area that GXT proposes to survey from Delaware to Florida. GXT does not propose to conduct any survey activity within the 3 nautical mile limit of State Waters within the (State Coastal Zone), though vessels may use shipping channels during operational transition times and service. The proposed seismic survey would be conducted by two survey vessels that would start on opposite ends of the proposed survey area and collect data simultaneously traveling at ~ 4 knots. Two support and chase

vessels will also be present along with each survey vessel. The surveys will be conducted 24 hours per day and will be completed within 3 consecutive days until all transects are completed. The survey data will be collected using towed seismic airgun arrays streamers. When in operation, the airgun arrays would create seismic pulses. When released, compressed air (aimed down) travels to the seafloor, bounces off layers of rock beneath the seafloor, and returns to the survey vessels. The returning sound waves are detected by thousands of sensors (hydrophones) towed behind the survey vessels. The composition of the streamers consists of polyurethane – jacketed cables containing up to thousands of sensors (hydrophones). Single source arrays are typically 656 to 984 feet long and 16 to 33 feet deep and they often consist of 3 sub-arrays, each with 6 to 12 air source elements. The resulting data provides seismologists a graphic visual image of the features that make up the underground structure of the seafloor. Once the data is processed, geophysicists interpret the data, integrate that data with additional data, and make assessments of the existence of oil and gas reserves.

Based on the scientific information available to DHEC at the time, your federal permit application was determined to be Conditionally Consistent with the enforceable policies of the SC CZMP on May 16, 2015.

### **New Research Reveals Significant and Substantially Different Effects on Marine Fisheries**

Subsequent to the Coastal Zone Consistency determination issued on May 22, 2015, a body of additional published scientific research literature has been provided and reviewed by DHEC that examines the individual, cumulative and potential cascading effects of acoustic seismic surveying on the marine ecosystem. These effects are substantially different than those originally considered and include behavioral and physiological changes in fish and fish populations, fish lifecycle development, reef habitat colonization, zooplankton and dependent forage species in addition to previously unknown vulnerabilities among sea turtle species. A portion of this research was published after the conclusion of the PEIS and therefore does not inform the Biological Opinion. However, DHEC must consider this body of scientific research in its analysis to determine the proposed activity's consistency with the enforceable policies of the SCCZMP as they pertain to commercial and recreational fisheries, sea turtles and sea turtle habitat.

### **Summary of Scientific Research Findings**

#### *Zooplankton and Forage Species*

McCauley et al. (2017) investigated the impacts of a single airgun (similar to those used in commercial 3D arrays) on the local zooplankton field and demonstrated significant differences in both zooplankton abundance and mortality after airgun exposure. Comparison of control and exposed tows showed a greater than 50 percent decrease in abundance in 58 percent of all individual zooplankton taxa. The distribution of abundance decreases between exposed and control tows for all taxa showed a median decrease in abundance of 64 percent. Additionally, comparison of control tows (e.g., those occurring prior to airgun blasts) between day 1 and day 2 of the study demonstrated a decrease in mean and median zooplankton abundance of 89 percent and 96 percent, respectively. Assessment of mortalities from each day of the study showed two- to three-fold increases across all taxa as compared to controls.

Finally, impact ranges (i.e., the distances at which no impact versus varying degrees of impact would be expected) were calculated for both abundance and mortality and were found to be more than two orders of magnitude greater than previously assumed.

The Biological Opinion addresses these research conclusions by first clarifying that “in contrast to the intensive 3-D seismic surveys discussed in McCauley et al. (2017), the proposed seismic surveys are 2-D, and are designed as exploratory surveys, covering a large area in a relatively short amount of time.” Further, while the Biological Opinion concedes that the proposed seismic surveys may temporarily alter copepod and zooplankton abundance, it asserts that the overall effect would be insignificant because most copepods would be near the surface where sound from seismic airguns is limited and the high turnover rate of zooplankton and ocean circulation would minimize any effects, particularly in Sargassum habitat. However, the results of the McCauley study and those of Carroll, et al. (2017) raise additional concerns regarding potential effects on fish eggs and larvae (including those of commercial and recreational fishery groups), given similar sensitivity and size ranges as the zooplankton in the above-referenced experiments. Juvenile recreational and commercial fishery species and other species that forage for higher trophic level fishes depend on zooplankton for their dietary needs. A reduction in the availability of zooplankton across a broad region could potentially lead to cascading impacts within the base of the oceanic food chain, and ultimately on recreational and commercial fish populations. Published scientific research on these topic areas is currently extremely limited, thus increasing the risk associated with seismic surveying on commercial and recreational species, including their foraging needs, at various lifecycle stages.

#### *Finfish and Billfish*

According to PEIS, fishing offshore of South Carolina extends at least to the edge of the continental shelf. About 75 miles offshore, the Gulf Stream flows north out of the Florida Straits. This warm-water ocean current averages 62 miles in width. The irregular ocean floor offshore of South Carolina, particularly a raised area known as the Charleston Bump, breaks off portions of the Gulf Stream into giant eddies, spinning warm water and the organisms associated with it inshore from the main current. The Charleston Bump, located 80-100 miles southeast of Charleston, contains unique geological features that serve as spawning areas for many commercially and recreationally important species such as the Snapper-Grouper Complex and wreckfish. The PEIS states that the Charleston Bump is the only documented spawning location of wreckfish. Although wreckfish are found all along the east coast, most of the commercial fishery occurs over the Charleston Bump. According to the SC DNR, commercial species found in the offshore surface waters include king and Spanish mackerel, wahoo, several species of tuna, dolphin (mahi-mahi), sailfish, marlin and swordfish. Some of these fish occur singularly, others in large schools. According to the South Atlantic Fishery Management Council, additional offshore areas of importance to commercial and recreational fisheries include the Edisto Marine Protected Area (MPA), Northern South Carolina MPA and Charleston Deep Artificial Reef MPA.

In its Consistency Certification, GXT relies on the BOEM PEIS for its analysis on potential impacts to commercial and recreational fisheries. NOAA has found that impacts of seismic surveys to fish catch vary and catch reductions of nearly 70 percent have been found for a period of at least five days. Paxton et al. (2017) conducted in the southeast United States found a 78% decline in snapper grouper complex

species abundance during evening hours at a reef habitat site after seismic testing occurred. Notably, the research site was not directly in-line with survey tracks and was located at the greatest distance (7.9 km) among three study sites from the seismic survey track. Acoustic hydrophone data was also collected as part of the Paxton study. Researchers found that noise levels at the reef exceeded 170 dB re 1  $\mu$  Pa prior to the collection instruments being overloaded by noise levels. To estimate peak noise levels at the sites closest to the survey track, spherical and cylindrical spreading models were used. Based on a sound source level of 258.6 dB re 1  $\mu$  Pa, model results indicated that the received sound levels would have ranged from 202-230 dB re 1  $\mu$  Pa. Paxton found that fish detect and respond to seismic noise, reducing aggregation at reef habitats and potentially disrupting important life functions including foraging and mating.

The South Carolina Department of Natural Resources (SCDNR) has raised multiple related concerns regarding the proposed seismic exploration reflected in comments submitted to BOEM on March 2, 2018 in regard to the development of the 2019-2024 Draft Proposed OCS Oil & Gas Leasing Program (Docket BOEM-2017-0074) and comments submitted to DHEC on June 7, 2019 in regard to a pending federal permit application for seismic surveying activities. In both instances, SC DNR provided new and additional information regarding the potential harm posed by seismic surveying activities near concentrations of demersal and/or pelagic fish species. SC DNR asserts:

*The use of G&G surveys may negatively impact a variety of demersal reef fish species located on hard, sandy and soft bottom habitats year-round. Hearing is an important sense used by marine fishes. Many fish use auditory cues in addition to sight and other senses to derive significant information about their surrounding environment.*

*Depending on the intensity of the sound blasts, all organs of the fish may be affected, but it is probable that the swim bladder, vestibular apparatus (semicircular canal system that includes the otoliths), sound producing structure, and gonadal tissues may be particularly vulnerable to damage. In addition, many species (e.g. grunts, groupers) produce sound as part of spawning and social behavior.*

*Sound has been shown to be used by fishes for communication (Myrberg, 1980), navigation, predation, etc. While most fish species can only detect sounds up to 500-1000 Hz, certain species have been shown to exhibit hearing specialization (Mann et al. 2001). Ambient sound levels of 131 dB produced by ships alone have been shown to decrease hearing sensitivities up to 40 dB and reduce the detectability of communication sounds for certain species of marine fishes (Vasconcelos et al. 2007, Codarin et al. 2009). Seismic airguns produce considerable amounts of acoustic energy which have the potential to harm marine fishes. Source level sounds in excess of 230 dB have been recorded for seismic air gun arrays (Cummings, 2003). Acoustic surveys may affect sound reception and sound production by fish and disrupt behavioral interactions.*

*SCDNR conjectures that most fish would not swim out of a testing area when loud sound (blasts) approach, even if acoustic activities are increased gradually. It is possible that*

*larger and faster swimming pelagic species may swim out of the impacted area, perhaps chasing them from feeding grounds, spawning areas, or other important habitats. Elevated sound may also have deleterious effects on survivability and reproduction for certain species (Engas et al., 1996). However, based on staff's general knowledge of fish behavior, as well as video observations, bottom dwelling and reef species (such as groupers, Gray triggerfish, porgies, flounders, rays) and many others, will not swim away if a potential threat approaches. Reef fishes will hide near and within available bottom structure, under ledges or in crevices. Species such as flounders, rays and shrimp will most likely try to avoid loud sound by burying in the sediment. The behavior of many fish species may result in them hiding and staying in place when exposed to loud sound, making them extremely vulnerable for potentially damaging effects of acoustic surveys. In addition, some published information points at possible negative effects to fish larval stages, as well as planktonic prey species. Many reef fish species undergo larval development offshore before settling on reefs that they will inhabit for the rest of their lives (McCormick 2002). Research by Tolimieri et al. (2002) shows that these larval fish use sound to find reefs, and that intense offshore sounds may mask reef sounds, preventing larval fish from finding suitable reef habitat.*

Carroll, et al. (2017) conducted an extensive review of literature associated with scientific studies that examined the impacts of low-frequency sound on marine fish and invertebrates, with an emphasis on seismic surveying acoustics. Carroll concludes that “[t]here remains a vast gap in our knowledge about sound thresholds and recovery from impact in most fish and almost all invertebrates. Without this information, generalisations (sic) about impacts among taxa, airgun arrays, and regions are not scientifically valid.”

On August 6, 2019, DHEC received correspondence from the South Carolina Environmental Law Project, which included the Expert Declaration of Dr. Aaron Rice, a research scientist in the Bioacoustics Research Program at Cornell University (attachment). In his Declaration, Dr. Rice provides extensive summary of marine bioacoustics research pertaining to the use of seismic airguns employed for the purposes of G&G survey activities. Dr. Rice asserts that the frequency used in seismic airgun arrays overlaps with frequencies of greatest sensitivity among many fishes and invertebrates, resulting in disruption of the “acoustic habitat” utilized by these organisms for spatial and seasonal cues associated with movement, seeking refuge and foraging. These impacts would present detrimental effects on individual organisms, populations and communities. Further, Rice states that high-intensity, low frequency sounds typically travel long distances through seawater. This finding aligns with those of Paxton et al. (2017) and starkly contrasts with previous assessments conducted by regulatory agencies that assume that seismic airgun blasts do not affect marine life beyond a few kilometers from the source. Rice asserts that multipath sound propagation and reverberation result in noise that is “virtually continuous” at distance, comparing the noise resulting from an industry-scale seismic survey to a “continuous 4- to 6-month thunderstorm, a phenomenon that does not occur in nature.” In conclusion, Rice states that, “airguns have been shown to alter fish and invertebrate behavior and habitat use in ways that are biologically significant,” including immediate acute effects and chronic effects, resulting in

both lethal and sublethal impacts. According to Rice, these impacts include death, injury, changes in behavior and local abundance across all classes of marine organisms.

DHEC finds that your proposed seismic surveying activities may contravene the enforceable policies of the Coastal Management Program Document Chapter III, Wildlife and Fisheries Management, Section VII, Policy 1 of the Coastal Management Program Document due to the described acute and chronic effects to important recreational and commercially important fishery species in their abundance and behavior. Specifically, based on its review of the available information, DHEC has determined that the proposed seismic surveying activity poses a substantially different reasonably foreseeable and significant threat to commercial and recreational fish species at various stages of lifecycle development than originally described in your original Consistency Certification and considered by DHEC in its decision-making process.

### **New Research Reveals Significant and Substantially Different Effects on Threatened and Endangered Sea Turtles**

On November 28, 2018, the Biological Opinion on the Bureau of Ocean Energy Management's Issuance of Five Oil and Gas Permits for Geological and Geophysical Seismic Surveys off the Atlantic Coast of the United States, and the National Marine Fisheries Services' Issuance of Associated Incidental Harassment Authorizations (Biological Opinion) was issued by the National Marine Fisheries Service (NMFS). Therein, NMFS examines the potential impact of seismic surveying activities on ocean species and designated critical habitat resulting from pollution, vessel strikes, acoustic and visual disturbance and entanglement. According to NMFS, species and critical habitat likely to be adversely affected include: Blue Whale, Fin Whale, North Atlantic Right Whale, Sei Whale, Sperm Whale, Green Sea Turtle (North Atlantic Ocean Distinct Population Segment), Kemp's Ridley Sea Turtle, Leatherback Sea Turtle and Loggerhead Sea Turtle (Northwest Atlantic Ocean Distinct Population Segment). There are four species of federally and state protected endangered or threatened sea turtles that occur in South Carolina waters: Green (*Chelonia mydas*), Kemp's Ridley (*Lepidochelys kempii*), Leatherback (*Dermochelys coriacea*) and Loggerhead (*Caretta caretta*). The habitat of these species is defined as a Geographic Area of Particular Concern (GAPC) under the management purview of DHEC.

In its Consistency Certification, GXT relies on BOEM's Programmatic Impact Statement (2014) for its analysis on potential impacts to sea turtles. GXT also relies on the adoption of the mitigation protocol specified in the Biological Opinion associated with the reduction of impacts to marine mammals as its protocol for mitigation for sea turtles.

### **New Analysis of Proposed Mitigation for Sea Turtles Reveals Deficiencies**

According to the Biological Opinion, neither federal agencies nor permit applicants (including GXT) estimated exposure of Endangered Species Act-listed sea turtles to seismic airgun sounds associated with the proposed seismic surveys. As such, NMFS conducted its own exposure analysis and determined that the acoustic threshold for harassment of sea turtles is 175 dB re 1  $\mu$  Pa. This threshold is consistent with experimental trials conducted by McCauley (2000) in a controlled environment. Nelms, et al. (2015) notes that due to lack of research in unrestricted environments, it is not known what sound threshold

exposure or frequencies could cause permanent or temporary hearing loss and physical fitness among turtle species. However, Nelms cites numerous studies that document frequency detection and hearing abilities among sea turtles and the use of these abilities to perceive important biological signals, navigate, communicate, avoid predators and identify nesting beaches. Citing these previous studies, Nelms finds that “acoustic disturbance could potentially lead to exclusion from key habitats, interruption of behaviors, such as those necessary for breeding, foraging or thermoregulation (basking), as well as inciting responses which may compromise their energy budgets, such as changes to foraging duration, swim speed, dive depth and duration and restricting access to the surface to breath (sic).”

The Biological Opinion mistakenly assumes that mitigation measures associated with marine mammals are applicable and transferable to sea turtles. These mitigation measures include soft start, ramp up, clearance and shutdown, and the use of species observers to identify individual sea turtles within a 500m mitigation zone. For sea turtles, these mitigation measures are not required by NMFS and are voluntary for the applicant. Nelms, et al. (2015) was unable to locate any studies that evaluated the effectiveness of these mitigation measures for sea turtles. In reference to the proposed 500m mitigation zone, Nelms asserts that the appropriateness of this radius in terms of offering protection to turtles is unknown. Citing a previous study by Weir and Dolman (2007), Nelms states that “defining the radius of a mitigation zone is a fundamental component of the real-time mitigation measures used during seismic surveys, but in most regional guidelines no scientific rationale is provided to support the chosen radius”. Nelms asserts that “an appropriate mitigation zone for turtles should take into account data on emitted and received sound levels, turtle hearing ranges and information on the sound levels that are injurious to a sea turtle. However, at present all of this information is lacking. Consequently, the mitigation zones adopted for turtles have simply been selected as the same as those used for marine mammals, and their effectiveness for minimizing the potential impacts on turtles from airgun sound is unknown.” Further, Nelms notes that there are significant constraints associated with the visual detection of sea turtles, particularly at night, in poor weather conditions and adverse sea surface conditions. Alternative and supplementary detection methods, such as passive acoustic monitoring (PAM) designed for species with vocalizing abilities and night-vision/thermographic imaging technologies are also deemed ineffective due to inherent biological differences between the large, warm-blooded mammals for which these detection methods are designed and those of sea turtles. In correspondence with DHEC, S.C. Department of Natural Resources also articulates uncertainty and concern with the appropriateness of transferring mitigation protocols designed for marine mammals to effectively mitigate impacts to sea turtles.

DHEC finds that your proposed activity contravenes the enforceable policies of the Coastal Management Program Document Chapter IV *Special Management Areas*, Section A *Geographic Areas of Particular Concern*, Subsection (8) *Threatened or Endangered Species Habitats, Priority of Uses*, because the efficacy of mitigation measures identified by the applicant for the prevention and minimization of effects on sea turtles are unproven and potentially scientifically invalid. The proposed G&G seismic surveying activity, including the incorporation of the proposed mitigation measures, would result in an intensive use of coastal resources and cause irretrievable damage to threatened and endangered sea turtle species. DHEC has determined that that the proposed seismic surveying activity poses a substantially different reasonably foreseeable and significant threat to sea turtle species than initially



described in your original Consistency Certification and considered by DHEC in its decision-making process.

## **Conclusion**

A body of scientific research reveals compelling issues regarding the acute and chronic impact of seismic survey noise exposure on marine ecosystems, including the health, behavior and abundance of commercial and recreational fisheries and threatened and endangered sea turtle species. This research provides new insight into the physical and behavioral sensitivity that various species have to seismic surveying noise in addition to the identification of critical information gaps. Based on a review of this information, DHEC has determined that seismic surveying activities proposed by GXT would significantly and detrimentally impact the commercial and recreational fisheries that provide substantial economic benefit to the state of South Carolina and its coastal communities.

Further, both the PEIS and Biological Opinion make critical generalizations and assumptions regarding the physiological and behavioral effects of seismic surveying on these resources in addition to the efficacy of applying mitigation protocols associated with marine mammals to the prevention and minimization of effects on threatened and endangered sea turtles. GXT relies on this purported transferability of protocols in its Consistency Certification. However, the scientific basis and demonstrated practical application of these protocols for the protection of sea turtles is generally lacking. DHEC has determined that the mitigation protocols proposed by GXT expose threatened and endangered sea turtle species to unknown risk and are therefore inconsistent with the enforceable policies of the SCCZMP.

In summary, DHEC finds that the risks associated with 2D seismic surveying to the resources under the purview of the SCCZMP are significant due to the known and unknown physiological and behavioral impacts to individual fish and sea turtles, fauna populations and the ecosystems that support them. Your review of this information and response through the supplemental consistency certification process will help inform DHEC's determination of your proposed activities as consistent or inconsistent with the state's enforceable policies. Pursuant to 15 CFR 930.66, supplemental coordination is requested.

Sincerely,



Christopher Stout  
Manager, Coastal Zone Consistency Section

Cc: Ms. Elizabeth von Kolnitz, SCDHEC OCRM  
Mr. Dan Burger, Coastal Zone Consistency Project Manager, SCDHEC OCRM  
Ms. Myra Reece, SCDHEC Environmental Affairs  
Mr. Brian Cameron, US Bureau of Ocean Energy Management  
Mr. Kerry Kehoe, NOAA Office for Coastal Management



## Cited

Atlantic OCS Proposed Geological and Geophysical Activities, Mid-Atlantic and South Atlantic Planning Areas Final PEIS, BOEM 2014. Retrieved from: <https://www.boem.gov/Atlantic-G-G-PEIS/>

Biological Opinion on the Bureau of Ocean Energy Management's Issuance of Five Oil and Gas Permits for Geological and Geophysical Seismic Surveys off the Atlantic Coast of the United States, and the National Marine Fisheries Services' Issuance of Associated Incidental Harassment Authorizations, November 28, 2018.

Carroll, A.G., R. Przeslawski, A. Duncan, M. Gunning, B. Bruce, A critical review of the potential impacts of marine seismic surveys on fish & invertebrates, Marine Pollution Bulletin, Volume 114, Issue 1 (2017), Pages 9-24, ISSN 0025-326X. Retrieved from: <https://doi.org/10.1016/j.marpolbul.2016.11.038>

Codarin, A Wysocki, LE, Ladich F, Picciulin M (2009). Effects of ambient and boat noise on hearing and communication in three fish species living in marine protected area (Miramare, Italy. Marine Pollution Bulletin 58:1880-1887.

Engas, Arill and Lokkeborg, Svein and Ona, Egil and Vold, Aud. (1996). Effects of seismic shooting on local abundance and catch rates of cod (*Gadus morhua*) and haddock (*Melanogrammus aeglefinus*). Canadian Journal of Fisheries and Aquatic Sciences. 53. 2238-2249. 10.1139/f96-177.

Lovell, S.J. et al., The Economic Contribution of Marine Angler Expenditures in the United States, 2011, NOAA Technical Memorandum NMFS-F/SPO-134 (2013). Retrieved from: <http://www.st.nmfs.noaa.gov/economics/publications/marine-angler-expenditures/marine-angler-2011>

Mann, D.A., Higgs, D.M., Tavalga, W.N., Souza, M.J. and A.N. Popper (2001). Ultrasound detection by clupeiform fishes. Journal of the Acoustical Society of America, 109:3048-3054.

McCauley, R.D., R.D. Day, K.M. Swadling, Q.P. Fitzgibbon, R.A. Watson and J.M. Semmons. (2017). Widely used marine seismic survey air gun operations negatively impact zooplankton. Nature Ecology and Evolution 1:0195. Doi 10-1038/s41559-017-0195

Myberg, A.A., Jr. (1980). Ocean noise and the behavior of marine animals, Bioacoustics, 12:313-315.

Nelms, S. and Dow Piniak, Wendy & Weir, Caroline & Godley, Brendan. (2015). Seismic surveys and marine turtles: An underestimated global threat? Biological Conservation. 193. 49-65. 10.1016/j.biocon.2015.10.020. Retrieved from: <https://www.sciencedirect.com/science/article/pii/S0006320715301452>

Paxton, Avery, B, J. Christopher Taylor, Douglas P. Nowacek, Julian Dale, Elijah Cole, Christine M. Voss, Charles H. Peterson, Seismic survey noise disrupted fish use of a temperate reef, Marine Policy, Volume 78, Pages 68-73, (2017). ISSN 0308-597X, <https://doi.org/10.1016/j.marpol.2016.12.017>

Policies and Procedures of the South Carolina Coastal Management Program, an Excerpt of the South Carolina Coastal Management Program Document, July 1995.

Rice, Aaron, Expert Declaration in Support of Plaintiffs' Motion for a Preliminary Injunction. Civ. No. Civ. 2:18-cv-3326-RMG (Consolidated with 2:18-cv-3327-RMG).

South Carolina Department of Natural Resources, Marine – Offshore Waters. Retrieved from: <http://www.dnr.sc.gov/marine/habitat/offshorewaters.html>

South Carolina Department of Natural Resources, Letter from Lorianne Riggin, Director, Office of Environmental Programs to S.C. Department of Health and Environmental Control, June 7, 2019.

South Carolina Department of Natural Resources, Letter from Alvin A. Taylor, Agency Director to Kelly Hammerle, Bureau of Ocean Energy Management, March 8, 2018.

South Atlantic Fishery Management Council Atlas. Retrieved from: [http://ocean.floridamarine.org/safmc\\_atlas/](http://ocean.floridamarine.org/safmc_atlas/)

Tolimieri, N., O.Haine, J.C. Montgomery and A. Jeffs (2002). Ambient sound as a navigational cue for larval reef fish. *Bioacoustics*, 12:214-217.

Vasconcelos, R.O., Fonseca, P.J., Amorim MCP, Ladich, F. (2011). Representation of complex vocalizations in the Lusitanian toadfish auditory system: evidence of fine temporal, frequency and amplitude discrimination. *Proc. Roy. Soc. Lond., B. Biol. Sci.* 278-826-834.

Weir, C.R., Dolman, S.J., Comparative review of the regional marine mammal mitigation guidelines implemented during industrial seismic surveys, and guidance towards a worldwide standard. *J. Int. Wildl. Law Policy* 10, 1–27 (2007). <http://dx.doi.org/10.1080/13880290701229838>.

Willis, D. and Straka, T., The Economic Contribution of Natural Resources to South Carolina's Economy, Clemson University (2016), Accessed from <http://www.dnr.sc.gov/economic/index.html>