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November 20, 2017

Delaware River Basin Commission
P.O. Box 7360
West Trenton, New Jersey 08628

Re: COMMENT on Docket No. D-2017-009-1 Delaware River Partners LLC – Gibbstown Logistics Center, Greenwich Township, Gloucester County, New Jersey

This comment is submitted by Delaware Riverkeeper Network (DRN) on behalf of our approximately 20,000 members throughout the Delaware River Watershed including residents in the closest Gloucester County communities. DRN is a private non-profit membership organization, championing the rights of our communities to a Delaware River and tributary streams that are free-flowing, clean, healthy, and abundant with a diversity of life.

DRN submits that, based on review of the materials submitted to Delaware River Basin Commission (DRBC) by the applicant, this project will have substantial negative impacts on the Delaware River, its water quality, its habitats, and the species that live, forage, shelter, migrate through and reproduce in the River, Estuary and Bay. DRN also submits that the application is substantially lacking in critical information for and assessment of described and yet-to-be described or assessed aspects of the proposed project. DRN requests that Docket approval be denied or, in the alternative, the draft docket be withdrawn and specific reviews and analyses are conducted before further consideration of the project.

Attached to this comment is a copy of DRN's April 5, 2017 comment filed with the Army Corps of Engineers on Public Notice CENAP-OP-R-2016-0181-39 for the SRP Gibbstown Logistics Center; those comments are included as part of DRN's comment on the draft docket.

General Comment

DRBC states its draft Docket is to approve dredging and the construction of a deepwater berth for the proposed Delaware River Partners (DRP) Gibbstown Logistics Center ("the Proposed Project"). However, the current draft docket, despite claiming to approve only the dredging and deep-water berth construction project, approves stormwater outfalls and land disturbances. Furthermore, the docket states that DRP "…is required to submit detailed site plans to the DRBC for the remainder of the Logistics Center, including the proposed: Automobile import area/parking lot; processing facilities; perishables, bulk-liquids and gases, and

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bulk cargo handling areas; warehouses and associated buildings; stormwater management system (including stormwater outfalls); and the associated infrastructure".[1]

This is a huge omission of information about the activities and infrastructure that this project would entail. Based on this lack of essential information, until all plans are completed, submitted to and assessed by DRBC, the draft docket for the Proposed Project should be put on hold. It is unreasonable to move ahead with an application that is so obviously incomplete and lacking in adequate assessment and review. It is impossible to fully assess the potential impacts that this project would have on the water resources of the Basin with the information made available for only a portion of the Proposed Project and its activities.

Essential Environmental Issues

PCB contamination in upland and river sediments

Despite the fact that this former DuPont site (now Chemours) remains among the top-10 biggest PCB loading point-source facilities in the Delaware Estuary, and the near-shore sediments show a pattern of contamination consistent with sources on-site, DRBC appears ready to approve this docket and allow the expansion of PCB contamination in the Delaware Estuary. This is unacceptable and counter to DRBC's dedicated role in reducing PCBs in the Estuary and its role to ensure that PCB Pollution Minimization Plans (PMP) are effectively implemented.

The draft docket approves stormwater outfalls and land disturbances that will significantly increase PCB loading to the already-impaired Delaware Estuary (a TMDL exists for PCBs) but without any plan to monitor or control these elevated PCBs flowing to the Estuary. Instead, the docket defers review of these significant effects until a later time through a New Jersey Department of Environmental Protection (NJDEP) permitting process. DRBC should not approve the draft docket until it reviews all plans and fully assesses potential impacts from the movement of PCBs.

The draft docket acknowledges that DRBC has neither received nor reviewed critical documents about the larger project, including the stormwater management system, and yet seeks to approve the project and the stormwater outfalls without knowing the source of the runoff, the composition of that runoff, and the extent to which already-known PCB contamination on-site will be mobilized and discharged into the Delaware Estuary because of the activities allowed in the draft docket.

The pattern of sediment contamination clearly shows local sources of material, but there is no effort to address these local sources and prevent further contamination of the near-shore environment. The area adjacent to and just to the north of the proposed wharf is a known "hot spot" outfall for PCBs. DRP offers an unsubstantiated conclusion that Dupont and Chemours "has substantially remediated the site"[2] through their redevelopment of the Repauno site since the 2005 Pollution Minimization Plan (PMP).

There is no evidence shown in the application materials of soil or water sampling of the upland areas that contribute to the runoff of PCBs from the site that would support a conclusion that the area to be impacted has been fully remediated and will not release PCBs to the Estuary. There is also no data that demonstrates that the areas to be disturbed by the dredging of 27 acres, for the construction of the wharf and the

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[1] Docket No. D-2017-009-1, p. 3.
[2] Ibid., p. 5.

construction of other components of the Proposed Project, as well as areas that will continue to be disturbed by the operation of the channel and activities at the Proposed Project site, have been fully remediated and will not release PCBs to the Estuary. Furthermore, there are areas discussed above that are planned by DRP to be built out as part of the Logistics Center but are not yet reviewed by DRBC; in these areas there is likewise no evidence or sampling results shown in the application materials that would support a conclusion that the area to be impacted has been fully remediated and will not release PCBs to the Estuary. It is wholly inappropriate for DRBC to issue a docket without this information and, based on the information that is available to DRBC, PCB contamination can reasonably be expected to expand into the Estuary if the Docket is approved and the Proposed Project is constructed.

In fact, the draft docket states that an estimated 72,000 cubic yards of "fine grained" sediments that are planned to be dredged are so contaminated that they don't meet the standards for disposal at the White Basin CDF. The dredging activities themselves will mobilize and increase exposure to these highly contaminated near-shore sediments. The dredging exclusion between March 15 and July 15 does not eliminate exposure to critical early life stages of the federally-endangered Atlantic Sturgeon. Figure 2-2 from the DRBC docket application shows the zone of highly contaminated sediments immediately adjacent to the shore and port facility. The remobilization (and dewatering of dredged sediments) will create higher exposure to PCBs and other contaminants, and the Atlantic Sturgeon spawning and rearing that begins in June and extends the early-life-stages through July and August, with increasing evidence for high aggregations of young-of-year in the Proposed Project vicinity, means that elevated exposure will occur for larval and juvenile stages of this endangered species in the Delaware River. There is no evidence offered that it would be otherwise. The currently proposed methods and timing are insufficient to protect this endangered species, and more evidence and analysis would be required in order to claim that the project does not impair NOAA Trust Resources, fish and wildlife, and the water resources of the Basin.

<u>Atlantic Sturgeon Critical Habitat</u>

The DRBC draft docket fails to acknowledge that the federal government established the Delaware Estuary as Critical Habitat for the New York Bight DPS of Atlantic Sturgeon in August 2017, after the submission of the docket application to DRBC.

DRBC's Water Quality Regulations at §4.30.5-B.1 acknowledge that the Commission must evaluate Critical Habitat, and that this evaluation must follow its Rules of Practice and Procedure. Despite the federal ruling, DRBC has yet to initiate its procedures for verifying the Critical Habitat established by the federal government, and the role that Critical Habitat will play in docket decisions.

DRBC should not approve any project that could directly and indirectly affect this Critical Habitat until such time as it has completed all necessary procedures in the Critical Habitat evaluation. To do so would be premature, would undermine the required process for DRBC review and approvals, would be unfair in terms of just application of its regulations, and jeopardizes the Critical Habitat of the Atlantic Sturgeon. The DRBC is not ready to grant approval to any project that involves the Critical Habitat of the Delaware Estuary for the New York Bight DPS of Atlantic Sturgeon.

The U.S. Army Corps of Engineers' Biological Assessment also acknowledges that the increased ship traffic is estimated to result in 3.3 Atlantic Sturgeon and 0.4 Shortnose Sturgeon deaths in the next 30 years.[3] If every port facility results in 3 or more deaths of Atlantic Sturgeon in the next 30 years, its long-term persistence is clearly in danger. DRBC, National Marine Fisheries Service (NMFS), NJDEP, and the Army Corps of Engineers have failed in their duty to protect this endangered species if they accept this continued and increasing rate of ship-strike mortality (see attached paper; Brown & Murphy 2010 say that ship strikes may doom the species).

The substantial harm that will result to the species of concern and its Critical Habitat and the death of 3.3 Atlantic Sturgeon is unacceptable and should not be tolerated. Considering the evidence of the low population of Atlantic Sturgeon in the Delaware, these lethal takes are significant (fewer than 300, maybe even fewer than 100 individuals are left). These takes could be a substantial percent of this genetically unique population; it is reasonable that these losses could represent a death blow to the species in the Delaware River, especially when considered cumulatively with other port facilities and dredging operations that are occurring in the same area. For instance, the new Paulsboro Marine Terminal is extremely close to the Proposed Project site. Atlantic Sturgeon takes from that terminal and other operations should be consider by DRBC cumulatively in terms of impacts to Critical Habitat and Estuary conditions.

Submerged Aquatic Vegetation

NJDEP has accepted DRP's proposed mitigation, but US Fish and Wildlife Service (USFWS) has continued to comment on the risks to the larger bed of Submerged Aquatic Vegetation (SAV) identified as wild celery (*Vallisneria Americana*) to the east of the port/berth. There is ample evidence to suggest that re-establishment of *Vallisneria* is non-trivial, and that higher ratios of mitigation should be part of the request.

USFWS states that there needs to be careful monitoring of the larger eastern SAV bed because there are numerous risks to its long-term survival and persistence given the significant changes to the surrounding bathymetry and to the local ship traffic. During dredging, NMFS points out that 0.06 acres of *Vallisneria Americana* will be lost and that it is important forage and refuge habitat for several local fish species, including striped bass, American shad, alewife, and blueback herring.[4] However, even after construction is complete, the increase in vessels in the area would continuously churn up the water and increase turbidity, degrading SAV habitat, and the 0.06 acres that DRP will create or enhance as mitigation under NJDEP permitting will likely not be enough. Without monitoring as USFWS proposes, further losses of the larger bed will not be accounted for. This monitoring should be required by DRBC.

Incomplete Information and Erroneous, Unsubstantiated Conclusions

DRBC reliance on reports from DRP and its consultants for information in the draft docket is not supportable. Many of the measures proposed by DRP and its consultants to "minimize" dredging impacts are not measurable or enforceable. Following are several examples of incomplete information, and unsupported or erroneous conclusions.

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[3] U.S. Army Corp of Engineers, "Biological Assessment For Potential Impacts To Species Listed Under The Endangered Species Act Resulting From The Proposed DRP Gibbstown Logistics Center, Gibbstown, NJ", August 2017, page 110.

[4] National Marine Fisheries Service (2017). Comment Letter to the U.S. Army Corps of Engineers on Gibbstown Logistics Center. May 5, 2017.

- One of the proposed measures is "Controlling the "bite" of the bucket to: (a) minimize the total number of passes needed to dredge the required sediment volume."[5] How will this be measured and controlled in real time? If there is some means of measurement, what will be the enforcement mechanism should this proposed minimization be unsuccessful?
- Regarding TSS concentrations and its effects on NOAA Trust Resources, DRP assumes that the effects from suspended sediment would be too small to measure and this assumption automatically makes the effects insignificant. This is a baseless conclusion to jump to and there is no evidence presented to verify this conclusion. In fact the evidence that is available, as discussed above, contradicts this conclusion.
- The DRBC draft docket states that approximately 10.6 acres of the dredging is "new dredging" and the rest of the 27 acres of dredged area are "…areas of the Delaware River that have previously been dredged or otherwise modified". It is unclear from the documents available if there will be any disturbance of the portions of the river "previously been dredged or otherwise modified". This information should be made clear. Any disturbance of the river should be addressed by this draft docket, even if the area was previously modified, because the disturbance has impacts that must be considered and accounted for.
- Regarding noise during construction, it is dismissed by DRP as disrupting sturgeon. DRP claims that that sturgeon would avoid going near the noisy areas and therefore there is no impact[6]. However, avoidance is a behavior alteration due to the construction activity and can therefore be considered a form of disturbance. Furthermore, DRP indicates that underwater noise levels would be less than 150 dBRMs at distances greater than 289 ft. However, they go on to say that anadromous fish are expected to begin avoidance behavior at 282 ft. To insinuate that there would be no impact or disturbance, even if it is avoidance behavior, is grossly inaccurate.
- Regarding the projected increase in connectivity of the floodplain to the river, DRP claims the increase in connectivity would not have a significant effect on the transport of contamination or TSS from the site to NOAA Trust Resources but provides no basis for this conclusion. In fact the evidence that is available, as discussed above, contradicts this conclusion.
- In questioning the need for the Proposed Project and all its proposed components, NMFS asks if elimination of one or more components would minimize the adverse impacts of the project. The applicant states in response that there needs to be a wide range of cargoes to be "attractive to end-users now and in the future"[7]. But economic viability and attractiveness to end-users are not genuine needs for the project. These are desires by the applicant, but they do not demonstrate a purpose and need for the project that outweighs the environmental impacts. In fact, because of the close proximity of a competing terminal that is now complete, the Paulsboro Marine Terminal, and other planned and ongoing terminals in this region (i.e., Gloucester City and Philadelphia), there is no demonstrated need for the Proposed Project, removing the justification for any adverse impacts to the Estuary and Delaware River water resources.
- Regarding the Proposed Project's design and location's impact on SAV, DRP states they changed the outfall location outside the SAV and designed a berth cutoff wall[8] but these modifications do

[5] George, L. (2017). Reponses to National Marine Fisheries Comments CENAP-OP-R-2016-0181-39 Delaware River Partners, LLC. Ramboll Environmental.
[6] Ibid.
[7] Ibid.
[8] Ibid.

nothing to address the increase in vessels and the dredging activities, one of the most important impacts with which NMFS was clearly concerned.

- DRP admits the proposed inshore berth would permanently shade 1.9 acres and that "shading may reduce photosynthesis in these areas and may reduce prey biomass in the shaded area"[9] but concludes it will not have any measurable effect on NOAA Trust Resources. However, a permanent area of reduced photosynthesis and prey biomass is still a negative impact to NOAA Trust Resources and there is no evidence presented to the contrary and information that substantiates that this will not have a measurable negative impact.
- Regarding the adverse impacts of ships moving in and out of the port is DRP's claim that the slow speed of vessels will not increase turbidity beneath the wharf. The speed of the vessel is only one factor that affects how much water it disturbs as it moves (and increases turbidity). Other factors include vessel size, draft, hull shape, depth, current, and wind. Most of these vessels are very large and would certainly increase turbidity regardless of slow speed. Yet these important factors are not even mentioned or considered.
- The conclusion that DRP draws that the "…Project activities including construction, dredging, and operations of the port and upland Marine Terminal are not expected to have a significant adverse effect on NOAA Trust Resource species"[10] and that the proposed mitigation will be sufficient is not supportable by the evidence in the record. DRP jumps to the conclusion that because they have certain expectations (such as expected sediment level thresholds) that they can say that there will be no impacts. Is someone going to measure sediment thresholds to make sure they don't exceed their expected amount? Is someone going to study the impacts to prey species? On May 17, 2017, DRP submitted a modification of the Proposed Project design to the Army Corps of Engineers which described shifting the pile-supported open wharf structure 50 feet channelward. As a result of this modification, the dredging footprint has been reduced from 29 acres to 27 acres. This response is not nearly enough to address all of the concerns raised by NMFS, there is no evidence presented to show that it does sufficiently reduce negative impacts and certainly this mitigation is not enough to support the approval of this draft docket by DRBC.

<u>"Existing Uses" Not Captured</u>

DRP fails to recognize that fish "propagation" is an Existing Use and instead defers to "Designated Use", which is not protective enough. Even though DRBC and other agencies also do not recognize the validity of the "Existing Use" designation, it doesn't make this miss-classification right. Rather, it highlights a continued failing at DRBC and across the regulatory community to correctly recognize required "existing Uses" of the Estuary, resulting in inadequate protection for species and habitat.

<u>Rush to Judgment</u>

DRBC has moved the Proposed Project through to a draft docket at an accelerated pace. This draft docket should never have been considered ready for consideration due to the lack of information and the many erroneous, poorly reasoned, and faulty conclusions put forward by DRP. And it never should have been considered at this time because DRBC has not developed the regulations that will assess and implement the Critical Habitat of the Delaware Estuary for the New York Bight DPS of Atlantic Sturgeon.

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[9] Ibid.
[10] Ibid.

Conclusion

DRN requests that DRBC disapprove the draft docket based on the evidence presented showing substantial harm to Delaware River water resources. If DRBC does not disapprove the draft docket, DRBC should at least remove it from consideration until NJDEP reviews and issues the required NJPDES permit for the stormwater discharge system; until sampling can be done and a decision is made regarding the need for a new Pollution Minimization Plan; and until there is enough evidence to demonstrate that the Proposed Project will not have the adverse impacts that it can be expected to have on the water resources of the Delaware River, Estuary and Bay. If using only the available information, DRBC should deny approval based on the reasonable likelihood that the project will cause harm to the water resources of the Basin and a lack of demonstration to the contrary and because there is not a demonstrated need for the Proposed Project and all its components that justifies the adverse environmental impacts.

Thank you for the opportunity to comment.

Sincerely,

Maya van Rossum — the Delaware Riverkeeper

Tracy Carluccio — Deputy Director

Attachments:

1. Delaware Riverkeeper Network April 5, 2017 comment filed with the Army Corps of Engineers on Public Notice CENAP-OP-R-2016-0181-39 for the SRP Gibbstown Logistics Center

2. J. Jed Brown and Gregory W. Murphy, "Atlantic Sturgeon Vessel-Strike Mortalities in the Delaware Estuary" Fisheries, vol 35 no 2, February 2010, www.fisheries.org

DELAWARE RIVERKEEPER NETWORK

April 5, 2017 Submitted by Fed Ex Overnight

District Engineer, U.S. Army Corps of Engineers
Philadelphia District, Wanamaker Building
100 Penn Square East
Philadelphia, PA 19107-3390

Re: Comment on Public Notice CENAP-OP-R-2016-0181-39 for the SRP Gibbstown Logistics Center

Dear District Engineer of the U.S. Army Corps of Engineers,

The Delaware Riverkeeper Network has reviewed Public Notice CENAP-OP-R-2016-0181-39 for the SRP Gibbstown Logistics Center located in the Township of Greenwich, Gloucester County, New Jersey. The Delaware Riverkeeper Network submits this comment in response to this Public Notice.

It is our position that in accordance with 33 CFR parts 327.4 that this letter serve as a written request for the US Army Corps of Engineers to hold a **Public Hearing** to hear the public's concerns regarding this application including the reasons identified below:

1. **Environmental Impacts of Dredging**

`The proposed Gibbstown Logistics Center in Greenwich Township, Gloucester County, NJ would have a substantial impact on the natural resources in this part of the Delaware River and there is no indication that this project is needed by the public. The stated purpose in the application is,

"... to redevelop (the) site and create a deep water marine terminal that can accommodate vessels with a maximum length of 870 feet with a maximum of a 40-foot draft."[1]

In order to achieve this goal, the application further states that,

"An area approximately 29 acres in size would be dredged to a depth of -40 feet mean lower low water ± 1 foot overdraft."[1]

[1] U.S. Army Corps of Engineers (2017). Public Notice CENAP-OP-R-2016-0181-39. March 7, 2017. Retrieved from http://www.nap.usace.army.mil/Portals/39/docs/regulatory/publicnotices/Public_Notice_2016-0181-39.pdf

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"Approximately 1264 square feet of open water habitat would be filled between the proposed sheet pile and the existing earthen berm."[1]

"457,000 cubic yards of material would be removed from the waterway."[1]

The Delaware Riverkeeper Network has commented in the past on the significant environmental impacts that dredging causes in this section of the Delaware River. First, deepening 29 acres of river area to a depth of -40 feet mean lower low water ± 1 foot overdraft will open this newly deepened area to the potential for an increased risk of harm if there is a catastrophic spill event. With a deepened area, ships will access the proposed deepwater port and, when filled for export will be heavily laden with natural gas liquids or other chemicals. Using the catastrophic experience of the Athos I oil spill of November 26, 2004, the volume of carried material available to leak and wreak havoc on the environment and our communities will be greater and therefore more dangerous with the added capacity of the proposed port's dredging of 29 acres.[2]

The Athos I catastrophe exposed 115 miles of River, 280 miles of shoreline, 16,500 birds, as well as many species of fish, shellfish, and wildlife and a variety of important habitats to the heavy crude it dumped into the Delaware River.[2] Habitats, wildlife, water quality, air quality, industry, recreation, and communities were all significantly harmed by the spill. Any project that will increase the magnitude of such a tremendous level of damages in the event of a future catastrophe is a danger to all of these natural and human resources.

2. Contaminated Dredge Spoils

The dredge spoils from this proposed activity would clearly not be clean. According to the application,

"…based on initial testing, approximately 106,000 cubic yards of the material proposed to be dredged appears to be contaminated."[1]

"The material would then be dried on-site or at the Camden facility and then deposited on the adjoining uplands."[1]

Dredge spoils significantly increase the amount of heavy metals and toxins that would be released into waterways and the environment[2], especially with the amount of material that appears to be contaminated at this site. The impacts of the spoil disposal plans and potential pollution impacts could have significant community and environmental effects. The threat posed by dredged spoils is known to be a source of water pollution after on-land disposal.[2] In addition to polluting the water and land, there are likely to be air quality impacts including NOx emissions associated with the construction and associated traffic from this project that should be considered as well.

3. Impacts to Sturgeon

This project would also adversely affect both species of sturgeon found in the Delaware River. From the application:

"A preliminary review of this application indicates that the proposed work may impact 2 fish species listed on the Endangered Species List pursuant to Section 7 of the Endangered Species Act as amended. The first

[2] Delaware Riverkeeper Network (2011). Comment Re: 2011 Draft EA for Delaware River Main Channel Deepening Project Philadelphia. Submitted to U.S. Army Corps of Engineers on July 6, 2011.

would be the Short-nose Sturgeon (Acipenser brevirostrum) and the second would be Atlantic Sturgeon (Acipenser oxyrhynchus) and its proposed critical habitat."[1]

Both direct take and incidental take of sturgeon are a distinct possibility with a project of this nature. Both the Atlantic sturgeon and shortnose sturgeon are threatened and adversely affected by dredging and effects to water quality including dissolved oxygen (DO) levels, water temperature, and contaminants.[2] The proposed project will entail significant levels of dredging as well as significant water quality effects and dramatic changes in important habitats including juvenile habitat and spawning grounds.

The dredging of river systems significantly impacts aquatic ecosystems in a number of ways that will harm both sturgeon species. Among the effects that the project will have on the Delaware River populations of both sturgeon species are:

- ✓ Deep-draft vessel traffic in the Delaware River has been cited as the biggest threat to the survival of the Delaware River population Atlantic sturgeon; the increased vessel traffic and increased area for deep-draft vessels to strike Atlantic sturgeon directly resulting from this project will significantly increase sturgeon vessel strikes and could accelerate the extinction of this endangered species population.[3]
- ✓ Dredging activities remove, disturb, dispose of and re-suspend river sediments, modifying the river bottom substrate and impacting the community of benthic macrofauna;
- ✓ Dredging operations can remove or bury organisms and destroy benthic feeding areas;
- ✓ Dredging operations can create noise and disturbance, and can disrupt spawning migrations;
- ✓ Dredging activities can re-suspend contaminants, affect turbidity and siltation, and deposit fine sediments in spawning habitats; and
- ✓ Dredging activities alter the hydrodynamic regime, alter physical habitats, and create the loss of riparian habitat.[2]

The act of dredging can entrain sturgeon, taking them up into the dredge drag-arms and impeller pumps and resulting in death.[2] New data from tagged Atlantic sturgeon continue to show their presence in or near the main navigation channel, making them vulnerable to direct take by dredging operations, as well as direct take from the larger vessels that will be using the channel.[2] These lethal takes are significant for a species that is at such low levels (fewer than 300, maybe even fewer than 100), and as genetically unique as the Atlantic sturgeon of the Delaware River are.[2]

Dredging in the portions of the River near Philadelphia is likely to be detrimental to the successful spawning of sturgeon in the Delaware – not just because of the act of dredging but also because of the degradation of spawning habitat.[2] Dredging increases the level of suspended sediments and contaminants in the water. An increase in suspended sediments could be detrimental to egg survival of sturgeon – increasing the probability that eggs adhere to suspended solids and suffocate.[2] Increasing contaminant loads can alter growth and reproductive performance in sturgeon.[2]

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[3] Brown and Murphy. 2010. Atlantic Sturgeon Vessel-Strike Mortalities in the Delaware Estuary. Fisheries 35(2): 72-83.

Dredging is a factor in the destruction, modification, or curtailment of the Atlantic sturgeon's habitat and range.[2] The environmental impacts of dredging include direct removal or burial of organisms, elevated turbidity or siltation, contaminant re-suspension, noise or disturbance, alterations to hydrodynamic regime and physical habitat, and loss of riparian habitat.[2] Furthermore, an increase in vessel traffic on the Delaware River resulting from the project would increase the likelihood of vessel strikes to sturgeon.[2]

A study of mortality rates on Atlantic sturgeon in the Delaware River between 2005 and 2008 found that 50% of the mortalities were the result of vessel strikes. The remaining 50% were too decomposed to determine if they were caused by vessel strikes but it is likely most were.[2] For small remnant populations of Atlantic sturgeon, such as that in the Delaware River, the loss of just a few individuals per year due to anthropogenic sources of mortality, such as vessel strikes, may continue to hamper restoration efforts.[2] According to a 2010 research article on vessel strikes, "Both the dredging to deepen the channel and the subsequent increase in large vessel traffic may further hamper the recovery of the Delaware River Atlantic sturgeon population."[2] Of critical importance, this study is concerned about the size of the vessels resulting from deepening as opposed to any increase in the volume of vessels. The larger size of the vessels from the deepened channel will likely increase the number of vessel strikes for both sturgeon species.[2]

The continued dredging of new deep-water areas will further impact Atlantic sturgeon spawning by accelerating the intrusion of brackish water into the hard-bottom spawning grounds, and thus forcing Atlantic sturgeon to spawn further upstream in the zone of depressed dissolved oxygen. This shift then exposes the eggs and larvae of newly spawned Atlantic sturgeon to low oxygen conditions from which they may not survive. This "squeeze" between increased salt intrusion in the estuary downstream (exacerbated by channel deepening, new deep-dredged berthing areas, and rising sea levels) and the near-lethal dissolved oxygen levels upstream limits the ability of Atlantic sturgeon to successfully reproduce, and increases the likelihood of extinction. This project makes a significant contribution to such salt-intrusion by adding 29 acres of new deep-water channel and berthing to an estuary under siege.[4]

4. Mussel Impacts

In November of 2010, researchers discovered beds of freshwater mussels in the Delaware River between Chester, PA and Trenton, NJ.[2] The species found included the alewife floater (*Anodonta implicata*) and the tidewater mucket (*Leptodea ochracea*), only found in New Jersey in the tidal Delaware River; the pond mussel (*Ligumia nasuta*) and the yellow lampmussel (*Lampsilis cariosa*), both considered critically-imperiled; and the creeper (*Strophitus undulatus*) and the eastern floater (*Pyganodon cataracta*) both considered vulnerable; as well as the eastern elliptio (*Elliptio complanata*), the only mussel known to be native to our Delaware River that is not considered to be in jeopardy.[2] Mussels are not mentioned in the application or in the applicant's Compliance Statement. Particularly because some of these estuarine species are state-listed and/or critically imperiled, the extent and composition of these mussel beds needs to be accurately surveyed prior to any in-water work at the site. Once the locations, abundance, and identify of these species are documented, a relocation plan would be needed to move individual mussels out of areas where direct mortality might occur.

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[4] Moberg and DeLucia. 2016. Potential Impacts of Dissolved Oxygen, Salinity and Flow on the Successful Recruitment of Atlantic Sturgeon in the Delaware River. The Nature Conservancy. Harrisburg, PA. 69 pp.

Freshwater mussels can live 80 to 100 years old, and most species do not begin reproducing until they are 8 to 10 years old.[2] Because they are so slow growing and don't begin to reproduce until this older age, they are not able to quickly recover from disturbances and the population cannot recover quickly from impacts that result in death to individuals.[2] Freshwater mussels require a fish host, a specific species depending on the mussel, to complete their life cycle. Activities that damage the needed fish hosts in turn do direct harm to the freshwater mussel species they help serve in the life cycle.[2]

Mussels are vital for filtering pollution and filling important habitat niches. Experts believe that revitalizing freshwater mussels in the Delaware River could improve water quality downstream and thereby benefit estuarine species.[2] All of the freshwater mussels in the Delaware River system, except for one (the Eastern elliptio, *Elliptio complanata*), are identified by one or more of the states as endangered, threatened, imperiled, vulnerable, critically impaired, very rare, extremely rare or extirpated.[2]

Freshwater mussels are very sensitive to water quality. Exposure to contaminants either directly via dissolved compounds or contaminants that are particle-mediated can have adverse consequences.[2] Freshwater mussels are highly exposed to changes in water quality because of their filtering activities and the passage of large volumes of water across many thin tissue layers. Dissolved toxins, such as heavy metals, are rapidly taken up by direct absorption and indirectly via food.[2] Because this project will likely result in pollution both directly and through contaminants from spoil disposal, the implications of this pollution for the mussels in this area must be examined.

Stressed mussels require more oxygen. The dredging described for this project is a threat to any submerged aquatic vegetation in the area that is critical for providing oxygen in the Estuary, including the Philadelphia reach of the River, which includes the location of the proposed project. Although dissolved oxygen levels can become excessively low in this area even today, they have improved significantly compared to decades past. In fact, the DRBC is considering elevating their "Aquatic Life Designated Use" rule in this section of the Delaware River to maintain and protect dissolved oxygen levels.[5] Increased sedimentation from dredging activity inhibits mussels and their host fish species from taking in oxygen.[2] Additionally, invasive or exotic species resulting from interbasin transfers of water can be a very direct threat to freshwater mussels as well as many other species. Increased ballast water from deeper ships, and increased ship traffic, brought up the River by a deeper channel could heighten this risk.[2] The issue of invasive and exotic species and ballast water and their ecological and economic implications for freshwater mussels and other River fish and wildlife species must also be considered.

Identification of host fish needed for freshwater mussels is one of the least studied aspects of freshwater mussel life history. American eel are known to be hosts for *Elliptio complanata*; some believe they are in fact the preferred host.[2] Some species of trout and yellow perch too can serve as hosts and data shows that some of the species found in the tidal estuary, *Strophitus undulatus*, can use pumpkinseed and yellow perch.[2] Shad too are considered by some as possible host species.[2] The potential impacts to these host species are additional factors to consider when assessing the threats to mussels.

5. Additional Fish and Wildlife Impacts

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[5] Delaware River Basin Commission (2017) Draft Resolution, February 23, 2017. Retrieved from http://www.nj.gov/drbc/library/documents/Res_EstuaryAquaticLifeUses_draft022317.pdf

As indicated in Appendix E of Ramboll Environ's Compliance Statement, there are bald eagle *(Haliaeetus leucocephalus)* nests and osprey *(Pandion haliaetus)* nests near or within the project site.[6] From the Compliance Statement:

"There are currently two (2) active bald eagle nests located within l km of the Project Site: one located on Mond's land and a second located east of the Project Site near Clonmell Creek."[4]

"Field observations have confirmed that four osprey nests were established on the Project Site on man-made structures including utility poles and a loading arm located at the wharf."[4]

Even with the best mitigation plan in place, there would inevitably be some level of disturbance to these nests versus the no-action alternative which would leave the nests as they currently are. The nests are not even mentioned in the public notice and this is an issue that the public should be aware of. While formerly a highly-degraded site when DuPont owned and operated the property, the wetland and upland portions of the site have reverted to a natural state with a diverse ecosystem suitable as nesting habitat for these two imperiled bird species. Any disturbances or alterations to these nesting areas could be detrimental to the breeding success of these birds and therefore the future viability of their populations in this area.

Additionally, there is evidence that the acoustic impacts from construction activities, such as those described for this project, can significantly harm fish.[7] The effects of underwater sounds created by pile driving on fish may range from a brief acoustic annoyance to instantaneous lethal injury depending on many factors.[5] Even at non-lethal levels, low levels of acoustic damage may result in the fish not being able to swim normally, detect predators, stay oriented relative to other fish in the school, or feed or breed successfully.[5] This is a potential threat to all fish, including both sturgeon species as well as all the fish that serve as host species to mussels.

6. Increased Ballast Water Needs and Discharge

The deepened 29 acres of river area that would provide access to the proposed deepwater port would result in larger and deeper draft vessels coming up the River which means more ballast water needs, discharges, and impacts. Impingement and entrainment of the variety of species discussed in this comment and beyond due to the intake and discharge of ballast water could be significant. The increased intake of ballast water from the River as a result of the commercial vessels coming into the River due to this project would entrain early life stages of commercially and recreationally important fish including American shad, alewife, blueback herring and striped bass.[2] The cumulative effects of this impingement and entrainment need to be considered in conjunction with the impingement and entrainment that already occurs at existing cooling water intakes operating in the Delaware Estuary and River, including the nearby Paulsboro and West Deptford Township facilities.

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[6] Ramboll Environ (2016). Compliance Statement in Support of Multiple Individual Permit Applications. Appendix E, Habitat Impact Assessment Report, July 2016.

[7] Delaware Riverkeeper Network (2011). Supplemental Comment Re: 2011 Draft EA for Delaware River Main Channel Deepening Project Philadelphia. Submitted to U.S. Army Corps of Engineers on July 6, 2011.

In addition, the concerns about invasive exotic species that may result from larger discharges of ballast water from larger vessels cannot be overstated in terms of either ecological or economic impacts. The invasion of such species into major ports and waterways of the U.S. have cost billions of dollars in control efforts and lost economic value from damage to important fish and wildlife species as well as the habitats that support them.[2] For more information see

http://water.epa.gov/polwaste/vwd/ballastwater/invasive_species_index.cfm

http://water.epa.gov/polwaste/vwd/ballastwater/invasive_species_bal_links.cfm

http://www.invasivespecies.gov/index.html

7. Submerged Aquatic Vegetation

As with mussels, there is lack of survey information by the applicant regarding the presence of any submerged aquatic vegetation (SAV) in the project area and it is not even mentioned anywhere in the application or in their Compliance Statement. SAV is vital habitat for many of the life stages of prey base, young-of-the-year striped bass, and river herring.[2] It functions as a substrate for macroinvertebrates and as cover for small fish as well as a source of dissolved oxygen for the water.[2] For the Delaware Estuary, the current high levels of dredging and industrial shipping limit the extent and abundance of this vital habitat, necessitating the protection and preservation of each SAV bed. If present in the project area, the resulting implications for water quality and species require careful consideration.

8. Recreational Impacts

This project would likely introduce toxic contaminants into the River and food chain. The Delaware River and Estuary are major destination points for recreational fishing. Exacerbating the already contaminated conditions of the fish, subjecting them to extended fish advisories due to the addition of more contaminants into the River system, or resulting in new advisories, are potential harms to this major recreational use of the River. Spending in the Delaware River and Estuary region by recreational anglers is valued at $62 to $100 per angler per day.[2] NOAA reported in 1991 that roughly 155,000 people spent almost $60 million fishing in Delaware’s waters resulting in $29 million in earnings, and supporting 1,605 jobs.[2]

In that same year, 950,000 people spent more than $630 million fishing in New Jersey's waters, resulting in $400 million in earnings, and supporting 16,750 jobs.[2] While the Delaware Estuary is not responsible for all of this fishing and related jobs and income, it is responsible for a fair share of it. Further contamination and/or even the perception of additional contamination from this project could create significant recreational and economic harms.

9. Economic Costs

In addition to the numerous environmental costs of this project, there would also be extensive economic costs. There are potentially hundreds of millions of dollars a year that could be lost in river jobs and economic returns (present and future) associated with the environmental resources put at risk from the project.[2] The project puts at risk the fish, shellfish, wildlife, and habitats that are critical for providing hundreds of millions of dollars of income and jobs in the present and future. Finally, there is no demonstrated public benefit that outweighs the level of public, economic, and environmental harms that will result from implementing this project.

10. Secondary Impacts

The proposed project does not appear to sufficiently address compliance with the Clean Water Act's Section 404(b)(1) guidelines for consideration of alternatives. The fundamental objective of these guidelines was to ensure that discharges of dredged or fill materials into waters of the US, including wetlands, should not occur unless it can be demonstrated that such discharges either individually or cumulatively, will not result in unacceptable adverse effects on the aquatic ecosystem (40 CFR 230.10(a)). As such, the applicant is required to evaluate opportunities for use of non-aquatic areas and other aquatic sites that would result in less adverse impacts of the ecosystem.

It is not clear from the public notice how secondary impacts to the aquatic ecosystem were evaluated by the applicant. In many cases the secondary impacts result in significant impacts to the environment including impacts to delegated wetlands and waters. The overall project contemplates impacts to 7.22 acres of riparian zone as well as 8 acres of freshwater wetlands, 6 acres of coastal wetland, 0.39 acres of open water and approximately 47 acres of freshwater and coastal wetland buffer areas. The applicant has not satisfied its obligation to show that it exhausted attempts to avoid and then minimize of impacts to regulated resources such as riparian zones, coastal and freshwater wetlands and wetland transition area. Compliance with the 404(b)1 guidelines has not been seriously attempted or any effort to adequately illustrate compliance. The project proposed before the Army Corps should not be reviewed as approval of the waterfront portion in isolation of all other impacts of this project as these impacts are inextricably associated with other significant impacts situated outside of the Corps' jurisdiction.

11. EPA Review

Section 404(q) of the Clean Water Act establishes a requirement that the Secretary of the Army and the Administrator of the EPA enter into an agreement assuring that delays in the issuance of permits under Section 404 are minimized. In August 1992, a Memorandum of Agreement (MOA) was created and the EPA may request that certain permit applications receive a higher level of review within the Department of Army. This project clearly demonstrates that there is the potential for adverse impacts to aquatic resources, as such, this project should receive a higher level of review. Has communication with the US Environmental Protection Agency occurred with regards to this project? If not, it is requested that the EPA be made aware of this project and initiate a higher level of review.

12. Compensatory Mitigation

In 2008, EPA and the US Army Corps of Engineers jointly promulgated regulations revising and clarifying requirements regarding compensatory mitigation. According to these regulations, compensatory mitigation means the restoration, establishment, enhancement and/or in certain circumstances preservation of wetlands, streams and other aquatic resources for the purpose of offsetting unavoidable adverse impacts which remain after all appropriate and practicable avoidance and minimization has been achieved. The public notice states that the applicant has

"avoided/minimized impacts to the aquatic environment by incorporating engineering/construction procedures into the process that will substantially reduce impacts to aquatic resources. Additionally, the applicant states that the amount of fill in open water has been minimized by designing a portion of the multi-purpose pier as an open deck structure and by removing existing deteriorated and unnecessary

marine structures. Due to the large area and volume of existing structures to be removed, there is an overall decrease in the area and volume of fill in open water compared to previous conditions. Therefore, it is the opinion of the applicant that the new fill is more than offset by the removal of existing structures and fill, no compensatory mitigation is being offered.

The applicant does not provide any factual basis in their alternatives analysis to support this claim. As such, compensatory mitigation should be provided in accordance with 40 CFR Chapter 1 – Subpart J to address the losses of aquatic resources.

Delaware Riverkeeper Network opposes the approval by the Corps of the proposed permit that is being considered under Section 10 of the Rivers and Harbors Act of 1899 (33 U.S.C. 403) and Section 404 of the Clean Water Act (33 U.S.C. 1344) for the reasons discussed herein and because the proposed permit does not serve the public interest, would have a substantial impact on the natural resources of the Delaware River and because there is no indication that this project is needed by the public.

Respectfully submitted,

Maya van Rossum
the Delaware Riverkeeper

Tracy Carluccio
Deputy Director

Atlantic Sturgeon Vessel-Strike Mortalities in the Delaware Estuary

ABSTRACT: The Atlantic Sturgeon Status Review Team has recommended that the Secretary of Commerce list the New York Bight distinct population segment of Atlantic sturgeon (*Acipenser oxyrinchus oxyrinchus*), which includes the Delaware River and Hudson River populations, as threatened under the federal Endangered Species Act. Between 2005 and 2008, a total of 28 Atlantic sturgeon mortalities were reported in the Delaware Estuary. Sixty-one percent of the mortalities reported were of adult size and 50% of the mortalities resulted from apparent vessel strikes. The remainder of the mortalities were too decomposed to ascertain the cause of death, but the majority were likely the result of vessel strikes. For small remnant populations of Atlantic sturgeon, such as that in the Delaware River, the loss of just a few individuals per year due to anthropogenic sources of mortality, such as vessel strikes, may continue to hamper restoration efforts. An egg-per-recruit analysis demonstrated that vessel-strike mortalities could be detrimental to the population if more than 2.5% of the female sturgeon are killed annually. We report on our observations of vessel-strike mortalities in the Delaware Estuary, discuss the possible implications for the Delaware River population, and recommend further research.

Mortalidad del esturión del Atlántico en el estuario Delaware por colisión con embarcaciones

RESUMEN: El grupo de trabajo que revisa el estado del esturión del Atlántico recomendó que la Secretaría de Comercio enliste al segmento distintivo de la población de esturión del Atlántico (*Acipenser oxyrinchus oxyrinchus*) que habita en la Bahía de Nueva York, la cual incluye a las poblaciones de los ríos Delaware y Hudson, como especie amenazada dentro del Acta Federal de Especies en Peligro. Entre 2005 y 2008, se reportó un total de 28 esturiónes muertos en el estuario Delaware. Sesenta y un porciento de dichos animales eran de talla adulta y 50% de las mortalidades parecen haber sido resultado de colisiones con embarcaciones. El resto de los individuos muertos se encontraban en un estado de descomposición tan avanzado que no fue posible determinar la causa de muerte, sin embargo la mayoría de ellos muy probablemente perecieron como resultado de una colisión. Para las pocas poblaciones remanentes del esturión del Atlántico, como aquellas que habitan el río Delaware, la pérdida anual de algunos pocos individuos por mortalidad antropogénica, como la provocada por las colisiones con embarcaciones, pueden entorpecer los esfuerzos de restauración. Mediante un análisis de huevos por recluta se demostró que las mortalidades causadas por impacto con embarcaciones pueden ir en detrimento de la población, si perecen más de 2.5 por ciento de las hembras por año. En la presente contribución reportamos nuestras observaciones sobre la mortalidad de esturiones el estuario Delaware causadas por colisión con embarcaciones, se discuten las posibles implicaciones para la población del río Delaware y se recomiendan futuras líneas de investigación.

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INTRODUCTION

The Atlantic Sturgeon Status Review Team (ASSRT), a group comprised of federal agency biologists, recently reviewed the status of Atlantic sturgeon (*Acipenser oxyrinchus*) populations in the United States and recommended that several distinct population segments (DPS) be listed as threatened under the federal Endangered Species Act. The ASSRT concluded that the Delaware River population had a moderately high risk (> 50% chance) of becoming endangered in the next 20 years (ASSRT 2007). The ASSRT grouped the Delaware River and Hudson River populations into a single New York Bight DPS and made a recommendation to the Secretary of Commerce that this DPS be listed as threatened under the Endangered Species Act. The states of Delaware and Pennsylvania, which border sections of the Delaware Estuary, have already placed Atlantic sturgeon on their respective state endangered species lists, and New Jersey lists this species as a "species of special concern" and its Endangered and Nongame Species Advisory Committee recommended an endangered status listing.

Given the long generation time and slow rate of population growth of Atlantic sturgeon, any anthropogenic sources of mortality may continue to hamper restoration efforts (Boreman

1997; Secor and Waldman 1999; Gross et al. 2002). Many factors including historical overfishing, habitat degradation, and the construction of dams have been implicated in the decline of Atlantic sturgeon populations. Due to the decline of populations along the Atlantic Coast, the Atlantic States Marine Fisheries Commission instituted a coastwide moratorium on the harvest of Atlantic sturgeon in 1998, which is designed to remain in effect until there are at least 20 protected year classes in each spawning stock. Collins et al. (1996) and Stein et al. (2004) detailed the impact of bycatch mortality on Atlantic sturgeon. We report here on another anthropogenic source of mortality that has not been widely considered—mortality from vessel strikes, and examine how these vessel strikes may be affecting the population of Atlantic sturgeon in the Delaware River. We use the term "vessel strike" to indicate mortality caused by entrainment through the propellers of vessels and direct collisions with vessel hulls.

The Atlantic sturgeon is one of nine species/subspecies within the family Acipenseridae present in North American waters (Cech and Doroshov 2004). Although intensely studied since the 1970s, many aspects of Atlantic sturgeon life history remain unknown (Murawski and Pacheco 1977; Bain 1997; Bemis and Kynard 1997; Smith and Clugston 1997; Kynard and Horgan 2002; ASSRT 2007). Specific life history characteristics vary latitudinally along the Atlantic Coast, but the Atlantic sturgeon is generally characterized as a long-lived, late-maturing, estuarine-dependent, anadromous species (ASSRT 2007). Anadromous species are those that spend the majority of their life cycle in marine environments but reproduce in freshwater habitats. The historic range of Atlantic sturgeon included major estuarine and riverine systems spanning from the Saint Johns River, Florida, to Hamilton Inlet on the coast of Labrador (Murawski and Pacheco 1977; Smith and Clugston 1997; ASSRT 2007), with the Delaware River historically supporting the largest population along the Atlantic Coast (Secor and Waldman 1999; ASSRT 2007).

Atlantic sturgeon are slow maturing, with females typically reaching sexual maturity at 16 years or older and males at least 12 years in mid-Atlantic systems (Van Eenennaam et al. 1996). Spawning is not believed to occur every year, with spawning intervals ranging from 2 to 5 years for females (Vladykov and Greeley 1963; Van Eenennaam et al. 1996; Stevenson and Secor 1999; ASSRT 2007). Fecundity has been correlated with age and body size and typically ranges between 400,000 and 8 million eggs per female (Smith et al. 1982; VanEenennaam and Doroshov 1998; Dadswell 2006; ASSRT 2007).

Spawning adults are generally thought to migrate upriver in their natal systems during April and May in mid-Atlantic systems (Murawski and Pacheco 1977; ASSRT 2007), with recent studies suggesting that spawning may occur as late as mid to late June in the Delaware River (Simpson and Fox 2007). Spawning is believed to occur in flowing water between the salt wedge and fall line of large tidal rivers, where optimal flows are between 46 and 76 cm/s and depths are between 11 and 27 m (Borodin 1925; Crance 1987; Bain et al. 2000; ASSRT 2007). The highly adhesive eggs are deposited on hard-bottom substrates and fertilized externally (Smith et al. 1980; Gilbert 1989; Smith and Clugston 1997; ASSRT 2007).

Spawning locations in the Delaware Estuary were historically reported between river kilometer (rkm) 75 and rkm 130, with locations such as Pea Patch Island near Delaware City, Delaware, and Penn's Grove, New Jersey (rkm 85–110), noted as likely spawning areas. However, these conclusions were based primarily on fishery dependent information from the caviar fishery (Ryder 1890; Cobb 1900; Borodin 1925). Recent information from the movements of telemetered adult Atlantic sturgeon coupled with substrate and water quality information suggests that present day spawning may occur between north Philadelphia, Pennsylvania (rkm 176), and Trenton, New Jersey (rkm 211), in the Delaware River (Simpson and Fox 2007). However, the area between Marcus Hook, Pennsylvania (rkm 125), and Trenton could be considered potential spawning habitat based on substrate and water quality information (Simpson and Fox 2007). The majority of hard-bottom substrates, particularly coarse-grained substrates, occurring at depths suitable for Atlantic sturgeon spawning between Marcus Hook and Tinicum Island (rkm 136) either neighbor or are located within the shipping channel (Sommerfield and Madsen 2003).

After hatching, juvenile sturgeon move downstream into brackish waters, and eventually become residents in estuarine waters for months or years (Smith and Clugston 1997; ASSRT 2007). Upon reaching sizes of approximately 76 to 92 cm, the juveniles may emigrate to coastal waters (Murawski and Pacheco 1977; Smith 1985; ASSRT 2007), where they may travel widely, undertaking long range migrations and wandering among coastal and estuarine habitats (Dovel and Berggren 1983; Bain 1997; ASSRT 2007). Studies on the movements of telemetered juvenile and adult Atlantic sturgeon tracked manually in the Delaware Estuary indicate that sturgeon commonly utilize the shipping channel for upriver and downriver movements. These studies also identified three riverine concentration areas for juveniles during the summer months located at Artificial Island (rkm 89), Cherry Island Flats (rkm 110), and the Marcus Hook Anchorage (Shirey et al. 1999; Simpson and Fox 2007). Genetic studies and tagging programs indicate that a large percentage of the juveniles utilizing these concentration areas originated in other systems, mainly the Hudson River (King et al. 2001; ASSRT 2007; Wirgin et al. 2007).

Although the Delaware River once supported the largest population of Atlantic sturgeon along the Atlantic Coast (Secor and Waldman 1999; ASSRT 2007), overfishing, beginning in the 1880s and continuing throughout the early 1900s, led to recruitment failure and stock collapse. Habitat degradation and continued fishing prevented the population from recovering, and thus the population has apparently maintained itself at a very low level since the early 1900s. Currently, it is believed that Atlantic sturgeon are still reproducing in the Delaware River based on the capture of sexually mature adults during the historic spawning season (Simpson and Fox 2007). Genetic analyses from nuclear (King et al. 2001) and mitochondrial DNA (Wirgin et al. 2007) indicate that the Delaware River population is distinct from others on the Atlantic Coast. However, the ASSRT found that the Delaware River population was not sufficiently distinct to stand as its own DPS, and was grouped together with the Hudson River population as part of the New York Bight DPS.

The ASSRT speculated that the current population size of the Delaware River population is probably less than 300 spawning adults (ASSRT 2007). Although the ASSRT did not provide any empirical data to justify this population size, their rationale for using this figure was that the river systems for which adult population size estimates were available, the Hudson and the Altamaha, had approximate population sizes of 860 and 350 spawning adults, respectively. They speculated that these two populations are the largest populations in the United States and assumed that the other U.S. populations would be smaller than these two systems, hence the 300 spawning adults figure (ASSRT 2007). Rigorous estimates of the size of the Delaware River population are not available due to the difficulties associated with capturing a sufficient number of fish for study, particularly adults, the vast size of the Delaware Estuary, and the long-range migrations and coastal wandering behavior of juveniles and adults.

STUDY AREA

The Delaware Estuary, the tidal portion of the Delaware River, stretches from Trenton, New Jersey, and Morrisville, Pennsylvania (rkm 217), south to Cape May, New Jersey, and Cape Henlopen, Delaware, and includes all of Delaware Bay (Figure 1). It encompasses approximately 17,600 km^2 and is bordered by the states of New Jersey, Delaware, and Pennsylvania. The estuary is highly industrialized and hosts one of the largest petrochemical port complexes in the United States. Many large commercial vessels transit the estuary to reach these ports in the Wilmington, Delaware; Camden, New Jersey; and Philadelphia, Pennsylvania areas. The Maritime Administration of the U.S. Department of Transportation groups 17 ports in the Philadelphia, Pennsylvania, area together as Philadelphia/Delaware River Ports. These ports stretch from Salem, New Jersey, and Delaware City, Delaware, at rkm 97 to the ports of southern Bucks County, Pennsylvania, at rkm 203. In 2007, a total of 3,148 ocean-going vessels greater than 10,000 deadweight tons (DWT) visited the Philadelphia/Delaware River Port Complex, making it the fifth busiest port complex in the United States, following Houston, Los Angeles/Long Beach, New York, New Orleans, and San Francisco (USDOT 2008). Within the port complex, the Port of Philadelphia at rkm 159 handles the greatest volume of cargo (USACOE 2006).

Vessels transit the estuary through a shipping channel, the depth of which is maintained by the U.S. Army Corps of Engineers. The lower portion of the shipping channel, which extends 203 rkm from the mouth of Delaware Bay to the south of Bordentown, New Jersey (approximately 24 rkm upriver of the northern boundary of the city of Philadelphia), is currently maintained at a depth of 12.2 m (40 ft). The width of the channel varies from 122 m to 305 m, with the channel being wider in the lower estuary and narrower upriver. North of Bordentown to the southern boundary of Trenton, a distance of 8.6 km, the channel depth is maintained at 7.6 m (25 feet). Through the city of Trenton, a distance of 2 km where there is a small port, the channel depth is maintained at a depth of 3.7 m (12 feet). The Delaware River is non-navigable by large vessels above Trenton. The relatively long distance vessels need to travel from the sea through the estuary to reach their ports is unusual; most of the other major Atlantic Coast ports such as New York and Norfolk, Virginia, are located close to the sea. The long distance that vessels transit through the Delaware Estuary allows for a greater chance of interaction with sturgeon. In addition to commercial vessels, many recreational and commercial fishing vessels also traverse the Delaware Estuary.

METHODS

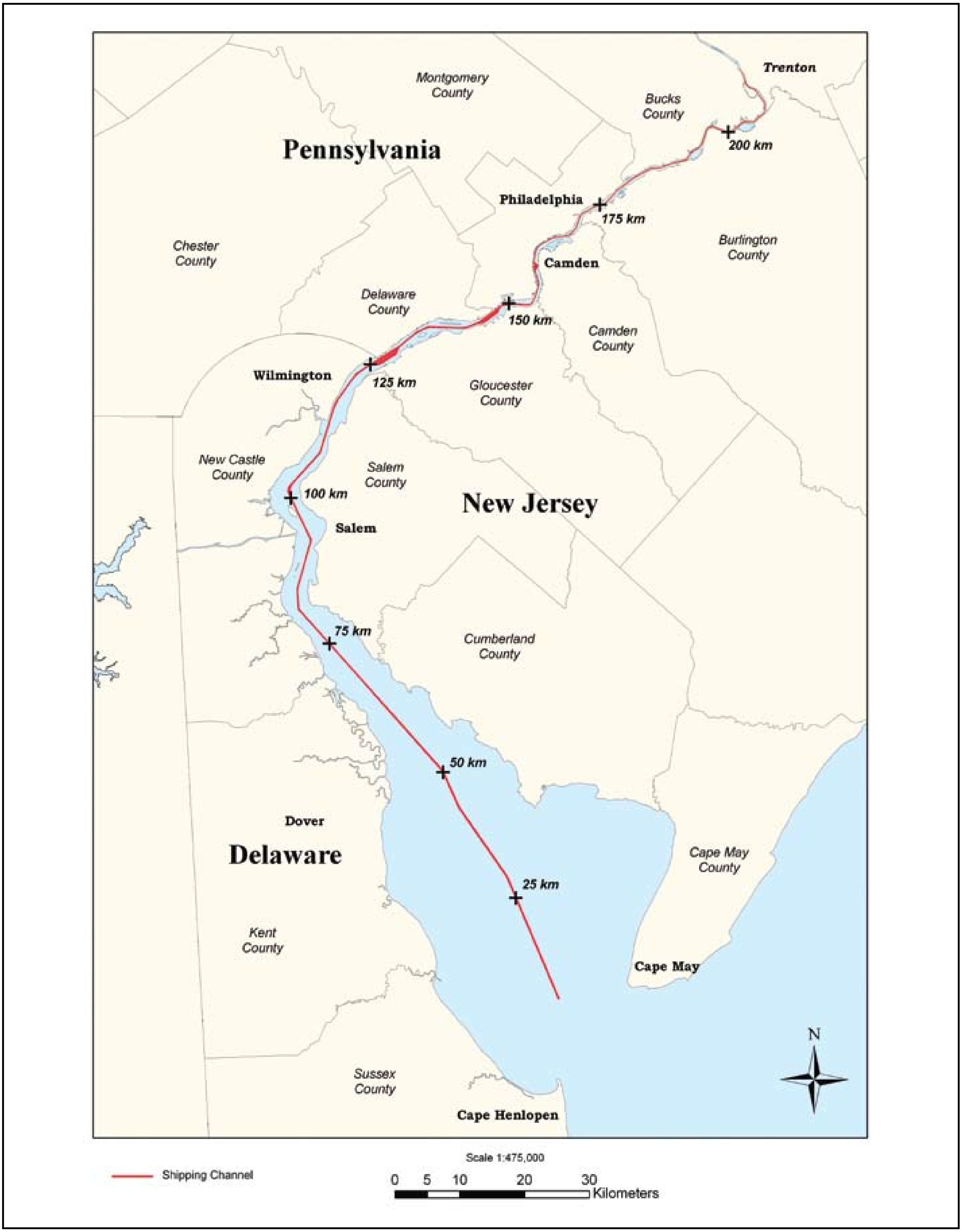
To evaluate the occurrence of Atlantic sturgeon vessel-strike mortalities in the Delaware Estuary, the Delaware Division of Fish and Wildlife (DEDFW) began tracking reports of sturgeon mortalities in 2005. The DEDFW received several reports of Atlantic sturgeon mortalities annually prior to 2005 but the reports were not formally documented. All of the sturgeon mortalities were reported by interested citizens or directly by agency biologists who encountered the carcasses while conducting surveys on other species. A dedicated survey program has not been implemented by DEDFW. However, the DEDFW Natural Heritage and Endangered Species Program has integrated logbooks and contact information into their shorebird monitoring program training guide. The shorebird monitoring program surveys a large portion of the beaches along Delaware Bay during spring and typically accounts for several of the sturgeon mortality reports annually. The majority of sturgeon reported were measured for total length (or length of portion found), scanned for internal and external tags, sexed when practical, examined for injuries, photo documented, and marked prior to being buried to eliminate double reporting. Tissue samples were taken and archived for future genetic stock analysis and a subset for contaminant analysis depending on the stage of decomposition.

To explore the effect of vessel-strike mortalities on the Delaware River Atlantic sturgeon population, we conducted an egg-per-recruit (EPR) analysis (Boreman 1997) to examine the impact on lifetime fecundity. The equation of the EPR is:

$$EPR = \sum_{i=2}^{n} \lambda_i \varphi_i \prod_{t=1}^{i-1} e^{-(VS_t + M)}$$

where n is the oldest spawning age, λ is the proportion of females that are mature at age i, ϕ_i is the mean fecundity of a female at age I, VS is the instantaneous rate of vessel-strike mortality during the period t, and M is the instantaneous natural mortality rate. All maturity and fecundity schedules were taken from Kahnle et al. (2007). We evaluated a range of VS values from 0 to 0.25 at intervals of 0.01. We assumed a maximum age of 60 years, a constant M equal to 0.07 over all ages, fishing and bycatch mortality rates equal to zero, and that sturgeon become fully vulnerable to vessel strikes starting at age 3 (assuming knife-edge recruitment). We assumed that sturgeon become vulnerable to vessel strikes at age 3 because this age corresponds approximately to the length of the smaller sturgeon carcasses that were observed (Stevenson and Secor 1999). Vessel-strike mortality rates that result in EPRs of 50% or more of the EPR from an unexploited population were considered sustainable based on Kahnle et al. (2007).

Figure 1. Map of the Delaware Estuary, the tidal portion of the Delaware River, which stretches from Trenton, New Jersey, and Morrisville, Pennsylvania, south to Cape May, New Jersey, and Cape Henlopen, Delaware, and includes all of Delaware Bay. The estuary encompasses approximately 17,600 km^2 and is bordered by the states of New Jersey, Delaware, and Pennsylvania. The shipping channel is shown and rkm points are indicated.



RESULTS

A total of 28 Atlantic sturgeon mortalities were reported in the Delaware Estuary between 2005 and 2008 (Table 1). The locations of reports ranged from Little Tinicum Island on the Delaware River near Chester, Pennsylvania, to Cape Henlopen near the mouth of Delaware Bay (Figure 2). Sixty-one percent of the sturgeon reported were of adult size, which was defined as sturgeon exceeding or likely to exceed 150 cm total length if not severed, with the majority (71%) of mortalities reported in spring during the months of May and June. Only one carcass was reported from the New Jersey side of the estuary.

Fifty percent of the sturgeon reported had injuries consistent with being struck by a vessel, while the remaining sturgeon reported were too decomposed to definitively determine the cause of death. Of the carcasses that had injuries consistent with being struck by a vessel, 71% were severed through the torso or head region (Figures 3 and 4), which is consistent with being entrained through the propeller of a large vessel. A few sturgeon had injuries that were consistent with a strike from the propeller of a small vessel, such as a recreational or commercial fishing vessel (Figure 5). Field observations indicate that it is unlikely that the injuries are occurring post-mortem. For instance, a DEDFW marine patrol officer encountered an adult Atlantic sturgeon that surfaced in the wash of a large vessel navigating upstream in the Delaware River in May 2005. The sturgeon was bleeding and moribund from a laceration near the dorsal fin described as a propeller strike (T. Penuel, DEDFW, pers. comm.). In addition, a Delaware commercial crabber reported hitting an adult-size Atlantic sturgeon with his outboard motor during late spring while moving through a shallow section of the lower Delaware River (C. Shirey, DEDFW, pers. comm.).

Results from the EPR analysis are shown graphically in Figure 6. We plotted the percentage of female sturgeon killed annually by vessel strikes versus the percent reduction in maximum EPR. Eggs per recruit declined rapidly from the maximum of 7.1 million eggs, if the only source of mortality was natural mortality, to less than 10% of this amount if the annual percentage of female sturgeon mortalities exceeded 9% of the population. The $VS_{50\%}$, or the vessel-strike mortality rate that results in a 50% reduction of the maximum EPR, occurs when

Table 1. Summary of Atlantic sturgeon carcasses reported in the Delaware Estuary between 2005 and 2008. Adults were defined as sturgeon exceeding or likely to exceed 150 cm total length if not severed. The dates and locations reported are the dates and locations where the carcasses were found and are not necessarily the dates and locations where the vessel strikes occurred.

Date reported	Location found	Life stage	Apparent cause of death	Injuries noted
5/7/2005	Artificial Island, NJ	Adult	Vessel strike	Severed at anal fins, blunt force trauma to head
5/17/2005	Woodland Beach, DE	Adult	Vessel strike	Severed through torso, crushed scutes, anterior section only
5/18/2005	Woodland Beach, DE	Adult	Vessel strike	Laceration through mid torso
5/19/2005	Slaughter Beach, DE	Adult	Unknown	Badly decomposed, head region missing,
5/23/2005	Conch Bar, DE	Adult	Unknown	Badly decomposed, head region missing
7/5/2005	Woodland Beach, DE	Juvenile	Vessel strike	Laceration near caudal peduncle
5/2/2006	Augustine Beach, DE	Adult female	Vessel strike	Severed through lower torso at anal fins, anterior section only
5/9/2006	South Bowers Beach, DE	Juvenile	Unknown	Badly decomposed, head region missing
5/15/2006	Port Mahon, DE	Juvenile	Unknown	Badly decomposed, head region missing
5/16/2006	Brockonbridge Gut, DE	Adult	Unknown	Badly decomposed, severed through lower torso at anal fins, anterior section only
5/17/2006	Kitts Hummock, DE	Adult	Unknown	Badly decomposed
5/17/2006	Little Tinicum Island, PA	Adult	Vessel strike	Severed through lower torso at anal fins, anterior section only
6/1/2006	Bay View Beach, DE	Juvenile	Vessel strike	Severed through mid torso region, anterior section only
8/15/2006	New Castle, DE	Adult	Unknown	Badly decomposed
8/17/2006	Augustine Beach, DE	Juvenile	Vessel strike	Laceration to head region
5/11/2007	Collins Beach, DE	Adult	Vessel strike	Severed through torso, posterior section only
5/13/2007	Pea Patch Island, DE	Adult	Unknown	Unreported
5/14/2007	Pickering Beach, DE	Juvenile	Vessel strike	Severed through torso, posterior section only
5/25/2007	Pea Patch Island, DE	Juvenile	Vessel strike	Severed through torso, posterior section only
6/11/2007	Bay View Beach, DE	Adult	Unknown	Badly decomposed
5/29/2008	Cape Henlopen, DE	Juvenile	Unknown	Badly decomposed, head region missing
6/23/2008	Marcus Hook, PA	Adult	Vessel strike	Severed head and crushed scutes
6/29/2008	Augustine Beach, DE	Juvenile	Vessel strike	Laceration posterior to head region and side of torso
7/10/2008	Port Mahon, DE	Juvenile	Unknown	Badly decomposed
7/12/2008	South Bowers Beach, DE	Adult	Unknown	Badly decomposed
10/21/2008	Ship John Shoal, DE Bay	Adult	Vessel strike	Head region severed
10/27/2008	Cape Henlopen, DE	Juvenile	Unknown	None observed
11/3/2008	Woodland Beach, DE	Adult	Unknown	None observed

Figure 2. Locations of Atlantic sturgeon carcasses reported in the Delaware Estuary between 2005 and 2008. The locations shown are where the carcasses were found and are not necessarily the locations where the vessel strikes occurred.

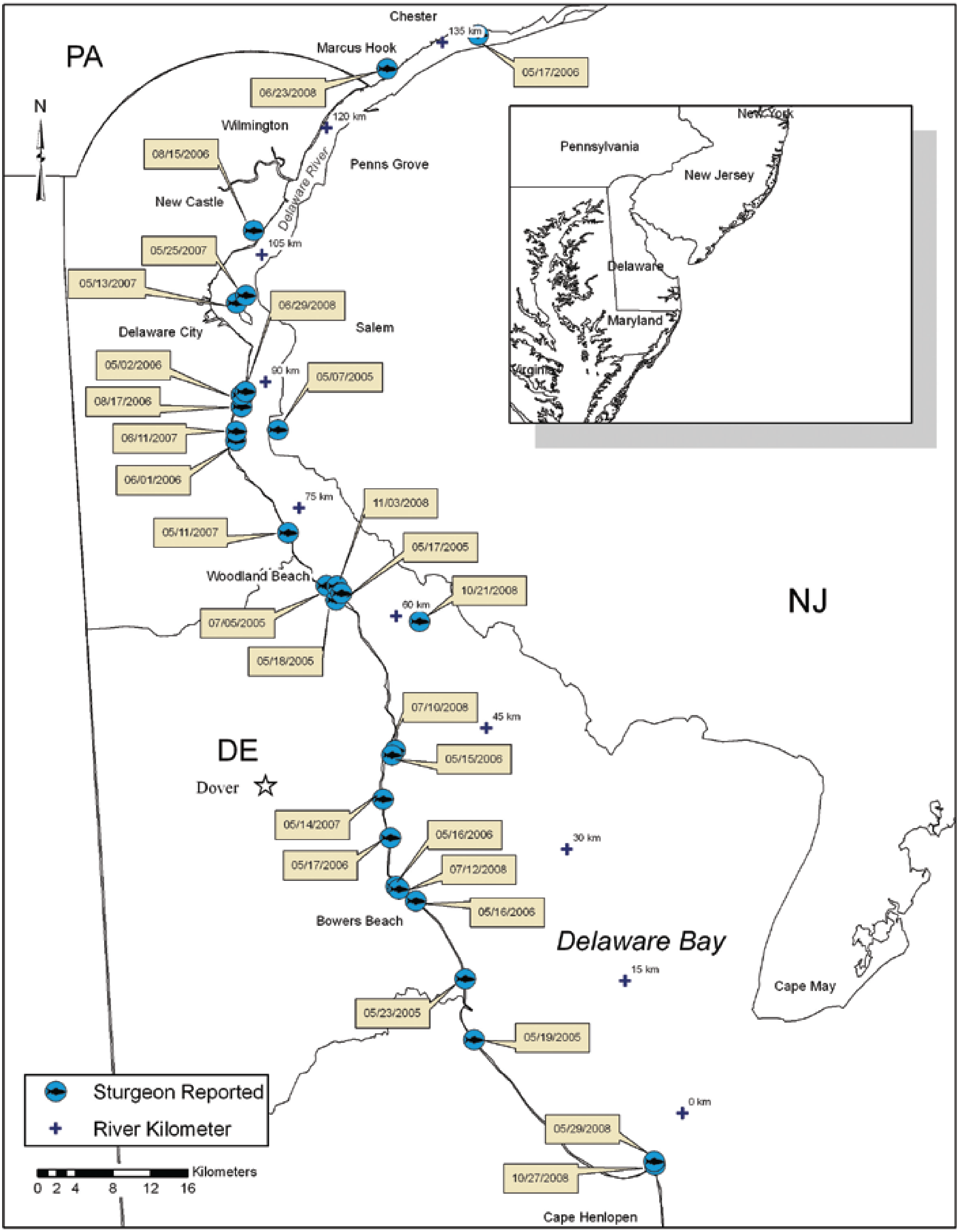


Figure 3. Gravid female Atlantic sturgeon found at Augustine Beach, Delaware, on 2 May 2006. This sturgeon appeared to have been struck by the propeller of a large vessel and was severed through the torso region near the anal fins. The anterior portion found measured 145 cm in length.

JARED JACOBINI, DEDFW

Figure 4. Large adult Atlantic sturgeon found at Woodland Beach on 17 May 2005. This sturgeon appeared to have been severed by the propeller of a large vessel. Greg Murphy of URS Corporation shown in photo examining the carcass.

JARED JACOBINI, DEDFW

Figure 5. Juvenile Atlantic sturgeon found at Augustine Beach, Delaware on 29 June 2008. The injuries were consistent with a strike from the propeller of a small vessel. This sturgeon measured 75 cm total length.

GREG MURPHY, URS CORPORATION

Figure 6. The percent of maximum eggs per recruit (EPR) versus the annual percentage of female Atlantic sturgeon in the Delaware River population killed by vessel strikes.

approximately 2.5% of the female Atlantic sturgeon in the Delaware River population are struck by vessels and killed annually.

DISCUSSION

The presence of gravid Atlantic sturgeon in the Delaware River during the historical spawning season is strong evidence that a remnant population continues to persist. However, the number of sturgeon being killed by vessel strikes may be detrimental to the long-term viability of the population. Because juvenile sturgeon inhabiting the Delaware Estuary are composed of mixed stocks, predominantly fish of Hudson River origin foraging in the Delaware River (King 2001; ASSRT 2007; Wirgin et al. 2007), the vessel strikes occurring in the estuary may be adversely affecting sturgeon populations from other systems as well. The impact of these mortalities on the viability of the Delaware River population would be better understood if population estimates were available. Therefore, it may be useful to assess estimates of adult spawning populations from other Atlantic Coast systems. Peterson et al. (2008) estimated the size of the spawning run population in the Altamaha River, which is thought to be one of the largest populations in the United States, to be about 350 fish. Kahnle et al. (2007) estimated that the size of the Hudson River population, purportedly the largest population on the Atlantic Coast, is approximately 860 adults. Neither of these studies estimated the total Atlantic sturgeon population (all age classes) for these rivers. Relative abundance estimates from gillnet surveys conducted by DEDFW indicate that the current Delaware River sturgeon population is much smaller by comparison than that of the Hudson or Altamaha rivers (Shirey et al. 1999).

Some studies have recommended harvest strategies using $F_{40\%}$ as the basis for formulating risk-adverse harvest strategies (Clark 1993; Mace 1994), that is, the harvest strategy that consists of fishing at a rate that reduces spawning biomass per recruit (equivalent to lifetime egg production per recruit) to 40% of the unfished value. However, other studies have indicated that using $F_{50\%}$, may be more prudent for long-lived stocks with low resiliency and for those stocks targeted for rebuilding (Boreman 1997; Clark 2002; Kahnle et al. 2007). Based upon the vulnerability schedule assumed in the EPR, a small increase in annual mortality due to vessel strikes can have a large impact on the lifetime fecundity of sturgeon. Our EPR analysis showed that the $VS_{50\%}$ (analogous to $F_{50\%}$) occurred at a vessel-strike mortality rate of approximately 2.5% per year. For example, if the Atlantic sturgeon population in the Delaware River is 100 female fish, then probably not more than 2 females could be struck and killed annually without having an adverse effect on the population. Similarly, if the Atlantic sturgeon population is 1,000 females, then probably not more than 25 females could be killed annually without negatively impacting the population.

There are very few beaches or access areas along the length of the Delaware Bay. Much of the shoreline consists of dense marsh vegetation limiting public access and reducing the likelihood that a carcass would be encountered and reported. Thus, only some fraction of the total vessel-strike mortalities that have occurred probably are reported. Another reason to suspect that the data reported here underestimate the total number of vessel-strike mortalities is that the data are derived primarily from reports received by DEDFW, and not from any agencies on the New Jersey side of the estuary. The New Jersey Division of Fish and Wildlife (NJDFW) does not have a program that tracks sturgeon mortalities in the Delaware Estuary and their biologists have not found carcasses on the New Jersey side of the estuary (R. Allen, NJDFW, pers. comm.).

Aside from the fact that the data reported here were primarily collected by DEDFW, physical oceanographic processes are probably responsible for the fact that most sturgeon carcasses were found on the Delaware side of the estuary. In the Delaware Estuary, dense, high salinity water flows into the estuary via the deep channel and the light low salinity water flows out along the surface of the Delaware and New Jersey shores. However, because the Coriolis force deflects the light, low salinity water flowing out of the estuary against the Delaware shore, the buoyant outflow is much stronger along the Delaware shore than the New Jersey shore (Wong and Munchow 1995).

In 2006, nine sturgeon mortalities were found in the Delaware Estuary. In the unlikely scenario that these mortalities represented 100% of the total sturgeon mortalities in the Delaware Estuary (and were all female), then the sturgeon population would need to exceed 360 female fish to avoid adverse population impacts. In the more likely scenario that the nine mortalities that were reported represented only 10 or 50% of the total sturgeon vessel-strike mortalities (and were all female), then the sturgeon population would need to be larger than 3,600 or 720 female fish, respectively, to avoid adverse impacts. Gutreuter et al. (2003) noted that entrainment kills are rarely observed even in abundant species, but that if vessel traffic is large, even low kill rates that are extremely difficult to detect have the potential to adversely affect the production of certain species.

Fifty percent of the sturgeon carcasses found were too decomposed to definitively ascribe the cause of death to vessel-strikes. It is possible that these sturgeon were killed in gillnets, partially preyed upon by large predators, or died from disease. However, because these sturgeon were found in the same general area as the less decomposed carcasses and 36% were missing their head region, it is not unreasonable to assume that the majority of these sturgeon were also vessel-strike mortalities. We are unaware of any large predators such as large sharks that would move up the Delaware Estuary and consume only a portion of a sturgeon. Seals are occasional visitors to the Delaware Estuary, but they tend to visit in the late fall and winter and for the most part are localized in the lower Delaware Bay (www.ocean.udel.edu/oilspill/wildlifeimpacts.html). Similarly, we are unaware of any epizootics targeting sturgeon. There is a gillnet fishery for American shad (*Alosa sapidissima*) and striped bass (*Morone saxatilis*) in the lower Delaware Estuary, which is mostly prosecuted on the Delaware side of the estuary (New Jersey prohibits the commercial harvest of striped bass and Delaware's jurisdiction extends to the New Jersey shoreline of the Delaware River north of Delaware Bay). None of the carcasses found showed any indication of being entangled in gillnet mesh, i.e., none of the carcasses were enmeshed in netting, and none showed any indications of gillnet scars. Additionally, many of the commercial fishermen in the gillnet fishery report releasing the vast majority of the sturgeon they catch alive in good condition, which has been substantiated by tag returns months after being caught as bycatch in Delaware Bay (C. Shirey, DEDFW, pers. comm.). Similarly, many of the sturgeon carcasses reported here were found upriver of the northern limit of the anchored gillnet fishery (Liston Point, Delaware, rkm 77). Because of the nature of the currents in the estuary, it is unlikely that these carcasses drifted upriver. Finally, the striped bass gillnet fishery in Delaware, which is the primary gillnet fishery in the estuary, is open only from 15 February to 31 May and then, depending on the amount of quota harvested in the spring, can be opened again from 15 November to 31 December. Yet 50 % of the carcasses were found from 1 June to 14 November, outside of the striped bass gillnet season window.

The Philadelphia/Delaware River port complex differs from most of the other major ports in the United States in that the port facilities are located far up in the estuary. This poses an additional liability for sturgeon. The port's distant location from the Atlantic Ocean requires that vessels navigate through most of the estuary into potential Atlantic sturgeon habitat, thereby increasing the possibility of interactions with sturgeon. Additionally, above the Salem, New Jersey, and Delaware City, Delaware area, the estuary narrows significantly. Therefore, there is less habitat outside of the shipping channel for sturgeon to inhabit, and consequently sturgeon may be more likely to be struck by a vessel in the upper estuary.

Currently, the U.S. Army Corps of Engineers is planning to deepen the main channel of the Delaware River by 1.5 m (5 feet), from 12.2 m (40 feet) to 13.7 m (45 feet), from the Philadelphia Harbor, Pennsylvania, and Beckett Street

Terminal, New Jersey, to the mouth of the Delaware Bay, a distance of 165 km, to allow larger vessels to enter the river (www.nap.usace.army.mil/cenap-pl/drmcdp/overview.html). Both the dredging to deepen the channel and the subsequent increase in large vessel traffic may further hamper the recovery of the Delaware River Atlantic sturgeon population.

The majority of vessel strikes appeared to result from interactions with large vessels, such as tankers, with a lower percentage likely resulting from interactions with small recreational or commercial fishing vessels equipped with outboard or inboard/outboard (stern drive) engines. Atlantic sturgeon are demersal fishes and thus if the sturgeon are spending most of their time at the bottom of the water column, then they are most likely being impacted by larger vessels. Large vessels that transit the shipping channel typically draft close to the bottom of the channel, thereby posing a threat to sturgeon positioned close to the bottom of the channel. Other species of sturgeon, such as the white sturgeon (*A. transmontanus*) are primarily found in the lower portion of the water column. Paragamian and Duehr (2005) tagged white sturgeon with depth-sensitive radio transmitters during prespawn and spawning periods in the Kootenai River, Idaho, located in the upper Columbia River basin, and found the sturgeon in the bottom one-third of the water column during 75% of the relocations. Fisher and Jacobini (2007) reported that Atlantic sturgeon surgically implanted with depth-sensing acoustic transmitters in the Delaware River were recorded at depths of 6.1 to 15.5 m and averaged 9.0 m in depth during manual relocations. Additional data on movements in the water column are still being collected and analyzed (Fisher and Jacobini 2007). Similarly, some of the sturgeon carcasses reported appeared to be too large to be severed by a small outboard propeller. Alternatively, sturgeon are known to frequently jump out of the water (Sulak et al. 2002). During jumping episodes, when sturgeon are located at or near the surface of the water, they may be more vulnerable to strikes from smaller vessels powered by outboards.

The problem of vessels striking and killing Atlantic sturgeon may be common in other estuaries and rivers as well. For example, five Atlantic sturgeon were reported to have been struck and killed by vessels in the James River, Virginia, in 2005, three in 2006, seven in 2007, and eight mortalities were reported in 2008. Most of the carcasses were found in a small area upstream of Hopewell, Virginia, where there is a significant narrowing of the shipping channel (A. Spells, U.S. Fish and Wildlife Service, pers. comm.). The James River is similar to the Delaware River in that commercial vessels transit long distances upriver to reach the ports. In the James River, vessels need to transit over 140 km to reach ports in Richmond, Virginia (www.nao.usace.army.mil/Partnerships/James%20River/homepage.asp).

Vessel-strike mortalities have also been noted in other sturgeon species. Gutreuter et al. (2003) examined mortality rates in adult fish entrained through the propellers of river towboats on the Upper Mississippi River and Illinois Waterway and found that a variety of fish were killed by towboat propellers, including shovelnose sturgeon (*Scaphirhynchus platorynchus*). They estimated that an average of 0.53 shovelnose sturgeon were killed per km of towboat travel. Partially or completely severed adult lake sturgeon (*A. fulvescens*) have also been recovered from the Upper Mississippi River (S. Gutreuter, U.S. Geological Survey, pers. comm.).

The only reports we were able to find of marine fish mortalities related to vessel strikes were for whale sharks (*Rhincodon typus*; Gudger 1938a, 1938b, 1940). The whale shark mortalities reported by Gudger were all rammings by the bow of vessels. There have been reports of marine mammals such as whales (Laist et al. 2001; Kraus et al. 2005; Panigada et al. 2006), dolphins (Wells and Scott 1997) and manatees (Marmontel et al. 1997; Laist and Shaw 2006) being struck by vessels. Additionally, there have been reports of sea turtle vessel strikes, e.g., from 1994–1999, 30% of the 109 sea turtles found dead in the Delaware Estuary were victims of vessel strikes (Stetzar 2002). To our knowledge, this represents the first reported account of Atlantic sturgeon being struck and killed by vessels.

Finally, vessel strikes in conjunction with other anthropogenic impacts may further impede the recovery of Atlantic sturgeon populations. Factors such as poor water quality, low dissolved oxygen levels (although dissolved oxygen levels in the Delaware Estuary have improved dramatically over the past 50 years; Sutton et al. 1996), habitat modification, and bycatch mortality may be affecting the Atlantic sturgeon populations. For example, under scenarios of low recruitment in the Hudson River, it was estimated that bycatch mortality of Atlantic sturgeon would exceed levels that would result in stable or growing populations, and it was noted that populations smaller than that of the Hudson River, such as the Delaware River population, would be expected to be disproportionately affected by bycatch as proportional removals have larger negative effects on less productive populations (ASMFC 2007).

RECOMMENDATIONS

Further research to quantify the extent of vessel-strike mortalities in the Delaware Estuary could include directed ground or aerial surveys, and a public outreach campaign to request public assistance in reporting Atlantic sturgeon carcasses to the relevant agency. The 2009 Delaware Fishing Guide, which lists the fishing regulations of the DEDFW, added a section which requests the public's assistance in reporting dead sturgeon to the agency (www.fw.delaware.gov/Fisheries/Documents/2009fishingguideweb.pdf). This approach could be adopted by other states. Creation of a centralized database to allow scientists to report vessel strikes on a coastwide basis would aide in gaining an understanding of the magnitude of the problem along the Atlantic coast. In an effort to evaluate the depth and area in the water column that Atlantic sturgeon utilize, DEDFW is currently tagging sturgeon in the Delaware River with depth-sensing ultrasonic transmitters, which will provide valuable information related to vessel strikes, perhaps identifying the depths at which sturgeon are being struck by propellers. Additionally, more sophisticated approaches to quantify sturgeon mortality could be considered, such as trawling behind vessels (Gutreuter et al. 2003).

Possible mitigation measures could include recommending reduced vessel speed during the Atlantic sturgeon spawning season for vessels transiting through known concentration or spawning areas in the Delaware Estuary or other rivers with Atlantic sturgeon populations. This strategy has proven effective for marine mammals (Laist and Shaw 2006). For marine mammals, it is thought that slower vessel speeds reduce vessel-strike mortalities by reducing the force of collision impacts and by allowing animals more time to detect and avoid oncoming vessels (Laist and Shaw 2006). Although reducing vessel speed to reduce mortalities from the force of collision may be important for large whales (Vanderlaan and Taggart 2007), which can survive collisions due their large body size, we expect that the primary benefit of reduced vessel speeds would be to allow sturgeon additional time to detect and avoid approaching vessels.

Alternatively, it may be useful to investigate the possibility of using underwater sound, light, or odor to divert sturgeon from the shipping channel and/or attract them to areas outside of the shipping channel. Ultrasound has been found to be effective in controlling the behavior of clupeid species (Gibson and Myers 2002; Plachta and Popper 2003; Popper et al. 2004) but findings from studies on other species using a variety of frequencies have been ambiguous (Popper and Carlson 1998). Studies to date have not shown any indication that sturgeon would be capable of detecting ultrasound (Lovell et al. 2005; Popper 2005). Similarly, studies on using light to divert fish have demonstrated that mercury and strobe lights can be used to attract some species and divert others (Popper and Carlson 1998). Other research has demonstrated that scent is used to attract sturgeon for feeding (Bardi Jr. et al. 1986) and for reproduction (Kynard and Horgan 2002), and therefore it may be worthwhile to investigate using odors to divert sturgeon from areas with heavy vessel traffic. However, if sturgeon require the channel habitat to spawn, then continually diverting them from the channel may be problematic.

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