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GREAT LAKES RESTORATION AND THE PUBLIC TRUST DOCTRINE:  
MILWAUKEE’S RESTORATION OBSTACLES AND OPPORTUNITIES

Sarah Martinez¹ & Melissa K. Scanlan²

I. INTRODUCTION

The Great Lakes are a bi-national treasure containing 84% of North America’s fresh surface water; but are also home to many sites of legacy toxic contamination, called Areas of Concern (AOC). The Great Lakes Legacy Act and Great Lakes Restoration Initiative accelerated the pace of restoring these sites.³ In 2021, President Biden signed the Infrastructure Investment and Jobs Act, which allocated $1 billion in funding for Great Lakes restoration to continue “addressing toxic substances and Areas of Concern . . . .”—a move that clearly demonstrates the priority of maintaining the health and resilience of the Great Lakes region.⁴

After decades of work on the Milwaukee Estuary AOC, the legacy contaminants in its sediments will soon be dredged in an effort to restore beneficial uses such as being able to consume the fish one catches without a health concern

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or enjoying a beach that is clear of harmful bacteria or algae. With funding from federal, state, and non-profit partners, the Milwaukee Estuary AOC restoration will cost roughly $200 million to complete. The preferred alternative for disposal of these dredged sediments is an in-lake containment, called a Dredged Material Management Facility (DMMF), adjacent to the Port of Milwaukee (the Port). The project involves the use of Lake Michigan’s lakebed, which implicates the public trust doctrine. This article analyzes the legal issues involved in filling the lakebed for this purpose and the need for a determination of future uses of the new land.

This article provides a succinct overview of the proposed use of the lakebed for the DMMF. Then it explains the public trust doctrine as applied to Lake Michigan and the special category of legislative lakebed grants. In fact, the most famous public trust case, Illinois Central, involved a lakebed grant in Lake Michigan. Illinois Central’s legal precedent grounds the discussion on lakebed grants, but this article goes further by bringing the reader into modern jurisprudence with Wisconsin Supreme Court decisions and applies that precedent to a proposed filling of lakebed. The larger discussion of lakebed grants serves as a short background for the subsequent investigation of the specific legislative lakebed grants to Milwaukee in the area managed by the Port. The lakebed grants at issue specify public trust purposes. Based on an analysis of those grants and the public

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trust doctrine, precedent should guide a fact-intensive inquiry of the use of lakebed for a DMMF and the future use of the newly created land.

II. PROPOSED USE OF LAKEBED AS PART OF CLEANING UP THE MILWAUKEE ESTUARY AREA OF CONCERN

In accordance with the Great Lakes Water Quality Agreement of 1972 between the United States and Canada, the U.S. Environmental Protection Agency (EPA) designates AOCs when there is “significant impairment of beneficial uses . . . as a result of human activities at the local level.”7 Currently, twenty-six AOCs remain in the Great Lakes Basin; Milwaukee is home to one of the larger AOCs.8 The Milwaukee Estuary AOC covers roughly ten miles spanning three rivers and parts of the inner and outer Milwaukee harbor.9 Upon completion of this project, the Milwaukee Estuary AOC will be one of the largest public works projects in Milwaukee’s history.10 This section briefly covers why the Milwaukee estuary is an AOC and then discusses the Wisconsin Department of Natural Resources’ (WDNR) preferred alternative for disposal of the dredged sediment—the DMMF.

A. A Brief History of the Milwaukee Estuary AOC

The Great Lakes Water Quality Agreement establishes a non-regulatory approach to addressing legacy contaminated sediments. These are pollutants for which there is often no identifiable responsible party liable to pay for cleaning up

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8 Milwaukee Estuary AOC, U.S. ENV’T PROT. AGENCY, https://www.epa.gov/great-lakes-aocs/milwaukee-estuary-aoc (last updated Jan. 18, 2022) (explaining that the original Milwaukee Estuary included a total of 8.6 miles of riverbed, and the inner and outer Harbors, but was expanded in 2008 to include parts of Cedar Creek, Lincoln Creek, and the Little Menomonee River). When the agreement was enacted in 1972 there were 43 AOCs identified in the Great Lakes. Id.
9 Id.
10 Id.
the contamination.\footnote{If there is a more recent identified responsible party in the mix, that entity may separately be under a Resource Conservation and Recovery Act order to remove contaminated sediment. This was the situation with the Tyco facility on restoring the AOC on the Lower Menominee River in Wisconsin. \textit{Lower Menominee River AOC}, U.S. ENV’T PROT. AGENCY, \url{https://www.epa.gov/great-lakes-aocs/lower-menominee-river-aoc} (last updated June 13, 2022).} Sediment in the AOCs is often contaminated with toxic chemicals such as polychlorinated biphenyls (PCBs), heavy metals like mercury, and oil, grease or other petroleum byproducts, that entered the waterbody prior to modern pollution controls.\footnote{U.S. ENV’T PROT. AGENCY, \textit{supra} note 3.}

The Milwaukee Estuary AOC includes the Milwaukee River, Kinnikinic River, Menomonee River, and parts of the inner and outer harbor of Lake Michigan.\footnote{Map of the Milwaukee Estuary Area of Concern, WIS. DEPT. OF NAT. RES., \url{https://dnr.wisconsin.gov/sites/default/files/topic/GreatLakes/MKE_AOCMap.pdf} (last visited May 27, 2022).} The EPA designated this area as an AOC in 1987 because these waterways’ sediments are contaminated with PCBs, polycyclic aromatic hydrocarbons (PAHs), and heavy metals.\footnote{Milwaukee Estuary Area of Concern: About the Milwaukee Estuary AOC, WIS. DEPT. OF NAT. RES., \url{https://dnr.wisconsin.gov/topic/GreatLakes/Milwaukee.html} (last visited May 27, 2022).} These contaminants are harmful to both humans and fish. Since the late 1980s, scientists have studied the effects of PCBs, and it is widely accepted that PCBs are highly carcinogenic.\footnote{Learn about Polychlorinated Biphenyls (PCBs), U.S. ENV’T PROT. AGENCY, \url{https://www.epa.gov/pcbbs/learn-about-polychlorinated-biphenyls-pcbbs} (last updated Jun. 5, 2022) (explaining “[s]tudies in humans support evidence for potential carcinogenic and non-carcinogenic effects of PCBs”).} According to the EPA, PCBs also cause adverse immune, reproductive, neurological, and endocrine effects in humans.\footnote{Id.} PAHs are also detrimental to human health. According to the Agency for Toxic Substances and Disease Registry, PAHs are also likely carcinogenic.\footnote{AGENCY FOR TOXIC SUBSTANCES AND DISEASE REGISTRY, POLYCYCLIC AROMATIC HYDROCARBONS (PAHs) TOXFAQS, \url{https://www.atsdr.cdc.gov/toxFAQs/RFacts69.pdf} (1996) (explaining that “[t]he Department of Health and Human Services (DHHS) has determined that some PAHs may reasonably be expected to be carcinogens.”).} Moreover, all three of these pollutants contribute to the degradation of eleven beneficial uses the EPA and WDNR identified.\footnote{WIS. DEPT. OF NAT. RES., \textit{Removal Target Updates for the Milwaukee Estuary Area of Concern} 3 (2021).}
The WDNR created a Remedial Action Plan to guide the cleanup of these waterways. Their remedial action plan strategizes how to remove the beneficial use impairments and tracks progress, with the ultimate goal to delist the Milwaukee Estuary as an AOC. According to the August 2021 Remedial Action Plan, the WDNR has removed one of the eleven identified beneficial use impairments, and the WDNR believes they are making significant progress towards removal of the others.

B. The WDNR’s Preferred Alternative for Disposal of Contaminated Sediments is a Dredged Material Management Facility on the Bed of Lake Michigan

According to WDNR’s estimates, the Milwaukee AOC contains between one to two million cubic yards of contaminated sediment. The WDNR, along with stakeholders, proposed to dredge these sediments, remove them from the AOC, and

https://widnr.widen.net/view/pdf/eg6c0gkmkj/GW_MKE_RAP2020.pdf?t.download=true (listing the following as impaired beneficial uses: dredging restrictions, fish tumor and deformities, bird or animal deformities or reproductive problems, restriction on fish and wildlife consumption, degradation of benthos, degradation of phytoplankton and zooplankton populations, Loss of fish and wildlife habitat, degradation of fish and wildlife populations, beach closings (recreational restrictions), eutrophication or undesirable algae, degradation of aesthetics).

20 Id. (stating that “[t]he DNR is committed to making progress in the AOC in order to delist, or remove, the Area of Concern designation and continues to work with stakeholders to identify goals and actions necessary to address legacy contamination in the AOC.”).
dispose of them in a new lakebed containment facility, near the Port, on the east side of Jones Island.23

The WDNR considered three options before recommending the DMMF as its proposed alternative: do nothing, truck the contaminated sediment to a landfill in Menomonee Falls, Wisconsin, or build the DMMF on the bed of Lake Michigan.24 Moreover, the DMMF is specifically designed to last for the next 100 years and control “potential releases of contaminants to the environment.”25 Once the DMMF is full, it will be capped with a clean material (e.g., sand).26 After it is capped, the WDNR’s assessment suggested that the newly created land, subject to the limits of the public trust doctrine, “can be developed for Port commercial expansion and other public uses.”27

In the WDNR’s assessment of alternatives, they identified nine criteria to determine the best route.28 As part of the criteria, the choice of where to dispose of the sediment must take both state and community acceptance into consideration.29 The WDNR concluded the DMMF alternative met all nine of these criteria.30

24 DMMF Fact Sheet, supra note 23, at 1.
25 Id. at 2.
26 Id. (explaining that “A cap is a layer of clean material, such as sand, that is placed over the contaminated sediments to mitigate the risk posed by those sediments.”).
27 Id. at 1–2 (stating that “[t]he area above the stored sediment becomes usable as newly created land, which can be developed for Port commercial expansion and other public uses.”).
28 ANALYSIS OF DREDGED MATERIAL MANAGEMENT ALTERNATIVES, supra note 22, at 1 (citing Natural Resources (NR) 722.07(4), the Wisconsin Administration Code, and the National Contingency Plan (40 C.F.R. § 300.430(e)(9)).
29 Id.
30 Id. at 12; see also MILWAUKEE METRO. SEWERAGE DIST., PERMIT APPLICATION FOR LOW-HAZARD WASTE GRANT OF EXEMPTION: MILWAUKEE ESTUARY AOC DREDGED MATERIAL MANAGEMENT FACILITY 1–2 (2021), https://dnr.wi.gov/topic/waste/documents/comment/MilwaukeeDMMF/LHERequest.pdf (explaining the regulatory requirements of the DMMF facility).
However, as of January 1, 2022, the WDNR has not yet issued a document with its final decision.31

It might be surprising to realize there are no federal or Wisconsin statutory or administrative code requirements that directly address the design and operation of a DMMF; the application to the WDNR to build the DMMF is for a low hazard waste exemption. There is also a regulatory review that involves the Army Corps of Engineers Section 404 and 408 permits under the Clean Water Act. When the Corps proposes to issue a 404 permit it triggers the WDNR’s determination whether to issue a Water Quality Certification per the Clean Water Act and its state regulations in NR 299.32

As noted, the DMMF is to be built on the bed of Lake Michigan. Is creating this DMMF on the bed of Lake Michigan consistent with the Wisconsin Legislature’s lakebed grant to Milwaukee and Wisconsin’s Constitutional requirements?33 Does the answer depend on defining the end use of the newly created dry land for a public trust purpose? While creation and future use of the DMMF obviously implicates the public trust doctrine, whether the WDNR is authorized to issue or deny a chapter 30 permit after it has considered the impacts on public trust rights is discussed in the next section.

31 E-mail from Gerald DeMers, Environmental Eng’r, Wisconsin Dep’t of Nat. Res., to Sarah Martinez, Water Pol’y Specialist, Ctr. for Water Pol’y. (Nov. 15, 2021, 10:46 CST) (on file with Center for Water Policy).
32 Section 408 of the Clean Water Act provides the Corps may grant permission to another entity to alter a civil works project when the alteration will not injure the public interest. Section 404 of the Clean Water Act provides the Corps may grant permission for the discharge of dredged or fill material in the waters of the United States. When the Corps proposes to issue a 404 permit for this project, the WDNR is required to follow procedures and standards in Wis. Admin. Rule NR 299 to issue or deny a water quality certification. The WDNR may deny a certification for any activity where the WDNR “does not have reasonable assurance that any discharge will comply with . . . any other appropriate requirements of state law as outlined in s. NR 299.04.” NR 299.01(2)(a). Then in NR 299.04 (1)(b)6, the regulation specifies the activity will comply with “[p]ublic interest and public rights standards, related to water quality, set forth” in a variety of subsections of chapter 30, the statute that is a key locus of public trust authority in Wisconsin.
III. THE PUBLIC TRUST DOCTRINE IN WISCONSIN CONTROLS THE USE OF THE BED OF LAKE MICHIGAN

Wisconsin’s long legal history developed the state’s public trust doctrine as it is known today. The public trust doctrine is “the body of law that directs the state to hold navigable waters in trust for shared use by the public.” Understanding the doctrine requires a review of the Wisconsin Constitution, state statutes and regulations, DNR guidance, and common law established by the Wisconsin judiciary and U.S. Supreme Court. When Wisconsin became a state, it incorporated language from Article IV of the Northwest Ordinance into Article IX §1 of the Wisconsin Constitution, which reads in pertinent part:

The state shall have concurrent jurisdiction on all rivers and lakes bordering on this state so far as such rivers or lakes shall form a common boundary to the state and any other state or territory now or hereafter to be formed, and bounded by the same; and the river Mississippi and the navigable waters leading into the Mississippi and St. Lawrence, and the carrying places between the same, shall be common highways and forever free, as well to the inhabitants of the state as to the citizens of the United States, without any tax, impost or duty therefor.

This section of the constitution imposes a duty on and gives authority to the state to act as a trustee of the state’s waters. This section also serves as the basis for public rights to use trust property. Public rights that are protected by the public trust doctrine—at their core—were the traditional rights of navigation, water-based commerce (such as using the rivers to float logs from timberlands to market), and fishing. Over time, Wisconsin courts expanded these to recognize public rights in navigable water to include the right to recreation, enjoyment of scenic beauty,

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35 Wis. Const. art. IX, § 1.
37 Scanlan, supra note 34, at 133–135.
protected shoreland, and to enjoy these rights the water must be managed to minimize pollution.\textsuperscript{38}

For example, in 1914, the Wisconsin Supreme Court held in \textit{Diana Shooting Club} that the right to hunt and fish on navigable water was incidental to the right of navigation.\textsuperscript{39} Following this, in 1930, the Wisconsin Supreme Court in \textit{Nekoosa} explained that "[a]s population increases, these waters are used by the people for sailing, rowing, canoeing, bathing, fishing, hunting, skating, and other public purposes."\textsuperscript{40} Twenty years later, in \textit{Muench}, the court recognized the enjoyment of scenic beauty as a public right.\textsuperscript{41} Finally, in 1969, the court held in \textit{Reuter} that before any water regulation permit could be issued, WDNR must look at potential water quality impacts. In so holding, the court recognized the right to clean, unpolluted waters.\textsuperscript{42} Thus, the judiciary has a long history of recognizing beauty, recreation, and the right to clean water as rights under the public trust doctrine. To guide implementation of the public trust doctrine, the legislature enacted chapters 30 and 31 of the Wisconsin Statutes, which authorizes the WDNR to issue permits for activities impacting the state’s waterways.\textsuperscript{43}

\section{Wisconsin has Two Ways to Allow the Use of Lakebed}

The state has two ways to allow the filling and use of lakebed protected by the public trust doctrine. The state legislature has limited authority to make lakebed grants. Lakebed grants convey the use of submerged lakebed for public use and are recorded in Wisconsin’s statutes. Many of the recorded lakebed grants to municipalities are over a century old. Without a lakebed grant, one may apply for a permit to deposit fill on a lakebed under section 30.12.\textsuperscript{44}

\begin{thebibliography}{99}
\bibitem{38} Rock-Koshkonong Lake Dist. v. State Dep’t of Nat. Res., 2013 WI 74, ¶ 76, 350 Wis.2d 45, 833 N.W.2d 800 (summarizing public rights in Wisconsin).
\bibitem{39} Diana Shooting Club v. Husting, 145 N.W. 816, 820 (Wis. 1914); see also Willow River Club v. Wade, 76 N.W. 273, 277 (Wis. 1898) (establishing a right to fish under the public trust doctrine).
\bibitem{40} Nekoosa Edwards Paper Co. v. Railroad Comm’n, 228 N.W. 144, 147 (Wis. 1930).
\bibitem{41} Muench v. Pub. Serv. Comm’n, 53 N.W.2d 514, 521 (Wis. 1951).
\bibitem{43} \textit{Wis. Stat.} § 30.01-99; \textit{Wis. Stat.} § 31.01-99.
\bibitem{44} \textit{Wis. Stat.} § 30.12.
\end{thebibliography}
Under either avenue, the state’s trust obligations to monitor and enforce the public trust doctrine continue. As trustee, the state cannot convey complete title in fee to anyone: The state may grant the lakebed only for public trust purposes. These purposes include the above-mentioned public rights, traditional public trust purposes like docks and wharfs, as well as parks. Notably, parts of Milwaukee’s Lincoln Memorial Drive and lakefront parks, beaches, marinas, and museums are built on land created through legislative lakebed grants.

Furthermore, the state may never divest itself of the affirmative obligation to maintain granted lands in trust for the public. Despite this, the legislature restricted the WDNR’s regulatory authority in some situations, which limits its ability to proactively serve as a trustee. For instance, the legislature removed the WDNR’s authority to require a municipality that holds a legislative lakebed grant in Lake Michigan to obtain a permit under chapter 30 before filling lakebed in the grant area. Despite the inability to proactively regulate through the issuance or

46 Scanlan, supra note 36, at 149 (stating that “[a]lthough Wisconsin’s legislature has made grants of public trust property, this property can only be used for public purposes and does not operate to transfer legal title from the state.”).
48 Act of April 22, 1893, ch. 197, 1893 Wis. Sess. Laws 239–241 (granting “to the city of Milwaukee a certain portion of submerged land, lying along and adjacent to the shore of Lake Michigan, on the eastern frontage of the city of Milwaukee, for public park and boulevard purposes.”).
49 City of Milwaukee v. State, 214 N.W. 820, 830 (Wis. 1927) (quoting Illinois Central in saying that “[t]he state can no more abdicate its trust over property in which the whole people are interested . . . .”); see also Scanlan, supra note 36, at 148 (explaining that “[a]s early as 1927, the Wisconsin Supreme Court . . . require[ed] affirmative actions to protect the trust . . . .”).
50 Wis. STAT. 30.05, (stating “Nothing in this chapter relative to the establishment of bulkhead or pierhead lines or the placing of structures or deposits in navigable waters or the removal of materials from the beds of navigable waters is applicable to submerged shorelands in Lake Michigan, the title to which has been granted by the state to a municipality.”).
denial of a section 30.12 permit, the WDNR has a statutory duty to enforce the public trust, including monitoring the use of lakebed grants.\textsuperscript{51} In practice this means the WDNR reviews the municipality’s proposed uses of lakebed grants and may offer a written analysis or speak at a public hearing about the consistency with the public trust doctrine. While these are not regulatory actions per se, they put the grant holder on notice of the WDNR’s position. As discussed below, the common law that articulates the constitutionality of lakebed grant uses helps to inform WDNR’s review of proposals and monitoring of implementation. If a grant holder proceeds in a way the WDNR determines as inconsistent with the public trust, among other things, section 30.03 empowers the WDNR to initiate enforcement actions on their own or through a referral to the state Department of Justice, to abate a nuisance related to violating public trust rights.\textsuperscript{52} This is a more reactive than proactive system for protecting public trust rights.

However, the cooperative federalism between the state and federal government under the Clean Water Act may offer a permit authority pathway that is more proactive about including an assessment of public trust rights. When the Army Corps of Engineers proposes to issue a 404 permit under the Clean Water Act for the proposed DMMF, it triggers the WDNR to issue or deny the related Water Quality Certification. This permit process may involve an analysis of public trust rights. According to state regulation, the WDNR may deny a water quality certification for any activity where the WDNR “does not have reasonable assurance that any discharge will comply with . . . any other appropriate requirements of state law as outlined in s. NR 299.04.”\textsuperscript{53} Those “appropriate requirements of state law” in NR 299.04 specify that the activity will comply with “[p]ublic interest and public rights standards, related to water quality, set forth” in a variety of subsections of chapter 30, the statute that is a key focus of public trust authority in Wisconsin.\textsuperscript{54} Thus, the WDNR’s Water Quality Certification may be a point where the agency

\textsuperscript{51}Wis. Stat. 30.03 (4)(a) (explaining that “[i]f the department learns of a possible violation of s. 281.36 or of the statutes relating to navigable waters or a possible infringement of the public rights relating to navigable waters, and the department determines that the public interest may not be adequately served by imposition of a penalty or forfeiture, the department may proceed as provided in this paragraph, either in lieu of or in addition to any other relief provided by law.”).

\textsuperscript{52}Wis. Stat. § 30.03.

\textsuperscript{53}Wis. Admin. Code § NR 299.01(2)(a).

\textsuperscript{54}Id. § NR 299.04 (1)(b)6.
can exercise its trustee review of the DMMF. The next section discusses public interest and public trust standards.

B. The Legislature’s Authority to Convey Lakebed is Limited and Must be in the Public Interest

In 1892, the United States Supreme Court addressed the states’ ability to alienate trust property in *Illinois Central*. The Illinois legislature granted and then repealed the use of lakebed in Lake Michigan for a railway company to construct a depot and harbor. Illinois Central Railway Company sought to reinstate the lakebed grant. The Court held the lakebed grant invalid because it violated the public trust doctrine. The Court reasoned that the state of Illinois held the bed of Lake Michigan in trust for the people and, as such, the legislature’s original grant was invalid because it violated the trust. The Court declared:

The state can no more abdicate its trust over property in which the whole people are interested, like navigable waters and soils under them . . . than it can abdicate its police powers in the administration of government and the preservation of peace.

Thus, *Illinois Central* effectively restricted the states’ ability to convey to a private entity, such as a railroad company, property held in trust for the public. However, this was not a total prohibition against legislative lakebed grants. The Court instead limited grants of trust property to those “used in promoting public interests” or those lands that “can be disposed of without any substantial impairment of the public interest in the land and water remaining.”

55 *Ill. Cent. R.R. Co. v. Illinois*, 146 U.S. 387, 453 (1892); *see also* *Ill. Steel Co. v. Bilot*, 84 N.W. 855, 857 (Wis. 1901) (explaining that the court remanded the case to determine which parts of Jones Island in Milwaukee were on lakebed fill and which were not because the state cannot abdicate its trust of these lands).

57 *Id.* at 448.
58 *Id.* at 460.
59 *Id.* at 453.
60 *Id.*
61 Scanlan, *supra* note 34, at 142.
After Illinois Central, Illinois continued to make grants of lakebed. These grants survived court challenges if they were for public purposes. For instance, the Illinois Supreme Court found the public benefitted from the expansion of Chicago’s Lakeshore Drive on filled lakebed and upheld these grants even though they were to private parties.\(^63\) However, the court invalidated grants that were not for a public purpose. For instance, in Scott, the Illinois Supreme Court held that a grant of submerged land to the United States Steel Corporation had no public purpose.\(^64\) The grant would have allowed the steel company to expand their operation and build facilities on lakebed fill in Lake Michigan.\(^65\) The court saw the expansion of steel operations as a private purpose and invalidated the grant.\(^66\) The court also noted any benefit to the public would only be incidental and that any economic benefit or additional employment would be too indirect to satisfy the requirement of public purpose.\(^67\)

C. The State Cannot Use a Lakebed Grant for Purely Private Interests

Wisconsin courts built on the foundation established by the U.S. Supreme Court in Illinois Central. Similar to Illinois, the Wisconsin judiciary rejected grants for private purposes. In 1893, in McLennan v. Prentice, the Wisconsin Supreme Court faced the issue of competing rights in lakebed under navigable water.\(^68\) There the defendant, a private party, attempted to convey water lots under Lake Superior.\(^69\) Regarding that conveyance, the court explained that “the state is the owner of the fee of all lands under navigable waters in the Great Lakes, but in trust only, for public uses and purposes of navigation and fishing, and they may not be granted . . . to a private person for purely a private purpose . . . .”\(^70\) Then, in 1896,

\(^{63}\) People ex rel. Moloney v. Kirk, 45 N.E. 830, 832 (Ill. 1896) (conveying submerged land to private owners for the expansion of Chicago’s Lake Shore Drive because they were paying for the construction, and it benefitted the public).
\(^{65}\) Id. at 779 (stating that “[t]he defendant steel company plans to construct an additional facility which will extend its South Work’s Plant some 194 acres into Lake Michigan.”).
\(^{66}\) Id.
\(^{67}\) Id.
\(^{68}\) McLennan v. Prentice, 55 N.W. 764, 769 (Wis. 1893).
\(^{69}\) Id. at 766.
\(^{70}\) Id. at 770.
the court held in *Priewe v. Wis. State Land & Improvement Co.* that a lakebed grant is invalid when it benefits a private interest in purpose and effect.\(^{71}\) Here, the Wisconsin legislature granted the lakebeds of two lakes to John Reynolds, a private party. In developing drainage systems throughout Wisconsin at that time, the legislature requested Reynolds drain the lakes. The court found that Reynolds used this grant purely for private purposes—to operate farming and resort enterprises—resulting in “pecuniary gain[s] to private parties” and as such, the court invalidated the grant.\(^{72}\) Thus, if a lakebed grant in purpose and effect solely benefits a private interest, the legislation will be void.

In the 1927 decision in *City of Milwaukee*, against the backdrop of the roaring twenties, the Wisconsin Supreme Court held that a lakebed grant for dock and wharf facilities did not violate the public interest because it was “an important factor in the industrial life of the city . . . .”\(^{73}\) The legislature granted the lakebed to the City of Milwaukee who allowed Illinois Steel Company to use the area in aid of navigation and commerce, to construct dock and wharf facilities, and for any other proper purpose.\(^{74}\) The court recognized that so long as the proposed use of the lakebed aided public trust purposes—here, constructing Milwaukee’s outer harbor for navigation—the use will be consistent with the public trust doctrine.\(^{75}\)

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\(^{71}\) *Priewe v. Wis. State Land & Improvement Co.*, 67 N.W. 918 (Wis. 1896).

\(^{72}\) *Id.* at 921–922 (Wis. 1896); *see also* *McLennan*, 55 N.W. at 770 (explaining that land under the Great Lakes “between the shoal water and navigable water” is held in trust for the people and cannot be used for purely private purposes.).

\(^{73}\) *City of Milwaukee v. State*, 214 N.W. 820, 830 (Wis. 1927).

\(^{74}\) *Id.* at 821.

\(^{75}\) *Id.* at 830; *see also* Letter from Grant Langley, Milwaukee City Att’y, to Alderman Tony Zielinski, City of Milwaukee (Jan. 26, 2011) [hereinafter Langley-Zielinski Letter] (on file with the Center for Water Policy) (explaining that the Wisconsin Supreme Court in *City of Milwaukee* “recognized that lakebed grant lands were held in trust for public uses and for the purposes of navigation and fishing, but that development along the lakeshore in aid of uses consistent with those parameters was in no manner inconsistent with that doctrine.”).
D. The Use of a Lakebed Grant Should Satisfy the Six-Factors Laid Out in Public Service Commission and City of Madison

In the 1957 decision State v. Public Service Commission, the Wisconsin Supreme Court held that the use of a lakebed grant to create a city park was valid.76 The state legislature made a lakebed grant to the City of Madison to use the newly created land as a park, parking lot, and highway, subject to the approval of the Public Service Commission.77 The challenger to the grant contended that “the public purpose to be served by the project [was] local . . . .” and thus violated the public trust doctrine.78 The court upheld the grant and Commission approval based on multiple factors it found relevant to the determination.79 The court concluded that using lakebed fill to construct a park satisfied the state’s duty under the public trust doctrine by attaching importance to these facts:

1. “Public bodies will control the use of the area.
2. The area will be devoted to public purposes and open to the public.
3. The diminution of the lake area will be very small when compared to the whole of [the lake].
4. No one of the public uses of the lake as a lake will be destroyed or greatly impaired.
5. The disappointment of those members of the public who may desire to boat, fish, or swim in the area to be filled is negligible when compared with the greater convenience to be afforded to those members of the public who will use the city park.”80
6. The use was not for such a local purpose that it would be an improper use of state property (this factor was introduced by the court in City of Madison v. State, discussed below).81

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77 Id. at 72.
78 Id. at 73.
79 Id. at 73–74.
80 Id. at 73–75.
81 City of Madison v. State, 83 N.W.2d 674, 678 (Wis. 1957).
That same year, in *City of Madison v. State*, the supreme court faced the issue of whether the city had the right to build a civic center (now known as Monona Terrace) on lakebed fill in Lake Monona.\(^82\) Due to railroad tracks and steep grades, there was little to no access to Lake Monona from certain parts of the city. In 1932, the legislature granted the lakebed for various municipal purposes.\(^83\) Years later the city issued $4 million in bonds to erect and equip a civic center on the granted lakebed. The state contended that the legislature did not intend for the grants to authorize construction of a building the size and character proposed, and if they did, the grants should be declared unconstitutional.\(^84\) The Wisconsin Supreme Court analyzed the same factors as *State v. Public Service Commission*, and reasoned that “purposes of the proposed building are in large part recreational . . . that the building will attract to the site large numbers of people . . . and . . . provide a vantage point from which these people may enjoy the natural beauty of Lake Monona.”\(^85\) The court explained that if a project on lakebed fill was for a local purpose, it would be an improper use of trust land.\(^86\) However, the court held the civic center was not so local as to run afoul of the public trust doctrine. There has not been further litigation to define what is too “local”, although it is suggested that “local” is related to public access. Thus, if a proposed use is open to the public, it is not so local as to be an improper use under the public trust doctrine.\(^87\)

IV. **CAN THE CITY OF MILWAUKEE USE THE LAKEBED GRANT TO ERECT A DMMF ON THE BED OF LAKE MICHIGAN?**

As discussed, the proposed DMMF will be a containment structure on the bed of Lake Michigan to hold sediment dredged from the Milwaukee Estuary AOC. In addition to the regulatory processes and permits required for this project, the lakebed fill for the DMMF needs to fit within the purpose of the lakebed grant. U.S.

\(^{82}\) *Id.*  
\(^{83}\) *Id.* at 675 (listing municipal purposes like “park purposes, park drives, and automobile parking areas.”).  
\(^{84}\) *Id.* at 677.  
\(^{85}\) *Id.* at 678.  
\(^{86}\) *Id.*  
\(^{87}\) *State v. Pub. Serv. Comm’n*, 82 N.W.2d 71, 75 (Wis. 1957) (stating that “[t]here is no contention here that the purpose authorized . . . is not public.”).
and Wisconsin Supreme Court precedent inform the meaning of the city’s lakebed grant.

A. The Legislature Granted Lakebed to Milwaukee in Multiple Acts

Starting in 1893, the state legislature made several grants to the City and County of Milwaukee for varying purposes. For instance, the state granted lakebed for the popular Bradford Beach and Summerfest grounds. The state also granted the lakebed to be filled and used for public roads and boulevards, parking lots, docks, fisheries, and railways.

The proposed DMMF would be built on submerged land granted to the City of Milwaukee in 1909, and later amended two times. The 1909 grant to the City was “to be held and used by said city for public slips, basins, docks, wharves, structures, roads, highways, railroads and railways, railway terminals and lake and rail facilities and spurs for shipping.” In 1923, the legislature amended section one of the 1909 grant to add subsection two of the grant which included expansive language allowing use for “any proper purpose.” This amendment reads, in pertinent part:

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90 *Map of Lakebed Grants near the Port of Milwaukee, in WIS. DEPT. OF NAT. RES., LAKEBED GRANT MAPPING: MAPS OF LAKEBED GRANTS IN THE CITY OF MILWAUKEE (1993), following p.10; Act of April 22, 1893, supra note 88 (ceding land for expansion of boulevards and a public park); Act of July 2, 1925, ch. 415, 1925 Wis. Sess. Laws 606–607 (granting submerged land for park, boulevard or highway purposes near the current Port of Milwaukee).
92 Act of June 12, 1909, supra note 91.
93 Act of June 22, 1923, supra note 91 (stating that the lakebed should be used “to construct dock and wharf facilities on any of said land and to use any or all of said land for any proper purpose.”).
2. That portion of said lands above described . . . owner or owners are authorized and empowered to fill in and reclaim any unfilled portions of said land and, in aid of commerce and navigation, to construct dock and wharf facilities on any of said land and to use any or all of said land for any proper purpose.\(^9^4\)

Then in 1931, the legislature amended the grant again. Section one, subsection one reads in pertinent part:

1. [The submerged land between the shore, north line of Russell avenue and harbor entrance] are hereby ceded . . . to the city of Milwaukee . . . for the purpose of improving, filling and utilizing the same for harbor purposes and in aid of navigation, in any manner the said city may -deem expedient, and particularly, but without by such specific enumeration limiting the aforesaid purposes, for the purpose of establishing and maintaining thereon breakwaters, bulkheads, piers, wharves, docks, slips, basins, warehouses, transfer sheds, structures, roads, highways, railway terminals, lake and rail facilities and spurs for shipping, airports and other harbor facilities, including the right to lease, either for exclusive or common use, such particular parcel or parcels of said lands as said city may deem expedient to any party or parties for any purpose or use requiring, involving or connected with the construction, maintenance, operation or use of any of the aforesaid harbor or navigation facilities.\(^9^5\)

Thus, read in its entirety, the lakebed grant includes the stipulated uses for harbor and navigation facilities, such as docks, slips, and breakwaters, and any other proper purposes under the public trust doctrine. In a 2011 letter from Milwaukee’s city attorney, he similarly describes the 1931 amended grant as follows:

[T]he express intent of the Legislature was to grant broad but not unlimited discretion to the City to use these lakebed grant lands for an

\(^{9^4}\) Id.  
\(^{9^5}\) Act of June 30, 1931, supra note 91 (emphasis added).
enumerated array of public purposes. These include transportation uses, commercial port uses, or traditional navigational and recreational uses as encompassed and envisioned by the underlying general public trust doctrine. While the City is granted considerable flexibility in the manner by which these lands may be used, that flexibility is by no means unlimited . . . 96

Therefore, the lakebed grant binds Milwaukee to devote the newly created land of a DMMF to harbor and navigation facilities and/or other public trust purposes, including recreation.

B. WDNR’s Guidance Sets a Policy that is Protective of Public Uses of Lakebed Fill Areas

In another part of the Milwaukee lakefront, it is instructive to see how Wisconsin’s attorney general interpreted public trust obligations on lakebed fill. In 1987, the attorney general responded to the WDNR’s request for guidance on legislative grants to municipalities.97 The attorney general explained that a restaurant (previously named Pieces of Eight, and currently Harbor House) was in no way compatible with the uses allowed under the lakebed grant to Milwaukee for navigation and fisheries.98 Lakebeds used inconsistently with the grant may revert to the state if the state brings a successful enforcement action.99 Despite its incompatibility, because the state allowed the restaurant to exist for twenty years without objection, the attorney general opined that it would not be an “equitable or reasonable use of the state’s prosecutorial discretion” to dismantle the restaurant.100 The attorney general recognized that leaving the restaurant in place would lead to future proposals that are inconsistent with the public trust doctrine.101 As a remedy, the attorney general advised the WDNR to “candidly acknowledge” the restaurant

96 Langley-Zielinski Letter, supra note 75.
97 Letter from Donald Hanaway, Att’y Gen., to Carroll Besadny, Wis. Dep’t of Nat. Res. Secretary (Aug. 11, 1987) (on file with the Center for Water Policy).
98 Id. at 1.
99 Id. (stating “[t]he legislation further provides that land used inconsistently with these stated purposes reverts to the State of Wisconsin’s ownership (Chapters 151 and 516, Laws of 1929).”
100 Id.
101 Id.
cannot be justified as a lakebed use consistent with public trust purposes, and pointed out that when the department newly discovers proposed or recent “lakebed development inconsistent with public trust purposes, it has a constitutional duty to prevent or abate misuse of the state’s lakebed.”

In the late 1980s, the WDNR developed guidelines for reviewing proposed uses of lakebed grants because it was fielding a variety of proposals for commercial developments in lakes and rivers. For the Harbor House and other food services provided on filled lakebed, the WDNR’s guidelines underscore the importance of public access. For instance, the WDNR’s guidelines establish that the “facility must be open to the public. This means that . . . [a] substantial majority (90%?) [sic] must be open to the public without charge during normal operating hours, [with an exception for rentals].” The guidelines continue, “[t]he facility must be designed and operated in such a manner that all members of the public making a ‘normal’, lawful use of the area in which it is located have free and open access to and use of the facility.”

More broadly, the WDNR’s 1989 guidance on development of lakebed grants clarified their policy that “filling of lakes and streams for development purposes be substantially related to navigation and its incidents.” The WDNR stated that this means the lakebed grants “must, where possible, be construed as only allowing what the Constitution itself permits.” That guidance contains a list of all lakebed grants and their approved purposes, which allows one to see the WDNR’s policy in practice. The use of lakebed for commercial purposes that are not directly related to navigation, such as the Pieces of Eight/Harbor House

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102 Id.
103 Meyer-Ament Letter, supra note 45.
104 WIS. DEP’T OF NAT. RES., GUIDELINES FOR FOOD SERVICE IN LAKEBED AREAS 1, Attachment 2 to Memorandum from Robert Roden, Director of Bureau of Env’t Analysis, Wis. Dep’t of Nat. Res., to District Directors re Lakebed/Riverbed Commercial and Public Development (Jan. 26, 1989) (on file with the Center for Water Policy).
105 Id.
107 Id. at 2.
restaurant are the aberration. Instead, allowed public uses revolve around parks, beaches, harbors, and the like.\textsuperscript{108}

C. The Port is Partly Operating on Lakebed Filled Pursuant to these Grants

The Port is partly operating on filled lakebed. The legislature granted submerged land in Lake Michigan to the city of Milwaukee for dock and wharf operations and/or other proper public trust purposes.\textsuperscript{109} Figure 1 below shows the area these lakebed grants encompass, and the proposed DMMF is within this area. This section briefly discusses the Port’s composition and governance as an entity of the City, and then provides a short overview of their obligations under the public trust doctrine.

\textsuperscript{108} Id. at 3.
\textsuperscript{109} Act of June 12, \textit{supra} note 91 (ceding original grant of submerged land for Port operations to the city of Milwaukee)
Fig- 1 Port of Milwaukee Lakebed Grant

110 FOTH INFRASTRUCTURE & ENV’T, LLC, PORT MILWAUKEE LAKEBED GRANTS 3 (2021)  
https://dnr.wi.gov/topic/waste/documents/comment/MilwaukeeDMMF/DRAappendixO.pdf. Image  
Courtesy of Wis. Dep’t of Nat. Resources.
The Port is a department within the City of Milwaukee.111 Their mission is to increase “international trade, business development, job creation, and public access to the waterfront.”112 The Port emphasizes its importance in maintaining Milwaukee as a “water-centric” city by supporting “water-based commerce, recreation and leisure.”113 The Port is governed by a seven-member Board of Harbor Commissioners.114 Its members are appointed by the Mayor of Milwaukee and confirmed by the common council.115 The Board of Harbor Commissioners supervises the Port’s day-to-day operations, including development, recreational use, and leases.116

Some of the Port’s operations exist on lakebed fill granted by the legislature to the city. In those areas of lakebed fill, the Port is obligated to abide by the purposes listed in Milwaukee’s lakebed grants and subject to the limits of the public trust doctrine. Thus far, the Port serves as the “landlord” for the Summerfest grounds, Discovery World, and the Harbor House restaurant.117 Furthermore, the Port’s website states that they maintain public access points across the Port during certain hours, including the area immediately west of the proposed DMMF facility depicted by the lime green line accompanied by the hooked fish icon. These areas are for “picnicking, fishing, and other outdoor leisure.”118

111 The City of Milwaukee, PORT OF MILWAUKEE, https://portmilwaukee.com/Port-Mke/About-Port-Milwaukee/City-of-Milwaukee (last visited Nov. 5, 2021); Port Leadership, PORT OF MILWAUKEE, https://portmilwaukee.com/Port-Mke/About-Port-Milwaukee/Port-Leadership (last visited June 1, 2022).
113 Id.
114 Id. supra note 111.
115 Id.
116 Id.
118 Public Access at the Port, PORT OF MILWAUKEE, https://portmilwaukee.com/Port-Mke/Cruises-Recreation/Public-Access (explaining that Kaszube’s Park and other public access sites for fishing and recreation are available) (last visited June 1, 2022).
In a 2011 letter addressed to Alderman Zielinski about siting a wind turbine at the Port, City Attorney Grant Langley described the Port’s obligations under the public trust doctrine. After analyzing the lakebed grants, the city attorney Langley noted there are standards to assess the compatibility of uses on lakebed. Specifically, the uses must “[bear] some relationship to transportation, commercial port development, or the more traditional array of uses relating to navigation, fisheries, and other forms of recreation” for the Port’s obligation under the public trust doctrine to be met. Ultimately, the city attorney emphasized two things: first, that any dispute would be a “fact-intensive inquiry,” and second, that his office’s reading of applicable cases indicated “courts would not sustain

119 Id. Image Courtesy of Port of Milwaukee.
120 Langley-Zielinski Letter, supra note 75.
121 Id. at 4. (explaining that “[w]hile the City is granted considerable flexibility in the manner by which these lands may be used, that flexibility is by no means unlimited, and both the Legislature and the courts have developed standards by which particular uses may be evaluated for compatibility with the public trust doctrine.”).
development of lakebed grant land subject to the public trust doctrine for purely private purposes unrelated to the use and enjoyment of the public.”

V. IS THE DMMF CONSISTENT WITH MILWAUKEE’S LAKEBED GRANT AND THE PUBLIC TRUST DOCTRINE?

As noted by the city attorney, the lakebed grant at issue is for commercial port development or the more traditional array of uses relating to navigation, fisheries, and other forms of recreation. Using the lakebed to construct an in-lake containment structure for contaminated sediment without defining a future use consistent with the public trust, does not appear to fit within the grant’s purposes. This could potentially be cured by specifying a public purpose for the ultimate end use of the newly created land.

A. Public Trust Doctrine Consistency Determinations

A public trust doctrine consistency determination involves applying the relevant case law and the six-factors derived from Public Service Commission and City of Madison. The DMMF could meet all of the factors to satisfy Milwaukee’s obligations under the public trust doctrine if the future use of the land is for public trust purposes and open to the public. To reiterate, the six-factors are as follows:

1. Whether public bodies will control the use of the area,
2. Whether the area will be devoted to public purposes and open to the public,
3. Whether the diminution of lake area will be very small when compared to the whole of the lake,
4. Whether any of the public uses of the lake as a lake will be destroyed or greatly impaired,
5. Whether the impairment of the public rights to use the lake for recreation is negligible compared to the greater convenience afforded to the public from the grant, and

122 Id. at 3.
6. Whether the use of the lakebed fill will be for more than a local purpose.\textsuperscript{123}

\textit{Factor #1 - Whether public bodies will control the use of the area}

Considering the first factor, the Port is anticipated to manage the DMMF in perpetuity.\textsuperscript{124} The Port is a department within the city government, so the facility would meet the first factor of public bodies controlling use of the DMMF.

\textit{Factor #2 - Whether the area will be devoted to public purposes and open to the public}

The second factor indicates the DMMF would need to be devoted to public purposes and open to the public. Drawing on City Attorney Langley’s words when evaluating the same lakebed grants at issue here, “courts would not sustain development of lakebed grant land subject to the public trust doctrine for purely private purposes unrelated to the use and enjoyment of the public.”\textsuperscript{125} If the future use of the land created by the DMMF were for a purely private purpose, a court would likely reject the project. Here, a DMMF created in the pursuit of cleaning up the Milwaukee Estuary AOC could be seen as a public purpose. In prior court cases, water quality was described as part of public trust rights.\textsuperscript{126} Despite this, there are no cases in Wisconsin finding a lakebed containment of dredged sediments to meet the public purpose requirements of the public trust doctrine. One should not read too much into this absence as it simply means there has not been a legal challenge of this type of use.

Further, while it is being built, the area cannot be open to the public. The 1931 grant allows the city to fill the lakebed “for harbor purposes and in aid of

\textsuperscript{123} City of Madison v. State, 83 N.W.2d 674, 678 (Wis. 1957); State v. Pub. Serv. Comm’n, 82 N.W.2d at 73–74. \textit{See also} Scanlan, \textit{supra} note 34, at 142–143 (discussing the first five factors of the test).
\textsuperscript{124} \textit{ANALYSIS OF DREDGED MATERIAL MANAGEMENT ALTERNATIVES, supra} note 22, at 4.
\textsuperscript{125} Langley-Zielinski Letter, \textit{supra} note 75.
\textsuperscript{126} Just v. Marinette Cnty., 201 N.W.2d 761, 768 (Wis. 1972); Reuter v. Dep’t of Natural Res., 168 N.W.2d 860, 861–63 (Wis. 1969).
navigation, in any manner the city may deem expedient. . .”\textsuperscript{127} Thus, the city could argue that they have the authority to use the lakebed for the DMMF facility, as a manner of filling they deem expedient. Given the WDNR’s position on an existing containment facility for sediments from navigational dredging, this weighs in favor of the DMMF fitting within the grant’s purposes.

However, after it is filled, there needs to be a purpose that is consistent with the public trust doctrine, and that points towards a use that is open to the public. The WDNR has a list of uses of lakebed grants that it found permissible and impermissible. Included in that list is a confined disposal facility (CDF), which the WDNR found permissible but noted the newly created land’s “ultimate use must be compatible with trust doctrine and Supreme Court guidelines.”\textsuperscript{128} This reference is to the Jones Island CDF and is located within the lakebed grant at issue here. The Jones Island CDF also holds dredged sediment that, given the location and time period of the dredging, is suspected to contain contaminants. It is the basis for expanding the Port’s harbor facilities. For instance, the Port converted a portion of the south end of the Jones Island CDF, immediately south of the proposed DMMF, into a docking facility and parking lot for the Lake Express ferry back in 1998.\textsuperscript{129}

Then, in November 2021, the Port of Milwaukee began searching for a developer “to build [a] terminal for cruise ships on 5 acres immediately east of the Lake Express building.”\textsuperscript{130} The Port has already entered into agreements with

\textsuperscript{127} Act of June 30, 1931, \textit{supra} note 91(stating that “dry or submerged under the waters of Lake Michigan, are hereby * * * ceded, granted and confirmed to the city of Milwaukee * * *, a municipal corporation, for the purpose of improving, filling and utilizing the same for harbor purposes and in aid of navigation, in any manner the said city may -deem expedient, and particularly . . . for the purpose of establishing and maintaining thereon breakwaters, bulkheads, piers, wharves, docks, slips, basins, * * * warehouses, transfer sheds, structures, roads, highways, railroads * * *, railway terminals * * *, lake and rail facilities and spurs for shipping, airports and other harbor facilities.”).

\textsuperscript{128} \textit{Wis. Dep’t of Nat. Res., Compilation of Department Positions to Date on Specific Types of Development 2} (on file with the Center for Water Policy).

\textsuperscript{129} U.S. Army Corps of Engineers, \textit{Phase II Dredged Material Management Plan Study: Milwaukee Harbor, Wisconsin} 17 (2008),

\url{https://www.lre.usace.army.mil/Portals/69/docs/PPPM/PlanningandStudies/milwaukeedmmp/MilwaukeeDMMPfinal2.pdf}.

\textsuperscript{130} Jannene, \textit{supra} note 117.
Viking Cruises and other operators to bring cruise ships to Milwaukee.\textsuperscript{131} According to the Port, they intend to “[expand] the recreational, entertainment, tourism, cultural, [and/or passenger vessel utilization]” on the property.\textsuperscript{132} Moreover, in the Port’s call for development proposals, the Port cites the public trust doctrine and the lakebed grants as requiring the port to develop the site for “public purposes and uses, including commercial navigation and recreation.”\textsuperscript{133} Currently, there are signs at the existing CDF which allow for limited use of the land for fishing, and once the CDF is stable it could potentially allow for more intensive public usage. Wisconsin Governor Tony Evers awarded the Port of Milwaukee a $3.5 million grant towards construction of what is being called the South Shore Cruise Dock on the existing CDF.\textsuperscript{134} The Port Director maintains that the new development will be a “dynamic experience” coupling economic development with cultural amenities and public access as required under the public trust doctrine.\textsuperscript{135}

As far as the status of the proposed DMMF goes, in February 2022, the Wisconsin State Assembly unanimously voted to approve construction of and funding for the DMMF through the use of Water Infrastructure Finance and Innovation Act loans, WDNR bond funds, as well as other funding sources.\textsuperscript{136} The legislation allows for the reservation of space for flood management projects, potentially extending the time it takes to fill the DMMF and establish any kind of

\textsuperscript{131}Id.
\textsuperscript{132}Id.
\textsuperscript{134}Jeramey Jannene, Port Building New Cruise Ship Dock, URBAN MILWAUKEE (Feb. 3, 2022, 3:26 PM), https://urbanmilwaukee.com/2022/02/03/eyes-on-milwaukee-port-building-new-cruise-ship-dock/ (explaining that “state’s grant will only cover half of the dock’s approximately $7 million cost. The city-owned port intends to cover the remainder with a $500,000 grant it received in 2021 from the Wisconsin Department of Transportation and the proceeds from the city’s sale of land for Komatsu Mining South Harbor Campus development in the inner harbor.”); \textit{see also} Press Release, Tony Evers, Gov. Evers Announces More Than $20 Million in Tourism Capital Investment Grants for Projects Across the State (Feb. 2, 2022) (on file with Center for Water Policy).
\textsuperscript{135}Jannene, \textit{supra} note 134.
public trust amenities on the newly-created land. The legislative decision to construct and fund the DMMF did not involve a public trust analysis on any publicly available official record. In sum, although mention of the public trust doctrine is plentiful in public-facing news stories, the proposed DMMF should have a more defined set of future uses that are open to the public in order to satisfy the second factor.

Factor #3 - Whether the diminution of lake area will be very small when compared to the whole of the lake

To evaluate the third factor, a court would consider the prospective size of the project in relation to the project area as a whole. It is hard to assess the diminution of the lake because of its sheer size. Here, the proposed DMMF will be 2,200 feet at its longest and 1,050 feet wide, extending into Lake Michigan. In comparison, Lake Michigan spans 22,300 square miles. Overall, the DMMF would take up a negligible amount of space when compared to the whole of Lake Michigan. The proposed DMMF is set for construction within the inner harbor, inside the breakwaters extending around Jones Island. Should the court consider the discrete area of the inner harbor compared to the DMMF, the project may be seen as more of a significant displacement of water and lakebed.

Factor #4 - Whether any of the public uses of the lake as a lake will be destroyed or greatly impaired

The fourth factor calls for an evaluation of how the DMMF will affect the current public uses occurring at the proposed DMMF site, such as fishing.

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138 PORT OF MILWAUKEE, supra note 133, at 2 (citing the public trust doctrine several times throughout and explaining that “The Wisconsin Public Trust Doctrine requires that the Site be developed for public purposes and uses, including commercial navigation and recreation.”).

139 Public Access at the Port, supra note 118.

Currently, the area has a sign marking it as open for fishing. There are anecdotes that the area is valuable to fishers for smelt and other species. However, official studies that evaluate the frequency of usage of the adjacent area around the proposed DMMF site for fishing or other uses would be helpful evidence to evaluate the impact. It is unclear how significantly the displacement of water to construct the facility or closure of the adjacent land might affect those who use the area to fish.

*Factor #5 - Whether the impairment of the public rights to use the lake for recreation is negligible compared to the greater convenience afforded to the public from the grant*

The fifth factor calls for a balancing of harms and benefits. The current location for the proposed DMMF is home to recreational fishing, boating, and sailing. The court in *City of Milwaukee* suggested that Lake Michigan was “naturally designed to serve commercial purposes” as justification for creating lakebed fill on which to build Port and harbor facilities.\(^{141}\) However, note that this ruling came out of the 1920s, in a time when the industrial revolution propelled every decision. Today, Lake Michigan serves as both a navigable water body for Port operations, and as a mecca for a host of recreational activities worth protecting and promoting. The Port is not only facilitating traffic with lake ferries, but also now investing to attract tourists on cruise ships.\(^ {142}\) Additionally, as mentioned, the area immediately west of the proposed DMMF is already open to public access. Should the DMMF proceed, that area will be closed to public use as the water is displaced and the facility constructed and filled. Not only that, but the DMMF is designed to last the next 100 years without leaching contaminants into the surrounding water.\(^ {143}\) The DMMF will need ongoing management to ensure that the containment is sound, and nothing leaches out to harm current and future

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\(^{141}\) City of Milwaukee v. State, 214 N.W. 820, 823 (Wis. 1927).

\(^{142}\) Diana Shooting Club v. Husting, 145 N.W. 816, 819 (Wis. 1914) (explaining that the public trust doctrine “should be interpreted in the broad and beneficent spirit that gave rise to it in order that the people may fully enjoy the intended benefits.”).

\(^{143}\) DMMF Fact Sheet, *supra* note 23, at 1 (stating that “[t]he DMMF is designed for a 100-year design life, including changes in Lake Michigan water level and 100-year probability rain and wave events.”).
generations who rely on clean Lake Michigan water for their drinking water supply. Thus, the DMMF may not meet this factor if it is found to impair current public uses and pose a risk to Lake Michigan. Any harms to public rights should be weighed against the benefits of the project. The WDNR and government participants indicate that the DMMF is critical if they are to move forward with dredging the AOC and restoring beneficial uses in the surrounding rivers and estuary. That benefit is potentially much larger than any displacement of public uses by constructing the DMMF. If the DMMF’s future end use is defined in a way that opened it as a recreational asset for the public, this would be an even clearer balancing analysis in favor of the DMMF.

Factor #6 - Whether the use of the lakebed fill will be for more than a local purpose

Finally, as to the sixth factor, the proposed DMMF may be less likely to be seen as too local if the newly created land is dedicated to public purposes and expands access to the exercise of public rights. Precedent suggests that this prong is met when public parks or similar gathering spaces are created because they attract visitors from all over the state and the country. So, if the DMMF is closed to public access, then it is more likely to fail this prong. Consider previous examples of lakebed fill for public purposes in Milwaukee: Bradford beach, Veteran’s Park, and Lakeshore State Park were created with the intent to provide the public with a natural green space to exercise enjoyment of scenic beauty, fishing, navigation, recreation, and more. Using these examples, the newly created land should similarly follow the model set by previous lakebed projects in order to satisfy this prong.

B. Further Considerations

Whether the DMMF and the newly created land meets the six-factors will be a fact intensive analysis if it is challenged in court. These factors could also be incorporated into the WDNR’s work as trustee. WDNR could use the factors to evaluate its position as it monitors and enforces whether the use of the lakebed is consistent with the grant and constitutional requirements. WDNR could also incorporate the factor analysis to guide the Water Quality Certification for the
DMMF when it assesses impacts on public rights. If the City and Port take steps now to clearly define the final disposition of the land in a way that is consistent with public trust purposes and open to the public this would weigh in favor of being a constitutionally sound use of the granted lakebed.

Consider the CDF the Corps of built between 1982 and 1984 as a cautionary tale. The Corps proposed to expand operations at the Chicago South Steel Works CDF.\textsuperscript{144} The Chicago Area CDF is a forty-three acre in-lake containment of sediments co-managed by the Illinois International Port Authority and the Chicago Park District.\textsuperscript{145} The Corps originally planned to transfer the CDF to the Chicago Park District when it reached capacity around 2022; however, the Corps now aims to continue dredging sediment and adding to the CDF for the next twenty years.\textsuperscript{146} Many residents believed the CDF would be converted into a park as far back as the mid-1990s; however, the park was never built.\textsuperscript{147} Instead, the Corps applied for an extension of the state permit that allows it to operate and applied for another permit allowing it to expand the facility.\textsuperscript{148} Multiple conservation organizations want the Corps and the city to reconsider the expansion.\textsuperscript{149} Community groups vowed to contest any permit needed for expansion of the facility.\textsuperscript{150} Other community organizations like Friends of the Parks advocated against the expansion of the CDF and urged for the creation of the park they were promised that would benefit South

\begin{footnotesize}
\begin{enumerate}
\item Id.
\item Id.
\item Id.
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Chicago, mostly comprised of Black and Latinx communities.  

What’s more, allowing for expansion of the facility would likely delay any plans to restore the CDF site to parkland by at least twenty-five years.  

Thus, specifying dates for filling and the end use of the land at the outset can serve to avoid public outcry later.

VI. CONCLUSION

With the Infrastructure Investment and Jobs Act of 2021’s boost of $1 billion in federal funding to cleanup and restore AOCs in the Great Lakes, along with state and local investments, restoring the Milwaukee Estuary’s AOC is within reach. This is an exciting opportunity for the area to tackle the complexity of addressing legacy pollution in this valuable freshwater system. The extent of public investment and effort underscores the need to ensure the restoration produces public benefits. There are a couple of key public trust legal issues implicated in using Milwaukee’s lakebed grant to construct a DMMF and any future uses of the newly created land.  

First, does the grant allow for the use of lakebed as to contain sediments in the DMMF? Second, if the grant allows Milwaukee to establish the DMMF adjacent to the Port, does the grant restrict the City’s choice of future uses of the new land to serve public trust purposes? To answer these questions, one must analyze the specific language in the legislative lakebed grants in light of the Wisconsin Constitution and relevant case law that articulates six relevant factors for lakebed grants. That will be a fact-intensive inquiry and the purpose of the newly created land will need to be clarified in order to fully assess compliance with the public trust doctrine.

151 Id.; CHICAGO METRO. AGENCY FOR PLANNING, SOUTH CHICAGO COMMUNITY DATA SNAPSHOT 3 (2021), https://www.cmap.illinois.gov/documents/10180/126764/South+Chicago.pdf (estimating that roughly 76.5% of south Chicagoans are Black, and 19.8% are Latinx).
152 Maxwell Evans, Lakefront Dump Site Opposed by Park Advocates, Southeast Siders Hasn’t Had A Valid Pollution Permit Since May 31, BLOCK CLUB CHICAGO (June 30, 2021, 8:45 AM), https://blockclubchicago.org/2021/06/30/lakefront-dump-site-opposed-by-park-advocates-southeast-siders-hasn-t-had-a-valid-pollution-permit-since-may-31/.
153 Act of June 12, 1909, supra note 91 (ceding original grant of submerged land for Port operations to the city of Milwaukee); Act of June 22, 1923, supra note 91 (amending chapter 358 from 1909 relating to cession of lakebed to Milwaukee and incorporating “any proper purpose” language); Act of June 30, 1931, supra note 91 (amending subsection one of section one of chapter 285 and clarifying public purposes).
While we will not predict how the decisions will be made, we note that today we are benefiting from the foresight the state legislature and Milwaukee’s political leaders had a century ago to dedicate lakebed grant areas to public gathering places, beaches, marinas, and parks. This stands in contrast to neighboring Great Lakes’ cities that lack such extensive public assets. The decisions government leaders make today about the DMMF will impact future generations, some of whom are not yet born and lack a political voice. In such a situation, it is critical for leaders to fully evaluate and protect the long-term goals for the community to exercise public rights in navigable waters.
CASTING A WIDER NET: EXPANDING EXISTING IUU FISHING FRAMEWORKS TO ADDRESS SEA SLAVERY

Rachel Rilee

“It was the Law of the Sea, they said. Civilization ends at the waterline. Beyond that, we all enter the food chain, and not always right at the top.”

– Hunter S. Thompson

I. INTRODUCTION

Human beings have been fishing the oceans since time immemorial. With the introduction of the steam engine and the continuing development of fishing technologies, the carved-out wooden canoes of artisanal fishermen have been relegated to a small subset of coastal communities. Fishing the oceans today are industrial trawlers with nets as wide as a football field and the capacity to decimate entire ecosystems. In 2020, 78.8 million tons of fish were caught in the oceans. Today, global fishing and aquaculture production has reached a historic level and is forecast to increase by approximately an additional 15% by 2030.

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As global seafood production increases, the sustainability of fish stocks steadily declines. The fraction of fish stocks within biologically sustainable levels decreased to 64.6% in 2019, 1.2% lower than in 2017. As fish stocks close to shore deplete, fishing vessels must travel farther out to sea to meet global seafood demand and keep the industry afloat. The dire situation in the world’s fisheries and the significant money involved in the seafood trade has led to illegal, unregulated, and unreported fishing (IUU fishing) practices in fleets around the world. Today, 20% of internationally traded fish are illegally caught.

IUU fishing could not occur with such regularity without vessels and crews funded by large industrial fishing companies desperate to remain viable. When the Gulf of Thailand, a lucrative hotspot for commercial fishing, became so overfished that fishermen could no longer make a living, they resorted to fishing further out on the high seas. These distant water fleets, which fish outside of their own country’s Exclusive Economic Zone (EEZ), venture into the high seas, and sometimes the EEZs of other nations, to land their catch. But, bringing workers that far out to sea and then returning them regularly to their families was

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9 FOOD & AGRIC. ORG., supra note 6, at xvi
14 U.N. Convention on the Law of the Sea, art. 57, Dec. 10, 1982, 1833 U.N.T.S. 397 [hereinafter UNCLOS]. The Exclusive Economic Zone (EEZ) is a term of art under UNCLOS. The EEZ of a coastal state extends out to 200 nautical miles from established baselines. Within the EEZ, a coastal state has sovereign rights over the exploitation of natural resources, like fish.
economically impractical and the high seas offered a new set of dangers to an already daunting industry. So, Thailand and other nations, resorted to modern-day slavery.

Deep water vessels in Thailand drugged, trafficked, debt-bonded, and enslaved vulnerable migrant workers to populate fishing vessels. Thailand is not the only nation in the world to struggle with sea slavery. Recent reports have detailed violence and slavery in the Chinese distant-water fleet, which is estimated to be worth more than thirty-five billion dollars. Sea slavery is a horrific byproduct of commercial fishing and corporate greed. Borne out of overfishing, sea slavery exists now to enable it.

Part I of this article describes the scope and impacts of IUU fishing and the extensive human rights violations occurring at sea enabled by IUU fishing practices. Part II outlines the existing and developing IUU fishing governance frameworks in international law, particularly the UN Agreement on Port State Measures to Prevent, Deter and Eliminate Illegal, Unreported, and Unregulated Fishing (2009), the International Labor Organization Work in Fishing Convention (2017), the European Union (EU) Regulation to Prevent, Deter and Eliminate Illegal, Unreported, and Unregulated Fishing, and the United States Seafood Import Monitoring Program. Part III recommends that by defining IUU

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16 Id.
20 Agreement on Port State Measures to Prevent, Deter and Eliminate Illegal, Unreported and Unregulated Fishing, FAO (Nov. 22, 2009), https://www.fao.org/3/i5469t/i5469t.pdf [hereinafter PSMA].
fishing to include sea slavery, the monumental strides that have been made to end IUU fishing can be leveraged to combat slavery at sea and ensure that both illegalities are addressed. To facilitate this coordinated effort, Part III proposes increased satellite surveillance to inform more expansive port inspections, national seafood import regimes, and changes in fisheries subsidies.

II. ESTABLISHING THE CONNECTION BETWEEN IUU FISHING AND SEA SLAVERY

IUU fishing and sea slavery are often recognized as related but seldom addressed as such. Solutions aimed at IUU fishing tend to be resource-driven, to preserve fish stocks for the seafood trade. Sea slavery exists to allow IUU fishing to continue, passing the human costs of slavery onto consumers in the form of cheaper seafood. This section defines IUU fishing and its detrimental effects, defines sea slavery and its expansive scope, and establishes the connection between IUU fishing and sea slavery, which are not merely related but so inextricably linked that they cannot be separated.

A. Defining IUU Fishing and Its Effects

The Food and Agriculture Organization of the United Nations (FAO) International Plan of Action to Prevent, Deter and Eliminate Illegal, Unreported, and Unregulated Fishing (IPOA-IUU) defines illegal fishing as

[F]ishing conducted by national or foreign vessels in waters under the jurisdiction of a State, without the permission of that State, or

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in contravention of its laws and regulations; conducted by vessels flying the flag of States that are parties to a relevant organization but operate in contravention of the conservation and management measures adopted by that organization and by which the States are bound, or relevant provisions of the applicable international law; or in violation of national laws or international obligations, including those undertaken by cooperating States to a relevant regional fisheries management organization.26

The FAO also defines unreported and unregulated fishing, though the definition of illegal fishing is most relevant to this analysis.27

IUU fishing has extensive environmental effects, which have spurred the relatively quick call to action by the international community.28 IUU fishing also diminishes efforts to conserve vulnerable fish stocks and achieve measurable progress toward sustainable fisheries.29 IUU fishing often targets already vulnerable stocks and fisheries already under moratoria or strict regulatory

26 INTERNATIONAL PLAN OF ACTION TO PREVENT, DETER AND ELIMINATE ILLEGAL, UNREPORTED AND UNREGULATED FISHING, FOOD & AGRIC. ORG. 2 (2001), https://www.wto.org/english/tratop_e/rulesneg_e/fish_e/2001_iboa_iuu.pdf [hereinafter IPOA-IUU]. The IPOA-IUU is a voluntary instrument addressing the nature and scope of IUU fishing. It proposes objectives and measures to prevent, deter and eliminate IUU fishing. The binding instruments that have followed the IPOA-IUU rely on the definition of IUU fishing outlined in article 3 of the IPOA-IUU.

27 Id.


controls.\textsuperscript{30} The further exploitation of depleted fisheries undermines those stocks’ capacity to rebuild.\textsuperscript{31}

IUU fishing leads to the economic undercutting of legitimate fishing vessels.\textsuperscript{32} Recently, a Chinese distant-water vessel at the center of current investigative reports, the \textit{Zhen Fa 7}, was tracked entering Ecuadorian and Peruvian waters, where, contrary to Chinese law, the ship turned off its location transponder several times for days, likely to fish in forbidden waters.\textsuperscript{33} If IUU fishers can target closed fisheries, fish in the EEZs of other nations, operate without licenses, or use falsified documentation, they create unfair competition in international trade.\textsuperscript{34}

B. Defining Sea Slavery and How it Has Developed

Modern slavery is defined as any “[S]ituation of exploitation that a person cannot refuse or leave because of threats, violence, coercion, deception, and/or abuse of power . . . including forced labor, debt bondage, forced marriage, slavery and slavery-like practices and human trafficking.”\textsuperscript{35} Due to the nature of the fishing industry and the historical difficulty in monitoring and enforcing potential violations on the high seas, the exact number of men and children enslaved at sea is unknown.\textsuperscript{36} However, studies conducted by Global Fishing Watch, which uses Automatic Identification Systems (AIS) on fishing vessels to identify vessels likely engaged in forced labor, have suggested that up to 26\% of 16,000 vessels

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\textsuperscript{30} \textit{Id.}

\textsuperscript{31} \textit{Blue Economy, THE WORLD BANK} (Sept. 15, 2023),

\textsuperscript{32} \textit{U.S. COAST GUARD, ILLEGAL, UNREPORTED, AND UNREGULATED FISHING STRATEGIC OUTLOOK 10} (2020),

\textsuperscript{33} Urbina, \textit{supra} note 15.

\textsuperscript{34} \textit{Id.}

\textsuperscript{35} \textit{INT’L LAB. ORG., GLOBAL ESTIMATES OF MODERN SLAVERY: FORCED LABOUR AND FORCED MARRIAGE} (2017),

tracked via AIS, were likely to be engaged in sea slavery, with as many as 100,000 people estimated to work on those ships.\textsuperscript{37}

The South China Sea hosts the most pervasive examples of forced labor in the fishing industry.\textsuperscript{38} The Outlaw Ocean Project, a non-profit journalism organization, has widely documented enslaved labor in the South China Sea, particularly within the Thai and Chinese fishing fleets.\textsuperscript{39} The investigations into slave vessels have documented inadequate safety and medical care, twenty-hour workdays, abuse, murder, debt bondage, and the forced usage of amphetamines to enable crews to work longer.\textsuperscript{40} An International Labor Organization (ILO) survey of 596 fishers aboard Thai vessels found that 25% worked between 17 and 24 hours each day, while another 41% reported they worked an indefinite period of time.\textsuperscript{41}

The fishers are regularly beaten, tortured, and restrained at sea.\textsuperscript{42} A report by the U.N. Inter-Agency Project on Human Trafficking (UNIAP) found that 59% of the migrants enslaved on Thai fishing vessels had witnessed the murder of a fellow worker.\textsuperscript{43} A report on the Chinese distant water fleet, the world’s largest fleet with up to 6,500 distant-water fishing ships,\textsuperscript{44} found that 85% of Indonesian workers aboard Chinese vessels worked in abusive working and living

\begin{itemize}
  \item \textsuperscript{38} Urbina, \textit{supra} notes 15 and 19.
  \item \textsuperscript{39} THE OUTLAW OCEAN PROJECT, \url{www.theoutlawocean.com} (last visited Nov. 14, 2023).
  \item \textsuperscript{40} Ian Urbina, \textit{Slavery is Not Gone, it Has Just Moved Out to Sea}, THE OUTLAW OCEAN PROJECT (Oct. 10, 2022), \url{https://www.theoutlawocean.com/reporting/slavery-is-not-gone-it-has-just-moved-out-to-sea/}.
  \item \textsuperscript{41} INT’L LAB. ORG., EMPLOYMENT PRACTICES AND WORKING CONDITIONS IN THAILAND’S FISHING SECTOR 52 (2013), \url{https://www.ilo.org/dyn/migpractice/docs/184/Fishing.pdf}.
  \item \textsuperscript{42} Id. at 75.
  \item \textsuperscript{43} UNITED NATIONS INTER-AGENCY PROJECT ON HUMAN TRAFFICKING, EXPLOITATION OF CAMBODIAN MEN AT SEA 5 (2009), \url{https://www.ilo.org/wcmsp5/groups/public/---ed_norm/---declaration/documents/publication/wcms_143251.pdf}.
  \item \textsuperscript{44} For reference, the United States has fewer than 300 distant-water fishing vessels. See Urbina, \textit{supra} note 15.
\end{itemize}
conditions. A staggering 97% said they had experienced debt bondage or had their passports confiscated, effectively rendering them powerless at the behest of vessel captains.

Men and boys enslaved on distant water fishing fleets come to be enslaved in several ways. Most often, workers are lured by “recruiters” with the promise of agricultural work and good pay. They are told that the recruiter will cover the cost to travel to the work site and in exchange, they can work off their debt at the beginning of their employment. Then, the men are taken illegally into the country and sold to fishing vessel captains who consider them indebted indefinitely.

To ensure that the workers are kept in forced labor, vessels stay out at sea for months, or even years at a time without ever docking. Supply ships will rendezvous with vessels to provide fuel and supplies to keep the ships functioning and the workers in floating prisons.


46 Id.


48 Thailand’s Seafood Slaves, supra note 13.


50 Id.

51 Ghost Fleet, supra note 17.

bonded workers, countries like Thailand could not continue to engage in IUU fishing to supply its $9 billion seafood industry.53

C. The Connection Between IUU Fishing and Sea Slavery

IUU fishing and sea slavery operate in a cycle that feeds into itself in the remote reaches of the seas. Unsustainable fishing practices lead to overfishing.54 Overfishing leads to a decrease in catches and an increase in the effort needed to successfully land a catch.55 This cost deficiency leads to a rise in fishing costs, which, if passed on to consumers, would not meet the demand for cheap seafood products worldwide.56 As a result, fishers are forced to cut operating costs.57 Some operating costs like fuel and gear are necessary and immovable. Labor costs, however, can be refashioned and misrepresented to keep the products affordable.58

The need for lower labor costs not only facilitates sea slavery but also creates deplorable conditions surrounding the work.59 These conditions often lead to the crewmembers becoming critically ill, yet unable to access medical attention because the ship captains do not want to risk being caught in the act of illegal fishing.60 The reduced labor cost then allows vessel owners to undercut the

55 Id.
57 A 2018 study revealed that up to 54% of high-seas fishing grounds would be unprofitable without government subsidization and extremely low labor costs. Enric Sala et al., The Economics of Fishing the High Seas, 4 SCIENCE ADVANCES 6 (2018), https://www.science.org/doi/10.1126/sciadv.aat2504 .
60 Urbina, supra note 15
market rates, to which fishers not utilizing slave labor are subject. It effectively creates a “race to the bottom,” wherein fleets must aim to catch the most fish with the lowest cost of labor. This, in turn, restarts the cycle by incentivizing overfishing. This overfishing happens all over the world’s oceans, including by fleets in the EEZs of other nations, thereby reducing their ability to utilize the resources in their own coastal waters.

The direct causal link between IUU fishing and sea slavery is widely documented. Yet, fishers are often called a hidden workforce. The vastness and inaccessibility of the high seas have largely shielded the fishing industry from enforcement, and existing international mechanisms for addressing human rights and labor have been ineffective. IUU fishing, however, has been effectively addressed through several international, regional, and national frameworks.

III. AN OVERVIEW OF EXISTING FRAMEWORKS TO ADDRESS IUU FISHING AND SEA SLAVERY

Existing legal mechanisms have failed to prevent sea slavery from developing because monitoring and enforcement of human rights on the high seas are difficult. Understanding the complexity of applying human rights to the high seas is challenging. However, the existence of international frameworks and initiatives provides hope for addressing this complex issue.

61 Id.
62 Blood and Water, supra note 55.
63 Testimony from recent escapees in the Kantang fishing district in Thailand revealed that fleets routinely “plundered the waters” of Malaysia and Indonesia. Thailand’s Seafood Slaves, supra note 13, at 7.
65 Blood and Water, supra note 55, at 10.
seas, Human Rights at Sea, a UK-based non-governmental organization (NGO), has worked with an interdisciplinary team to draft the Geneva Declaration on Human Rights at Sea.\(^{68}\) The declaration is a framework that refines and consolidates international law obligations, and “provides practical guidance to states on how to ensure human rights at sea.”\(^{69}\) The declaration is not legally binding as it has not been formally adopted by any international bodies, and it would not create systems for effectively addressing sea slavery in tandem with IUU fishing.\(^{70}\)

Existing international measures aimed at IUU fishing, attempt to bridge the gap in monitoring and enforcement, by broadening jurisdiction over fishing vessels and creating a cooperative transnational framework.\(^{71}\) This section explores that framework beginning with the UN Agreement on Port State Measures (PSMA),\(^{72}\) and the International Labour Organization Work in Fishing Convention.\(^{73}\) This section will also outline several important regional and domestic frameworks to address IUU fishing: The EU Regulation to Prevent, Deter and Eliminate IUU Fishing,\(^{74}\) the United States Seafood Import Monitoring Program,\(^{75}\) and the United States Moratorium Protection Act.\(^{76}\)

\(^{68}\) The Geneva Declaration on Human Rights at Sea, HUMAN RIGHTS AT SEA, https://www.humanrightsatsea.org/GDHRAS (last visited Nov. 29, 2023) [hereinafter GDHRAS].

\(^{69}\) Id. (quoting Anna Petrig).

\(^{70}\) GDHRAS seeks to highlight the issue of enforcement and give advice to states on how to better protect human rights at sea. However, it does not contain any enforcement mechanisms for its own provisions. It is a soft law agreement that, although aimed at the right goal, merely restates that existing human rights agreements “apply at sea as they do on land.” Id.


\(^{72}\) PSMA, supra note 20.

\(^{73}\) ILO C-188, supra note 21.

\(^{74}\) Council Regulation 1005/2008, Establishing a Community System to Prevent, Deter, and Eliminate Illegal, Unreported and Unregulated Fishing, 2008 O.J. (L 286) 1 (EC) [hereinafter EU Regulation].

\(^{75}\) Seafood Import Monitoring Program, 50 C.F.R. § 300.320 (2016) [hereinafter SIMP].

\(^{76}\) High Seas Driftnet Moratorium Protection Act, 87 Fed. Reg. 40763 (proposed Jul. 8, 2022) (to be codified at 50 C.F.R. § 300.201) [hereinafter MPA].
A. UN Agreement on Port State Measures

The UN Agreement on Port State Measures (PSMA) is the first binding international agreement aimed specifically at combating IUU fishing.\(^{77}\) It operates by implementing a system wherein port states can verify that vessels seeking to use their ports have not engaged in IUU fishing.\(^{78}\) The overarching goal is to ensure that illegally caught fish do not enter the international seafood market, thereby eliminating the profitability of IUU fishing, to discourage the practice.\(^{79}\) Under the United Nations Convention on the Law of the Sea (often referred to as UNCLOS), jurisdiction over a fishing vessel and the people on board is held by the flag state.\(^{80}\) Flag states are responsible for ensuring that the ship and its operators are observing all relevant laws and regulations, thereby placing the onus of enforcement on flag states.\(^{81}\)

Flags of convenience have created jurisdictional loopholes in the fishing industry.\(^{82}\) A flag of convenience (FoCs) is when the “beneficial ownership and control of a vessel is found to be elsewhere than in the country of the flag the vessel is flying.”\(^{83}\) Specific to the fishing sector, FoCs are usually also considered flags of non-compliance (FoNCs).\(^{84}\) FoNCs are those flag states that “exhibit a consistent pattern of failure with its international obligations” to enforce international laws and norms.\(^{85}\) This allows the vessels to escape the enforcement

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\(^{77}\) PSMA, \textit{supra} note 19.


\(^{79}\) \textit{Id.}

\(^{80}\) UNCLOS, \textit{supra} note 13, at art. 94.

\(^{81}\) \textit{Id.}


\(^{85}\) \textit{Id.}
of the nation they should be flagged under in favor of a different nation that will not engage in any enforcement at all.86

The PSMA is meant to supplement flag-state responsibility by allowing port states to contribute to the monitoring of vessel activities, share information, and even request that flag states take specific actions before they can be allowed port access.87 Presently, the PSMA adopts the definition of IUU fishing in the 2001 FAO International Plan of Action to Prevent, Deter and Eliminate IUU Fishing, one of the legal predecessors to the binding PSMA.88 There are currently 74 parties to the PSMA, including Thailand and the United States.89

Additionally, the PSMA establishes the Global Information Exchange System (GIES), which is currently in its pilot phase.90 This system enables parties to exchange information regarding port denials, inspection results, and flag-state response actions with other states, the FAO, International organizations, and regional fisheries management organizations.91 Currently, the GIES hosts data related to port entry and use, denials of port entry, withdrawal of denials of port entry, and port inspections.92 It is a way to increase the ability of states to effectively monitor and identify problematic vessels and hold each other accountable for their shared responsibilities to ensure the PSMA is effectively implemented.93

86 Id.
87 Agreement on Port State Measures (PSMA), supra note 79, at Benefits of Implementing PSMA.
88 IPOA-IUU, supra note 26, at art. 3.
89 Increasing the number of parties to the PSMA is critical to effective monitoring and enforcement. Agreement on Port State Measures (PSMA), supra note 79, at Parties to the PSMA.
90 The GIES system was launched in 2021 and is currently available to engage with in its pilot phase. In its current iteration, the GIES records port entry and denials, withdrawal of denials, and port inspections. See PSMA GIES Dashboard, FOOD & AGRIC. ORG., https://psma-gies.review.fao.org (last visited Nov. 29, 2023).
91 Id.
92 Id.
93 Id.
B. The International Labor Organization Work in Fishing Convention (C188)

The ILO Work in Fishing Convention (Work in Fishing) entered into force in 2017. 94 To date, 20 countries have ratified the treaty. 95 Thailand ratified the treaty in 2019 after facing pressure from the European Union. 96 China has not ratified the treaty and has done very little to curb sea slavery in its fishing fleet. 97 The Work in Fishing Convention establishes minimum safety, labor, and recruitment standards that each ratifying nation should implement in its commercial fishing industry and allows for vessels to be subject to labor inspections in foreign ports. 98

Articles 43 and 44 of the Work in Fishing Convention address the inspection of foreign vessels by member states. 99 If a member state receives a complaint or obtains evidence that one of its flagged vessels is not in compliance with the Work in Fishing Convention, the state must ensure that the vessels are brought into compliance. 100 Additionally, member states who obtain evidence that a foreign vessel in its port is not in compliance with the requirements of the Work in Fishing Convention may prepare a report for the flag state and the Director-General of the ILO outlining the hazardous conditions. 101 Additionally, member states are required to ensure that their implementation of the Work in

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94 ILO C-188, supra note 21.
97 Ratifications of C188, supra note 96.
99 ILO C-188, supra supra note 21.
100 Id. at art. 43.
101 Id.
Fishing Convention does not favor states that have not ratified the convention over those who have—thereby seeking to create a level playing field in the industry.

C. EU Regulation to Prevent, Deter, And Eliminate IUU Fishing

The EU Regulation to Prevent, Deter, And Eliminate IUU Fishing (EU Regulation) functions by imposing a catch certification scheme and carding process.102 The catch certification process requires that all wild-caught seafood being imported into the EU has a Legal Harvest document accompanying it.103 This document is validated by the competent authority in the flag state of the vessel that caught the fish.104 The Legal Harvest document specifies the origin and legality of the fish to ensure the traceability of seafood products imported into the EU.105

The EU Regulation authorizes the European Commission to take action against countries that inadequately address IUU fishing in their fishing fleets.106 Countries may be “yellow-carded,” meaning they require reforms to adequately address IUU fishing.107 After a country is carded, the European Commission details what changes must be made to restore good standing.108 If the yellow-carded country fails to comply with the suggested reforms, the EU issues a “red

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102 EU Regulation, supra note 75, at arts. 12-22.
103 Id.
104 Id.
106 EU Regulation, supra note 75, at arts. 23-24.
107 The most frequently cited shortcomings in Commission decisions to identify non-EU states under the regulation were related to national legal frameworks, fulfillment of flag state obligations, coastal state implementation of conservation management mechanisms, regional and multilateral cooperation, and market state measures and traceability. ENV’T JUST. FOUND. ET AL., IMPROVING PERFORMANCE IN THE FIGHT AGAINST ILLEGAL, UNREPORTED AND UNREGULATED (IUU) FISHING 8 (2016), https://www.iuuwatch.eu/wp-content/uploads/2015/06/3rdCountryCardingGuidelinesReport_FINAL.LOW_.pdf
108 Id.
card,” which can include sanctions and trade bans on the carded country’s fisheries products.109

Thailand received a yellow card in 2015 for failing to adequately address IUU fishing.110 Despite sea slavery not being included in the definition of IUU fishing, the EU raised concerns about forced labor in the Thai fishing fleets and required Thailand to take steps to ensure products entering the EU did not involve forced labor.111 After receiving the yellow card, Thailand signed on to the PSMA and implemented better laws and regulations.112 Thailand’s yellow card has since been removed.113 While Thailand has vowed to comply with labor standards, the regime it has implemented has done little to improve sea slavery in the region.

In response to the yellow card, Thailand established the Port-in, Port-Out (PIPO) system, which requires vessels to report for inspections upon departure and arrival.114 The system has been characterized as “largely a theatrical exercise for international consumption.”115 The farce of PIPO inspections plays out in the failure of inspection officials to conduct interviews with the actual workers, instead speaking only to ship captains and skippers and checking for

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109 To date, six nations have received red cards from the EU after failing to implement substantive improvements in their IUU fishing management schemes: Belize, Cambodia, Guinea, Sri Lanka, St. Vincent, and the Grenadines and Comoros. EUROPEAN PARLIAMENT, ILLEGAL, UNREPORTED, AND UNREGULATED (IUU) FISHING 2 (2022), https://www.europarl.europa.eu/RegData/etudes/ATAG/2017/614599/EPRS_ATA(2017)614599_EN.pdf.
112 Id.
115 Id.
documentation provided by the Thai government. The relevant documentation is a paper trail to feign compliance.

D. United States Seafood Import Monitoring Program and Moratorium Protection Act

The United States is the single largest country market for seafood. Since 2018, the Seafood Import Monitoring Program (SIMP), implemented by the National Oceanic and Atmospheric Administration (NOAA), has monitored the importation of about half of the seafood into the United States market. The goal of the program is to establish seafood traceability that allows the U.S. to ensure that the imported seafood is not the product of IUU fishing or seafood fraud. The SIMP is not public-facing and does not cover every species imported into the U.S., only those NOAA has identified as high-risk for IUU fishing and fraud. The SIMP does not currently monitor for forced labor in the supply chain.

On June 27, 2022, President Biden released the Memorandum on Combating Illegal, Unreported, and Unregulated Fishing, and Associated Labor Abuses. In the memorandum, President Biden acknowledges that “IUU fishing often involves forced labor…and other human rights abuses.” He directs government agencies to address IUU fishing and sea slavery comprehensively,
recognizing that they often occur together. The memorandum also directs agencies to use the “full range of existing conservation, labor, trade, and national security authorities to address the challenges.”

The memorandum’s recognition of sea slavery within the seafood supply chain is a sensible reframing of the issue in terms of the product it creates, and the memorandum should be applauded for what it establishes. Much like labor abuses in factories and “sweatshops” are viewed in terms of the products created, sea slavery must be tackled in the same way. For example, section 307 of the Tariff Act of 1930 prohibits imports produced with forced labor. U.S. Customs and Border Protection enforces the forced labor prohibition. However, due to a lack of information, transparency, and stakeholder cooperation, only a few vessels have seen their seafood imports seized. President Biden’s memorandum highlights the need for interagency and international cooperation by directing the Secretary of Labor in coordination with NOAA to apply lessons learned from U.S. policies addressing forced labor in the cotton sector to the seafood sector. The memorandum also highlights the importance of transparency throughout the process to engage consumers and invigorate consumer pressures on the seafood supply chain.

President Biden’s memorandum directed the NOAA Administrator to initiate a rulemaking to expand the SIMP to “include additional species and species groups, as appropriate.” The proposed rule expands the SIMP to include additional species; however, it does not seek to address forced labor in the

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125 Id.
126 Id. at § 1.
128 Id.
130 Biden Memorandum, supra note 120, at § 1(e).
131 Id.
132 Id. § 5(a).
supply chain.\textsuperscript{133} Instead, the agency seeks to use the Moratorium Protection Act (MPA) to redefine IUU fishing to include forced labor.\textsuperscript{134}

Under the MPA, the National Marine Fisheries Service (NMFS) produces a biennial report to Congress that lists the nations identified as engaging in IUU fishing, bycatch of protected species, or shark catches on the high seas.\textsuperscript{135} When a nation is identified, NMFS engages in a collaborative effort to help the nation improve its lacking regulations.\textsuperscript{136} If the nation does not make adequate strides to improve its regulatory and enforcement mechanisms, NMFS can issue a negative certification.\textsuperscript{137} Negative certifications can result in trade sanctions until the nation complies with U.S. regulatory advice.\textsuperscript{138}

In its newly proposed rule, NMFS seeks to amend the definition of IUU fishing in the MPA to include “fishing activities in waters beyond any national jurisdiction that involve the use of forced labor.”\textsuperscript{139} This proposed redefinition, if finalized, would be the first legal change to the definition of IUU fishing to explicitly include forced labor, and could have ripple effects throughout existing framework definitions.

The proposed change would give NMFS precautionary discretion in identifying vessels engaged in IUU fishing, with the inclusion of forced labor

\textsuperscript{133} Id.
\textsuperscript{134} MPA, supra note 77.
\textsuperscript{136} Id.
\textsuperscript{137} Id.
\textsuperscript{138} NOAA identified thirty-one nations and entities in its 2021 report to Congress under the Moratorium Protection Act. Seven nations were engaged in IUU fishing, and twenty-nine nations were engaged in the bycatch of protected species without bycatch reduction measures comparable to the U.S. in place. Mexico has been restricted from access to U.S. ports for illegally fishing in the Gulf of Mexico. The 2023 report to Congress identified seven nations and entities for reported IUU fishing activities. NOAA will announce the results of its consultations with these nations and entities in its 2025 report. NOAA Engagement with Nations and Entities Under the Moratorium Protection Act, NOAA FISHERIES, https://www.fisheries.noaa.gov/international/noaa-engagement-nations-and-entities-under-moratorium-protection-act#2021-report-to-congress (last visited Nov. 29, 2023).
\textsuperscript{139} MPA, supra note 72.
considered. Practically, this change would mean that NMFS could now issue negative certifications to other nations if their fleets are suspected of using forced labor in their fishing fleets.

IV. PROPOSING A SUBSTANTIVE REDEFINITION OF IUU FISHING TO INFORM PROCEDURAL CHANGED IN EXISTING LEGAL FRAMEWORKS

IUU fishing should be broadened in scope to include illegal slavery, human trafficking, and debt bondage in its definition and therefore subject these activities to existing governance mechanisms already addressing IUU fishing. Addressing IUU fishing in isolation not only foregoes a valuable chance to address sea slavery simultaneously, but it silos IUU fishing regimes into a purely resource-driven focus instead of promoting true sustainability, which must take into account the men and children undertaking the work. Target 8.7 of the UN Sustainable Development Goals states that nations should “take immediate and effective measures to eradicate forced labor [and] end modern slavery and human trafficking. . . “

The men and children enslaved in the industry must be protected at sea; however, the solution does not need to be implemented there. Like IUU fishing, sea slavery produces a product that enters an already heavily regulated supply chain on land. By utilizing the same monitoring and enforcement measures currently employed and in development to address IUU fishing, the international community can increase transparency and shared responsibility to facilitate solutions for sea slavery.

A. IUU Fishing Must Be Redefined to Include Sea Slavery

When IUU fishing is defined narrowly, or in terms of the illegal behaviors that affect only the fish stocks, reporting requirements, and regulatory regimes, it does not ensure sustainability. A more comprehensive definition of IUU fishing

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140 Id. at 47065.
141 Id.
142 G.A. Res. 70/1, Transforming Our World: The 2030 Agenda for Sustainable Development (Oct. 21, 2015) [hereinafter Sustainable Development Goals].
143 Id at 8.7.
would be in line with the UN Sustainable Development Goals and their vision of strategies that go ‘hand-in-hand’ with one another to create true sustainability. Sustainability is “firmly anchored in human rights principles and standards.” Ignoring sea slavery while attempting to ensure fish stocks are not negatively impacted only ignores the very practice that allows distant water fleets to negatively impact fish stocks in the first place. Since the 2001 FAO IPOA-IUU definition of IUU fishing is used in most subsequent IUU fishing frameworks, particularly the PSMA, the FAO should amend the definition to explicitly include sea slavery.

The expansion of the IUU fishing definition to include sea slavery would strengthen the PSMA, empowering ports to inspect vessels suspected of forced labor. The PSMA was meant to embrace the UN Sustainable Development Goals to ensure “a world where no one is left behind.” If the PSMA seeks to embrace the UN Sustainable Development Goals, it should embrace them all, particularly Target 8.7, which aims to eradicate forced labor, modern slavery, and human trafficking; and Target 8.8, which protects the rights and security of all workers, including migrant workers. Without addressing sea slavery, the PSMA cannot adequately address the sustainability of the fishing industry.

Under an expanded definition, the ILO Work in Fishing Convention could benefit from increased ratification as nations seek to demonstrate that their fishing fleets are governed by appropriate labor practices to avoid unnecessary port inspections. Increased ratification of the Work in Fishing Convention would help safeguard fair labor standards, wages, health and safety, and conditions of service for

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146 PSMA, supra note 20, at art. 1(e); IPOA-IUU, supra note 26, at art. 3.
147 PSMA Article 12 governs when a port shall prioritize vessel inspections, namely when (a) vessels have been denied entry or use of another port under the PSMA, (b) other parties, states or fisheries management organizations request that specific vessels be inspected and (c) there are clear grounds for suspecting that they have engaged in IUU fishing. PSMA, supra note 19, at art. 12.
148 PSMA, supra note 19, at viii.
149 Sustainable Development Goals, supra note 144.
all fishers in the industry, regardless of their migrant or debt-bondage status.\footnote{Fishing is the most dangerous industry worldwide. In 2021, the average fatality rate in the fishing industry was 15.96, almost a full 2 points higher than the next most dangerous industry, mining. While this data likely does not include the men and boys killed at sea in forced labor, it underscores the danger of a poorly regulated industry to those nations where sea slavery is not of concern. Notably, Canada had the highest fatality rate in the fishing sector. Jan Mirkowski, \textit{The World’s Most Dangerous Countries for Workers}, ARINITE (Oct. 20, 2021), \url{https://www.arinite.co.uk/the-worlds-most-dangerous-countries-for-workers}. \textit{See generally Regions: National Overview}, NAT’L INSTITUTE FOR OCCUPATIONAL SAFETY AND HEALTH, \url{https://www.cdc.gov/niosh/topics/fishing/nationaloverview.html} (last visited Nov. 29, 2023); \textit{Dino Drudi, Bureau Of Labor Statistics, Fishing for a Living is Dangerous Work} (1998), \url{https://www.bls.gov/opub/mlr/cwc/fishing-for-a-living-is-dangerous-work.pdf}; Press Release, Int’l Lab. Org., Fishing Among the Most Dangerous of All Professions, Says ILO (Dec. 13, 1999), \url{https://www.ilo.org/global/about-the-ilo/newsroom/news/WCMS_071324/lang--en/index.htm}.} With a definition that explicitly includes sea slavery in its scope, the U.S. and EU, which both currently use the FAO IUU fishing definition in their domestic frameworks, could expand to address forced labor in the seafood industry as they address IUU fishing.

The journey from bait to plate is convoluted. The seafood supply chain can be tangled, invisible, and unsuspecting, much like the ghost nets left behind by the industry’s fleets.\footnote{Ghost nets are fishing nets that have been abandoned or discarded in the ocean. The nets are often invisible to wildlife and entangle fish, dolphins, sea turtles, and other creatures. \textit{See} Graeme Macfadyen et al., \textit{Abandoned, Lost, or Otherwise Discarded Fishing Gear}, UNITED NATIONS ENVIRONMENT PROGRAMME (2009).} For the existing IUU fishing frameworks to effectively reel in the industry and eliminate IUU fishing, the definition must include the practices that enable IUU fishing. Once better defined, IUU frameworks can address sea slavery through improved monitoring, compliance, and shared enforcement.

**B. The Expanded Definition of IUU Fishing Should Be Used to Inform Existing Frameworks and Improve Monitoring, Compliance and Enforcement**

Increasing monitoring is critical to addressing IUU fishing and sea slavery, yet it is also one of the biggest challenges that existing regimes face. A redefinition of IUU fishing to include sea slavery would be ineffective without corresponding adjustments to monitoring and enforcement mechanisms. To increase the monitoring of vessels potentially engaged in IUU fishing and sea slavery, existing satellite
monitoring and data analytics should be employed to inform port inspections and government response. A database of vessels identified as potentially engaging in IUU fishing or sea slavery should be established to inform work under the PSMA, EU Regulation, and U.S. SIMP and MPA inspection regimes. To ensure that all vessels have the necessary technologies on board to submit to satellite monitoring, governments should focus fishing subsidies on the technological growth of their fleets to ensure compliance and participation in monitoring and include the requirement that the requisite technology is employed in their regional trade agreements.

i. Using Existing Satellite Monitoring and Data Analytics to Monitor, Track and Identify Vessels Engaged in IUU Fishing and Sea Slavery

There are presently two different types of satellite monitoring devices used by vessels in the fishing industry. The Vessel Monitoring System (VMS) is a tool specific to fisheries management systems, regulated regionally and nationally to assist in fisheries management and analysis. The Automatic Identification System (AIS) is a collision avoidance system that transmits vessel locations and is required by international law for vessels over a certain size.

Both systems operate by using satellite tracking to ping vessel locations. AIS vessel tracking is an open, public system, while VMS data is typically not public

155 Id.
facing, though governments are beginning to trend toward sharing VMS data.\(^\text{156}\) Regional fisheries management organizations (RFMOs) are increasingly beginning to manage centralized VMS databases on behalf of their members, increasing the efficiency and effectiveness of VMS monitoring.\(^\text{157}\)

Since AIS data is meant to prevent vessel collisions, it is always openly available and accessible.\(^\text{158}\) AIS devices also broadcast the vessel’s identity (callsign, name, IMO number, activity, and size), which allows the monitor to distinguish and track specific fishing vessels.\(^\text{159}\) AIS data is already being used to track vessels identified by RFMOs as known IUU fishing vessels.\(^\text{160}\) A partnership between Oceana, Google, and SkyTruth has created Global Fishing Watch, a nonprofit dedicated to tracking vessels in the fishing industry.\(^\text{161}\)

Satellite data from vessel AIS can be used to identify vessels likely engaged in IUU fishing and sea slavery.\(^\text{162}\) A recent study revealed that in analyzing certain behaviors obtained through AIS data, fishing vessels using forced labor can be correctly identified between 92-100% of the time.\(^\text{163}\)

\(^\text{156}\) The justification for not sharing VMS data is based on the concern that it would reveal proprietary information about the best fishing locations, and in which areas vessels typically see success. Nations worry that sharing VMS data would open them up to more competition for fisheries resources. However, states are increasingly entering into multilateral data-sharing agreements where they share data in real-time. See Understanding Fishing Activity Using AIS and VMS, supra note 156.


\(^\text{158}\) The lack of encryption in the system means that vessel positions can be manipulated; however, this “spoofing” or intentional manipulation of vessel location happens with great infrequency and is readily identifiable when it occurs. See Understanding Fishing Activity Using AIS and VMS, supra note 156.

\(^\text{159}\) Id.

\(^\text{160}\) Oceana hosts an interactive map that users can employ to track vessels currently included on RFMO’s IUU fishing lists. The tool takes data from the Combined IUU Vessel List, which merges all RFMO IUU vessels into one list. IUU Vessel Tracker, OCEANA, https://usa.oceana.org/iuuvesseltracker/ (last visited Nov. 30, 2023); Combined IUU Vessel List, TRYGG MAT TRACKING, https://www.iuu-vessels.org (last visited Nov. 30, 2023).


\(^\text{162}\) Id.

\(^\text{163}\) Id.
and insider information to identify behaviors likely indicative of forced labor on fishing vessels. These same behaviors are indicative of some forms of IUU fishing as well. Vessels engaged in sea slavery often travel farther from shore, fish more hours per day than other vessels, and take fewer voyages of longer duration.

To ensure the ability of groups like Global Fishing Watch to access AIS broadcasts, the PSMA should require that all vessels seeking port entry to install and maintain AIS systems in compliance with the AIS performance standards set by the International Maritime Organization (IMO). The PSMA could develop a system wherein vessels identified as “going dark,” are automatically added to the IUU fishing identification list, thereby triggering more stringent port inspections. By requiring AIS systems to always remain on, the PSMA would establish a mechanism for monitoring that spans the globe and reduces the ability of vessels to hide on the high seas. This monitoring would be useful for port inspections under the PSMA when vessels seek to land their catches, but also for import programs like the U.S. SIMP and EU regulation. With access to AIS information and associated databases of identified high-risk vessels, national and regional import systems can place more stringent certification requirements on flagged vessels.

**ii. Establish a Database of Identified Vessels for Use by Port and Import Inspectors Under the PSMA, EU Regulations and SIMP**

To ensure that AIS satellite monitoring and analytics are effectively used, a global database must be established that both identifies suspected IUU vessels and updates their locations. In doing so, port inspectors could have access to the

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164 Id.
165 Id.
167 “Going dark” refers to when ships turn off their AIS systems. There are methods to identify AIS signal drops that are not intentional. This is done by “analyzing the frequency and regularity of signals before and after a gap occurs.” Kimbra Cutlip, Going Dark: When Vessels Turn Off AIS Broadcasts, GLOBAL FISHING WATCH (July 30, 2016), https://globalfishingwatch.org/data/going-dark-when-vessels-turn-off-ais-broadcasts/.
detailed information obtained through AIS monitoring, to look for specific, identifiable indicators of IUU fishing in their inspections.\textsuperscript{168} The PSMA recognizes that communications technologies, databases, and networks are rapidly developing and can be valuable in supporting port inspections.\textsuperscript{169}

In fact, the technology to track, analyze and organize vessel data into a productive database already exists. Global Fishing Watch has just launched their Vessel Viewer, an open access database tool that provides information on a vessel’s identity, fishing activity, port visits, authorizations and transshipments.\textsuperscript{170} When utilized by ports, the Vessel Viewer, which also allows custom searches, vessel grouping and sharable PDF files, would allow ports to access the very data necessary to identify forced labor and illegal fishing.\textsuperscript{171}

The GIES pilot program, which is used to track and compile port inspection data, could be a useful medium for this database. The PSMA should establish the GIES system in tandem with databases like the Vessel Viewer, to identify potential IUU vessels, display their location, log which ports they visited, and facilitate the sharing of port inspection information. In doing so, not only would the PSMA empower port inspectors to contribute to the monitoring and enforcement of IUU fishing, but it would also create a shared responsibility for ensuring compliance. If AIS tracking and data analytics can identify potential IUU vessels and where those vessels are docked, the database can be used not only to identify the illegal actors but also to ensure that the individual ports are complying with what the PSMA requires.

Ensuring that IUU fishing is addressed not just on vessels but throughout the industry is integral to ending the practice. The Work in Fishing Convention, for example, enables corruption and non-compliance since it requires member

\textsuperscript{168} These inspections can be informed by the ILOs indicators of forced labor. SPECIAL ACTION PROGRAMME TO COMBAT FORCED LABOUR, INT’L LAB. ORG., ILO INDICATORS OF FORCED LABOUR (2012), \url{https://www.ilo.org/wcmsp5/groups/public/---ed_norm/---declaration/documents/publication/wcms_203832.pdf}.

\textsuperscript{169} PSMA, supra note 20, at viii.

\textsuperscript{170} Vessel Viewer, GLOBAL FISHING WATCH, \url{https://globalfishingwatch.org/vessel-viewer-tool/} (last visited Nov. 4, 2023).

\textsuperscript{171} Id.
states to validate their own fishing vessels.¹⁷² Since ratifying the Work in Fishing Convention, Thailand has instituted its PIPO system of inspection in which vessels are inspected before they leave the port and when they return. Under this system, however, inspectors are not required to board the vessels or interview crew members.¹⁷³

Pink cards are the primary registration mechanism for migrants in Thailand.¹⁷⁴ Under this regime, migrant workers are tied to specific vessels and employers, essentially giving the vessel captains control over the legal status of the workers.¹⁷⁵ Vessel inspections only verify the status of the worker’s pink cards and not whether they have been forced into labor.¹⁷⁶ This scheme ties the worker to the vessel captain, checking only whether the captain documents his workers and not whether he wrongfully enslaves them.¹⁷⁷ The Thai fishing fleet has remained unaffected by the PIPO and pink card systems, as reflected by Thailand’s determination that not a single case of child labor, forced labor, or human trafficking was detected on inspected vessels since PIPO’s inception in 2015.¹⁷⁸

Identifying a database to inform port inspections, trade certification schemes, and monitoring on the high seas would turn the satellite analysis of IUU fishing into actionable data accessible to everyone. The creation and population of a database would allow, not just states, but private security firms, NGOs, and other stakeholders to contribute to monitoring in the industry, which can then inform the shared enforcement of port states. Spreading out the responsibility of monitoring and enforcement would not only ensure that it occurs with more

¹⁷² ILO C-188, supra note 21, at art. 7.
¹⁷⁴ Hidden Chains, supra note 53, at 3.
¹⁷⁵ Id.
¹⁷⁶ Id.
¹⁷⁷ Id. at 7.
¹⁷⁸ Forced labor in the Thai industry persists. Human Rights Watch found that 90 of 138 fishers interviewed were in forced labor situations. Id. at 4.
regularity and a higher degree of effectiveness, but that states are held visibly accountable for their compliance.

Publicizing, compiling, and utilizing AIS data and behavior analytics in tandem with detailed port inspection reports creates a system in which noncompliance would be extremely difficult to hide. For example, AIS monitoring could identify when vessels disengage their AIS, thereby flagging an activity that could be indicative of IUU fishing. If a comprehensive database existed to inform port inspections, then when that vessel docks, the inspector would be aware of the AIS discrepancy and could respond accordingly. If the inspection fails to investigate the vessel for IUU fishing, despite the AIS discrepancy, that would also be available in the database, thereby alerting other ports that the vessel had been flagged for disengaging its AIS and that the port inspector failed to investigate it. In creating that system of checks, the vessels are more likely to be adequately investigated and ports that fail to adequately inspect vessels can be identified and pressured into better compliance.

Additionally, national and regional import programs could increase certification requirements to hold ports accountable. If certain ports are more favorable than others to IUU fishing vessels, regional and national frameworks could identify which port inspections are acceptable in terms of certification. For example, if a port has been shown to inadequately inspect vessels under the PSMA, is not a party to the PSMA, or has been warned by other nations for poor compliance in conducting inspections, the import certification schemes might disallow seafood landed or certified at those ports. This would increase port compliance under the PSMA as ports do not want to be ostracized and incentivize the use of ports that comply with PSMA standards.

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179 This database is not a distant technology. Global Fishing Watch can already synthesize this data and make it available. What is necessary is the political will to implement the PSMA to the highest ability and ensure universal ratification. Kimbra Cutlip, *What Ports Can Tell Us*, GLOBAL FISHING WATCH (Sept. 22, 2016), https://globalfishingwatch.org/data/what-ports-can-tell-us/.

180 Research suggests “that a country’s risk of illegal fishing is positively related to the number of commercially significant species found within its territorial waters and its proximity to known ports of convenience.” Gohar Petrossian, *Preventing Illegal, Unreported and Unregulated (IUU) Fishing: A Situational Approach*, 189 BIOLOGICAL CONSERVATION 1 (2014).
If IUU fishing vessels cannot land their catch at a port that inadequately inspects vessels under the PSMA, and national and regional systems refuse to accept their port certification, they would be left with no choice but to comply and submit to adequate port inspections. A change in just the U.S. and EU trade certification schemes could force the entire industry into compliance. The U.S. and EU represented a combined $62.1 billion USD in seafood imports in 2021.181

iii. Increase Compliance and Participation Through Government Subsidization of Monitoring Technologies

Subsidization of industrial fishing has been a longstanding international issue.182 In 2019 alone, $35.4 billion USD was used to subsidize fishing fleets.183 Of that, $22 billion USD was found to be harmful or capacity-enhancing subsidies, which allow fleets to engage in overfishing.184 These subsidies affect capital costs for fishing fleets by bolstering fuel costs or replacing engines, thereby reducing operating costs and increasing profit while helping vessels overfish.185

After more than two decades of negotiations, the WTO adopted a fisheries subsidies agreement in 2022.186 This agreement will not be binding until it is ratified by 109 member states.187 Notably, the agreement would prohibit any

182 Ending harmful fishing subsidies is recognized as a target in the Sustainable Development Goals. Sustainable Development Goals, supra note 144, at 14.6.
184 Id.
member from providing subsidies to a vessel engaged in IUU fishing, or activities in support of IUU fishing.\textsuperscript{188}

Under the agreement, a vessel can be affirmatively determined to be engaged in IUU fishing by a RFMO in accordance with the rules of international law.\textsuperscript{189} Additionally, member states can notify subsidizing members when they believe a vessel in one of its ports has engaged in IUU fishing and the subsidizing state must take appropriate action.\textsuperscript{190} If the definition of IUU fishing were expanded, satellite monitoring fully utilized, and a database created for port inspections under the PSMA, this information and the port state’s notification of the subsidizing state would be publicly available information. That degree of transparency and shared responsibility in monitoring would allow for both consumer and international pressure to be placed on states that fail to appropriately act. This makes the expansion of IUU fishing to include sea slavery an even more necessary and critical step.

Without implementing AIS and VMS systems on every vessel, it would be impossible to identify every vessel engaged in IUU fishing. If the vessels cannot be identified, governments cannot be expected to withhold subsidization. It is thus imperative that subsidies require and provide resources to implement AIS and VMS devices on every commercial fishing vessel.

Governments should therefore require working AIS and VMS devices on every vessel in their fleets as a condition of receiving any form of government subsidies. There may be latitude in these arrangements—for example, a government may provide only subsidies for labor costs and not for fuel unless the devices are installed and appropriately maintained. In requiring the installation, continued use, and maintenance of AIS and VMS devices on every fishing vessel in its fleet, governments create a system wherein subsidization provides for the technology to help end IUU fishing, and not the money to engage in it.

\textsuperscript{188} Draft Subsidy Agreement, supra note 188, at art. 3.
\textsuperscript{189} Id. at art. 3.2(c).
\textsuperscript{190} Id. at art. 3.6.
V. Conclusion

By substantively redefining IUU fishing to include sea slavery, existing mechanisms facilitating international cooperation to end IUU fishing can address sea slavery as well. IUU fishing encourages sea slavery, and in turn, sea slavery enables IUU fishing. To address one issue separately from the other not only ignores human rights in the quest for sustainability, but it undercuts any measure of success that can be feasibly achieved. Satellite monitoring and data analytics should be used to identify vessels engaged in IUU fishing and sea slavery. That information should be built into a database and required as a tool for port inspectors, which will inform port inspections, track inspection findings and queries, and more readily identify particular vessels and fleets operating outside the bounds of the law. The information gathered through the monitoring and inspection should inform government subsidization of fishing fleets in both quantity and quality, as governments should rely on demonstrated behavior to award subsidies. Additionally, subsidization should be conditioned on the presence and uninterrupted use of AIS and VMS devices on all fishing vessels.

The vastness of the ocean and its global utilization presents problems that require innovative, collaborative, and comprehensive solutions. Sea slavery is a uniquely difficult issue to address because it happens in a place where nobody is around to witness and respond to it. However, because it happens alongside IUU fishing, and helps to produce the most widely traded commodity on the planet, the existing avenues established to address IUU fishing are the most direct way to tackle the issue. To treat the issues separately ignores the symbiotic way the issues interact. If the international community fails to protect the men and young boys forced to feed the world on distant water vessels alongside its efforts to end IUU fishing, the world’s seafood can never be considered truly sustainable.
I. INTRODUCTION

"Scientists that are studying sea turtle hatchlings and eggs have found no boy sea turtles . . . only female sea turtles for the past four years," reports the manager of the Turtle Hospital, Bette Zirkelbach, in the Florida Keys. Because of climate change, the last four summers have also been the hottest on record, which has led to higher incubation temperatures of sea turtle eggs, and therefore, nearly all sea turtles being born female. Sea turtle scientists predict that in the coming years with less males available, there will be a decline in the sea turtle population and less genetic diversity.

All five sea turtle species in Florida are listed as either endangered or threatened under the Endangered Species Act ("ESA"), which protects the sea turtles from human development affecting them and their behavior, breeding, and feeding. It also prevents them from human harassment, possession, importing, exporting, and killing. All five are also protected by Florida Statute Section 379.2431, referred to as the Marine Turtle Protection Act ("MTPA"), which protects the turtles from interference from humans. The MTPA also permits the Florida Fish and Wildlife Conservation Commission ("FWC") staff to conduct research, conservation, and educational activities with the sea turtles and allows the Florida Department of Environmental Protection ("DEP") to regulate beach

1 Florida State University College of Law, J.D. May 2023
3 Id.
4 Id.
6 Id.
renourishment projects. The ESA does not directly address climate change, though some protections against it can be inferred, while the MTPA offers no wiggle room for any climate change interpretation.

The recent findings of nearly all female turtles and no new male turtles on the coasts of Florida spells disaster for the future of Florida’s sea turtles and highlights the large gap in protection in both the ESA and the MTPA when it comes to the new challenges that endangered and threatened species will face due to climate change. Part I of this paper will review the ESA’s current protections for Florida’s sea turtles and summarize the MTPA. Part II will expand upon the problems that sea turtles face in Florida due to climate change. Part III will underline how current legal remedies in the ESA and MTPA fall short in their goals to protect the species from extinction. Finally, Part IV will propose ways to improve the ESA with a new part of the statute that is inclusive to climate change and how Florida can strengthen the MTPA by allowing the agencies more power to regulate and mitigate climate change.

II. CURRENT PROTECTIONS FOR FLORIDA’S SEA TURTLES

The ESA and the MTPA share the same goals of “conserv[ing] and recover[ing] wild populations of threatened and endangered species,” including the five Florida sea turtles. The ESA provides endangered and threatened species with federal protection, while the MTPA provides them with an extra level of state protection, but both work together to conserve and protect all five species of turtles. The ESA is a broader umbrella that protects listed species behavior, breeding, and feeding from human harassment, possession, importation, exportation, and killing. The MTPA is a Florida-specific statute that restricts the take, possession, disturbance, mutilation, destruction, selling, transference,
molestation, and harassment of marine turtles, nests or eggs, in addition to protecting their habitat. The rest of this section will review the ESA’s current protections for Florida’s sea turtles and summarize the MTPA.

A. The Endangered Species Act

The ESA affords protections to two types of species: those listed by the Secretary of the Department of the Interior as endangered or threatened. The ESA defines endangered species as a “species which is in danger of extinction throughout all or a significant portion of its range,” while “threatened species” means “any species which is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range.” The mechanism that the ESA uses as a sword to enforce its prohibitions is the take prohibition in Section 9, which prohibits anyone doing anything that might harm, harass, or hurt the listed species. “Take” in the ESA is defined as “to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct.” Listing a species as endangered rather than threatened provides it with a higher protective status. Endangered species are provided with the full protection of the ESA, whereas under Section 4(d), the listing agency has the power to determine which ESA protections apply to provide for the conservation of threatened species. However, a threatened species do get federal protection before it becomes nearly extinct and when endangered species begin to recover, the slightly more relaxed status of “threatened” scales back the agency resources needed to protect it. The following subsections cover other

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20 Id.
sections of the ESA and how each of them do not properly take climate change into account to effectively protect Florida’s sea turtles.

1. Listing

Listing the sea turtles is the first step in trying to protect them from the devastating effects of climate change by offering them the protection of the ESA. The U.S. Fish and Wildlife Service (‘‘USFWS’’) has jurisdiction over land species while the National Marine Fisheries Service (‘‘NMFS’’) has jurisdiction over the marine species.\(^{21}\) However as sea turtles live in the ocean and come on land to nest, both agencies share jurisdiction over their protection. NOAA “leads conservation and recovery of sea turtles when they are at sea, while the USFWS has the lead when they are on nesting beaches.”\(^{22}\)

Section 4 of the ESA provides instructions on how a species can be listed as endangered or threatened.\(^{23}\) There are two ways this can happen. First, the USFWS or NMFS can act on its own to list a species. Under this route, the agency will make listing determinations based on the best scientific and commercial data available to it after conducting a review of the status of the species.\(^{24}\) Then, the agency will promulgate a rule to list the species.\(^{25}\) If the USFWS or NMFS does not act to list a species, an interested person may submit a petition, which requires the agency to make a finding as to whether the petition presents substantial scientific or commercial information indicating that the petitioned action may be warranted.\(^{26}\) Then the agency can choose whether to list the species.\(^{27}\)

When making the decision regarding the status of the species, the agency has to determine whether the continued survival of the species would be impacted


\(^{22}\) *Id.*


\(^{24}\) *Id.*

\(^{25}\) *Id.*

\(^{26}\) *Id.* § 1533(b).

\(^{27}\) *Id.*
by any of the following factors: “(A) the present or threatened destruction, modification, or curtailment of its habitat or range; (B) overutilization for commercial, recreational, scientific, or educational purposes; (C) disease or predation; (D) the inadequacy of existing regulatory mechanisms; or (E) other natural or manmade factors affecting its continued existence.” 28

Climate change does not fit into factors (B) or (C), but it can potentially be read into (A), (D), and (E). Climate change has led to rising seas, retreating shores, bigger storms, and hotter temperatures in Florida. 29 As a result, sea turtles’ ability to find food, reproduce, and access their habitat has been negatively impacted. 30 All of these negative impacts to their habitat can fall under factor (A), the present or threatened destruction, modification, or curtailment of its habitat or range. Climate change is a natural and manmade factor which is currently affecting the sea turtles’ continued existence, so it fits into factor (E), other natural or manmade factors affecting its continued existence. Finally, for factor (D) the inadequacy of existing regulatory mechanisms, the agency can look to the current version of the ESA, other federal statutes, and Florida statutes and regulations, to determine if the existing regulatory mechanisms are inadequate to address the problems climate change is causing.

2. Designation of Critical Habitat

After the USFWS or NMFS lists the species, the agency must implement a recovery plan, which includes designating critical habitat. 31 Designating critical habitat works with the Section 7 jeopardy prohibition to prevent any federal actions, federal authorization, or funding of actions that are “likely to jeopardize the continued existence of any endangered species or threatened species or result in the destruction or adverse modification of [critical] habitat.” 32 It is important to

28 Id. §§1533(a)(1), (b)(1)(A).
30 Id.
32 Id.
note that this part of the ESA only grants the species protection from federal actions, not from non-federal actors. Under the ESA, the Services may designate two types of critical habitat: specific areas within the geographical area occupied by the species, which contain the ‘physical or biological features essential to the conservation of the species’ and may require special management protections . . . and . . . areas outside the geographical areas occupied by the species if the Secretary determines that such unoccupied areas are ‘essential for the conservation of the species.’

The designation of critical habitat could be a key tool in protecting Florida’s sea turtles from losing more of their habitat and food sources due to climate change. Current case law has determined that due to the lack of foreseeability and scientific uncertainty of how climate change has directly affected and will continue to affect endangered and threatened species, the courts generally defer to what the USFWS determines in its reports. This deference has allowed the USFWS to designate other species’ habitat as critical habitat due to climate change, such as when the USFWS listed three areas of Alaska’s coast and waters as critical habitat for the polar bear in 2009. In Alaska Oil & Gas Ass’n. v. Jewell, the plaintiffs challenged this designation because they believed that “the designation was unsupported by the administrative record because FWS arbitrarily designated large land and sea ice masses, but did not identify specific areas containing the physical and biological features essential for polar bears.” However, the 9th Circuit ruled in favor of the USFWS because the point of the ESA is to ensure species recovery, not just the existing population, and that the

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33 Id. § 1536(a)(2).
35 TSANG, supra note 34.
36 Alaska Oil & Gas Ass’n. v. Jewell, 815 F.3d 544, 550 (9th Cir. 2016).
37 Id. at 553.
USFWS “relied on numerous published studies and reports describing the effects of climate change” when gathering information on climate change and sea ice.\textsuperscript{38}

The designation of critical habitat can therefore be used as a tool to protect endangered and threatened species, like Florida’s sea turtles, from federal action that might compound the effects that climate change has had on their habitat, as long as the USFWS reasonably considered evidence and data regarding climate change, even if such data is scientifically uncertain.\textsuperscript{39}

3. Consultation

When a federal agency proposes a project or action, under Section 7 of the ESA, the agency must request an informal consultation from either USFWS or NMFS.\textsuperscript{40} If no listed species will be affected, then the applicable service will provide a letter of concurrence and the consultation process ends.\textsuperscript{41} If the agency action may affect a listed species or their critical habitat, then the agency is required to produce a biological assessment using the best scientific and commercial data available to verify that its action will not jeopardize the existence of a listed species or adversely affect its habitat.\textsuperscript{42} If the agency determines that its action will likely have an adverse effect on the listed species or its critical habitat, then the formal consultation process begins and the agency must develop a biological opinion.\textsuperscript{43} A biological opinion ensures that the agency action will not reduce the likelihood of survival and recovery of a listed species and usually includes conservation recommendations and reasonable measures needed to minimize any harmful effects.\textsuperscript{44}

In the past, entities have brought lawsuits to ensure that the USFWS takes climate change into account when creating its biological opinion based on the best

\textsuperscript{38} Id. at 558-59.
\textsuperscript{39} TSANG, supra note 34.
\textsuperscript{40} 16 U.S.C. § 1536(a)(2).
\textsuperscript{41} Id.
\textsuperscript{42} Id.
\textsuperscript{43} Id. at § 1536(c).
\textsuperscript{44} Id. at §§ 1536(a)(2), (c).
scientific data available, as required by Section 7.\textsuperscript{45} In cases like \textit{Nat. Res. Def. Council v. Kempthorne}, the federal district court noted that the studies the USFWS conducted anticipated that “climate change would adversely affect future water availability” in the delta smelt’s habitat.\textsuperscript{46} The court concluded that the USFWS wrongfully failed to meaningfully discuss this data when it created its biological opinion for a water diversion project in the area.\textsuperscript{47} Accordingly, when lawsuits are brought to Florida courts, the courts can use the formal consultation process to ensure that the sea turtles are properly protected as long as there is a causal connection between the proposed federal action and climate change.\textsuperscript{48}

Additionally, the consultation requirement obligates the agencies to “evaluate the effects of the action and cumulative effects on the listed species or critical habitat” to formulate their opinion as to whether “the action is likely to jeopardize the continued existence of listed species or result in the destruction or adverse modification of critical habitat.”\textsuperscript{49} The cumulative effects analysis can be used to evaluate the effect that the federal action has on the listed species or its habitat in light of climate change. For example, in \textit{Wilderness Workshop v. BLM}, the court held that the federal agency had to take a hard look at the impacts of greenhouse gas emissions and climate change, considering the direct, indirect, and cumulative impacts of the proposed action.\textsuperscript{50}

\textbf{B. The Marine Turtle Protection Act}

The Florida Marine Turtle Protection Act was enacted to “ensure that the FWC has the appropriate authority and resources to implement its responsibilities under the recovery plans of the USFWS” for all five of Florida’s sea turtles.\textsuperscript{51} The act works in tandem with the ESA by using state power to restrict the take,

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\textsuperscript{45} TSANG, \textit{supra} note 34; See also 50 C.F.R. § 402.14.
\textsuperscript{47} Id.
\textsuperscript{48} TSANG, \textit{supra} note 34.
\textsuperscript{49} 50 C.F.R. § 402.14(g)(3)-(4).
\textsuperscript{50} Wilderness Workshop v. United States Bureau of Land Mgmt., 342 F.Sup 3d 1145, 1167 (D. Colo. 2018).
\textsuperscript{51} Marine Turtle Protection Act, FLA. STAT. § 379.2431(1)(b) (2023).
\end{flushright}
possession, disturbance, mutilation, destruction, selling, transference, molestation, and harassment of marine turtles, nests or eggs, in addition to protecting their habitat. “Take” in the MTPA is defined as “an act that actually kills or injures marine turtles, and includes significant habitat modification or degradation that kills or injures marine turtles by significantly impairing essential behavioral patterns, such as breeding, feeding, or sheltering.” The MTPA definition is broader in the amount of activities covered by the ESA because it does not list out specific acts that are prohibited, just an act that “actually kills or injures marine turtles.” However, the ESA is much broader in the conduct that it captures because the MTPA take definition does not include attempts, the conduct has to actually produce a harmful result to the marine turtles.

The FWC is granted the power to issue a take permit to a properly accredited person for the purpose of sea turtle conservation, fine violators, bring criminal charges against violators, deny take permits not authorized under Section 10 of the ESA (Incidental Take Permits), and give “special consideration to beach preservation and . . . nourishment projects that restore habitat of endangered marine turtle species.” The MTPA does not contemplate or provide any protections for climate change other than the application of the law to non-federal actors, which ESA Section 9 also covers in its prohibition against takes of endangered or threatened species.

As of now, there is no case law, substantial scholarly research, or law that has connected the MTPA and climate change.

III. IMPACT ON FLORIDA SEA TURTLES

Florida has five species of sea turtles, their common names are: the Loggerhead, the Green Turtle, the Leatherback, the Kemp’s Ridley, and the

52 Id.
54 Id.
55 Id. at § 379.2431(1)(i).
56 See generally Id. § 379.2431; 16 U.S.C. § 1538.
Hawksbill. The Green Sea Turtle and the Loggerhead are listed as threatened in their North Atlantic distinct population segments, while the Leatherback, the Kemp’s Ridley, and the Hawksbill are all listed as endangered wherever they are found. Loggerheads are larger sea turtles, weighing an average of 275 pounds, and are mainly carnivores, eating clams, crabs, and other armored animals. Green Sea Turtles are green, oval-shaped, weigh an average of 350 pounds, and are mainly herbivores, eating seagrass and algae. Green Sea turtles spend their days in shallow flats and seagrass meadows and their nights in rock ledges, oyster bars, and coral reefs. Leatherbacks eat mostly jellyfish and are larger, dive deeper, travel farther, and tolerate colder temperatures than any other sea turtle. Kemp’s Ridley turtles are small and eat crabs and other crustaceans. They are also the rarest sea turtle in the world, nesting on only one major beach in Mexico. The Hawksbill is also a smaller sea turtle, eating primarily sponges, and is frequently seen in the lagoons, reefs, and bays of the Florida Keys.

The USFWS has listed all five sea turtles, which affords them the protection of the ESA, and all five are included in the MTPA, which also grants them state protection through the FWC. Because of climate change, in 2022, the previous four summers were the hottest on record, which means that when a sea turtle lays her eggs in the sand, the ambient temperature of the nest is hot as well. The sex of sea turtles is determined, not by fertilization, but by the temperature of the egg during incubation, called temperature-dependent sex.

59 FLA. FISH AND WILDLIFE CONSERVATION COMM’N, supra note 57.
60 Id.
61 Id.
62 Id.
63 Id.
64 Id.
65 Id.
66 Id.; Cardona, supra note 2.
If the turtles incubate above 88.8º F, the turtle hatchlings will be female. Therefore, sea turtle scientists predict that in the coming years with less males available, there will be a decline in the sea turtle population, and less genetic diversity.

Climate change has led to rising seas, retreating shores, bigger storms, ocean acidification, and hotter temperatures in Florida. As sea turtles live primarily in the ocean and require beaches to reproduce, climate change has already begun to take its toll on their populations. Sea turtles have a magnetic map of the location of the beach from which they hatched imprinted within their memories, which is how they are able to return to the same beaches they hatched from to lay their eggs. Stronger storms combined with rising sea levels have changed and will continue to change the shape, size, and even existence of the beaches. Further, the addition of more carbon dioxide in the atmosphere has lowered the pH of the ocean, making it more acidic. This is called ocean acidification, which also threatens the survival of the turtles by negatively impacting their food sources.

Ocean acidification affects shelled animals like coral reefs, clams, oysters, and other smaller shelled animals, making it more difficult for them to grow and maintain their shells. Less available food combined with more difficulty finding their reproductive habitat, and the

68 Id.
69 Cardona, supra note 2.
70 See U.S. ENV’T PROT. AGENCY, supra note 29.
72 Id.
73 Id.
74 WASHINGTON STATE BLUE RIBBON PANEL ON OCEAN ACIDIFICATION, OCEAN ACIDIFICATION: FROM KNOWLEDGE TO ACTION (Hedia Adelsman & Lara W. Binder eds., 2012).
75 Id.
76 Id.
increasing number of female turtles born, will eventually threaten turtle genetic diversity.\textsuperscript{77}

The existing impacts on Florida sea turtles, which will be worsened as climate change continues to affect the globe, reveals the inadequate protection that the ESA and MTPA provide listed species. The latter half of this paper will underline how current legal remedies in the ESA and MTPA fall short in their goals to protect sea turtles from extinction. Then the final part will propose ways to improve the ESA, adding a new part of the statute that mentions climate change, and how Florida can change the MTPA to give agencies more power over the regulation and mitigation of climate change.

IV. FAILURE TO ADEQUATELY ADDRESS CLIMATE CHANGE

The current legal provisions of the ESA and MTPA are failing to adequately protect species from the effects of climate change. The listing procedures, designation of critical habitat, and consultation requirement fail to fully protect species because of the undermining of protections that occurs due to the lack of permeance in agency rules, issues within the listing of a species and the funding that goes with it, and the complete lack of guidance for Floridians under the MTPA.

A. Loopholes in the ESA

Listing species is the first step to offering them the protection of the federal government against acts that might jeopardize their continued existence. So far, the current mechanisms within the statute could allow for climate change impacts to be read into the five factor considerations that the Secretary must make when evaluating whether to list a species. However, even if a species is listed, issues exist in the actual implementation and enforcement of the statute that impact its efficacy.\textsuperscript{78} Despite being listed, threats to the species persist especially in the light of climate change, overall programmatic funding is insufficient and

\textsuperscript{77} SEA TURTLE CONSERVANCY, supra note 71.
\textsuperscript{78} See Daniel M. Evans et al., Species Recovery in the United States: Increasing the Effectiveness of the Endangered Species Act, 20 ISSUES IN ECOLOGY 1 (2016).
“the distribution of money among listed species is highly uneven.” The listing process itself is imperfect because “at least [ten] times more species than are actually listed likely qualify for listing.”

Currently, there is a deficiency in both the consideration of climate change in species recovery plans, as well as listing climate-threatened species because of climate change. As of 2019, only 13% of all species recovery plans actually addressed climate change as a threat, compared to the fact that scientists have identified climate change as the primary threat to almost 40% of listed species.

As of March 2021, the FWS had considered climate change in their considerations of listing four animals: the polar bear, the American Pika, the American wolverine, and the Gunnison sage-grouse. Of these animals, only the Gunnison sage-grouse and the polar bear are actually listed as threatened, the American wolverine is proposed threatened, and the American Pika is not listed at all.

By 2013, four of the five Florida sea turtle recovery plans, the Loggerhead, the Leatherback, the Hawksbill, and the Kemp’s Ridley, did mention climate change. The revised Recovery Plan for the Northwest Atlantic Population of the Loggerhead Sea Turtle discussed climate change as being a

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79 Id.
80 Id.
81 Aimee Delach et al., Agency Plans are Inadequate to Conserve US Endangered Species under Climate Change, 9 Nature Climate Change 999 (2019).
84 See Delach et al., supra note 81, data availability at https://osf.io/7pytr.
potential threat to Loggerhead populations. The recovery plan suggested developing “a model that describes the effects of sea level rise on loggerhead nesting beaches” and “implement measures” and more generally, to “develop agreements to reduce atmospheric greenhouse gasses.” The 5-year Review on the Leatherback’s endangered status mentioned that climate change will impact their habitat and biology. The Hawksbill 5-year Review was similar to the Leatherback’s 5-year Review in its discussion of climate change and its impact on the sea turtle’s nesting on beaches that are eroding and getting hotter, food sources, and habitat. The Hawksbill Review supplied that “additional information and data are particularly needed on long-term population trends based on both nesting and in-water population monitoring.” The Bi-National Recovery Plan for the Kemp’s Ridley Sea Turtle discussed similar effects as the other sea turtle recovery plans, however it suggested assessing the potential impacts of climate change on the sex-ratio of the turtles. However, all five of them were not originally listed because of climate change, but rather other factors. Additionally, the remaining sea turtle whose recovery plan is silent on climate change is the Green Sea Turtle which is only listed as threatened. If climate change was considered by the Secretary, they could be uplisted as endangered, offering them more protections than they are currently receiving.

Courts in the past have ruled that potential impacts on species due to climate change is a legitimate consideration in the Secretary’s determination on

86 Id. at II-26.
89 Id. at 54.
whether to list a species. In 2018, the U.S. District Court for the District of Colorado upheld the USFWS’s listing of the Gunnison Sage-Grouse after the Service concluded, in addition to other factors, that climate change was going to change the conditions in Colorado and that the Gunnison sage-grouse would not be able to effectively adapt in time to prevent negative effects on their populations.\footnote{Colorado v. U.S. Fish & Wildlife Serv., 362 F. Supp. 3d 951, 970-71 (D. Colo. 2018).} Because the agency relied on sufficient and reliable data, the court held that the “[s]ervice’s assessment of an increased threat from climate change and drought was not arbitrary and capricious.”\footnote{Id.}

While the listing of the Gunnison Sage-Grouse was a success, considering climate change as a factor in the Secretary’s determinations has not occurred for the vast majority of other species threatened by climate change. This presents a major gap in listing considerations, that if corrected, would help many climate-threatened species, including Sea Turtles. For example, the American Pika has yet to be listed, but it is rapidly disappearing from its habitat.\footnote{American Pika, NAT’L WILDLIFE FED’N, \url{https://www.nwf.org/Educational-Resources/Wildlife-Guide/Mammals/American-Pika} (last visited Sept. 27, 2023).} Their ideal habitats are the cool and moist mountain ecosystems, as they overheat and die in temperatures as low as 78°F.\footnote{Id.} Due to climate change, the temperatures in the western mountain habitats have been higher, with one-third of their population vanishing in Oregon and Nevada, in addition to their numbers in the Great Basin dwindling.\footnote{Id.} Like the canary in the coalmine, the American Pikas have been an indicator species of climatic variability since at least 2017, yet it remains to be unlisted as we near the end of 2023.\footnote{Id.}

One of the main issues may be the fact that the USFWS’s enforcement of the listings is susceptible to the politicization of climate change with presidents from different political parties disrupting species mitigation and adaptation to

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climate change.\textsuperscript{97} For example, the Obama Administration implemented policies on climate change, produced Executive Orders relating to species adaptation, and agreed to the Paris Accords, most of which were then undone by the Trump Administration.\textsuperscript{98} Now the Biden Administration has once again placed a focus on climate change. Currently the Administration is revising regulations for listing species and critical habitat, trying to reinstate previous versions of the regulation that required these determinations be made “without reference to possible economic or other impacts of such determination.”\textsuperscript{99} There are also currently revisions in place for Section 7 consultation to redefine “effects of the action” to make it more inclusive of climate change.\textsuperscript{100} And more importantly, the Biden Administration is reinstating the blanket 4(d) rule, which establishes an automatic default extension of the protections that endangered species receive to threatened species.\textsuperscript{101}

All of these changes from the Biden Administration provide a beacon of hope for species endangered and threatened by climate change. However due to the nature of our administrative agencies and the executive branch, the efforts of the Biden Administration agencies might be undone by the next president.\textsuperscript{102} The four to eight-year political back and forth on climate change is not enough time for a species to recover fully or adapt to climate change, so a better, more long-term solution is required if there is going to be more lasting change in the conservation, adaptation, and mitigation of risks to the listed species.\textsuperscript{103}

\textsuperscript{97} Id.
\textsuperscript{98} Id.
\textsuperscript{100} Id.
\textsuperscript{101} Id.
\textsuperscript{102} See President Biden, Remarks on Actions to Tackle the Climate Change Crisis (July 20, 2022), \url{https://www.whitehouse.gov/briefing-room/speeches-remarks/2022/07/20/remarks-by-president-biden-on-actions-to-tackle-the-climate-crisis/}.
\textsuperscript{103} Delach et al., supra note 81, at 1002.
Additionally, the current way that spending is allocated is failing to adequately protect listed species. The current imbalanced funding has negatively impacted species recovery. In 2012, 62% of the species recovery funding was used for a mere 10% of listed species. From 1980 to 2014, less than 25% of the required recovery funding was actually allocated annually, giving agencies a very restricted budget to work with. A lack of sufficient funding and allocation of the few resources the agencies do have access to hinders their ability to adequately implement and enforce the procedures that protect, mitigate, and assist in the recovery of listed species. As of 2020, the Loggerheads in the Northeast Atlantic Ocean received $388,457 in federal funding, the Green Sea Turtles in Florida received $7,500, the Leatherbacks received $3,808,076, the Kemp’s Ridleys received $3,620,214, and the Hawksbills received $913,058.

B. Absence in the MTPA and Florida Law

Currently, the Marine Turtle Protection Act has no mention of climate change or any protection for the future of sea turtles outside of individual takes and beach activities that affect sea turtles. Currently, FWC only has control over the takes of individual animals and the DEP has control over regulations for beach activities that affect the sea turtles like beach restoration, renourishment, and recreation. FWC cannot regulate habitat, but it can comment on permitting for beach activities, suggest guidance for the future which will be impacted by climate change, and regulate activities that involve takes, like forcing fishermen in Florida waters to have sea turtle friendly shrimp nets.

104 Id.
105 Id.
106 Id.
107 Id. at 1003.
109 Marine Turtle Protection Act, FLA. STAT. §§ 379.2431(1)(g), (i) (2023).
V. Resolution

The ESA is absolutely a necessary law to keep in place, as even some protection for endangered and threatened species is better than none. If it were to be scrapped entirely, it would leave many crucial species without protection, which could put the North American ecosystem in a bad situation. However, there are certainly ways we can improve upon the existing statute, reform how we fund and oversee the enforcement of the ESA, and add new sections that are more protective of species who will be significantly impacted by climate change.

The current issues with funding and the problematic disproportionate distribution of funds have served as roadblocks for the recovery and success of species that were able to be listed. The way that the ESA is set up allows its enforcement to be influenced by the whim of the party in power and four to eight years is not sufficient time for the listed species to adequately recover, especially in the face of climate change. Just getting species on the list of endangered or threatened has been an issue, like in the case of the American Pika, which has yet to be listed despite years of research showing that it is rapidly disappearing. Finally, the disproportionate spending has failed to protect listed species.

A. Changing the ESA

To fix these issues, the simplest solution would be to revise and add sections to the current ESA to close the loopholes that have allowed these climate-threatened species to suffer and in some cases, perish. The current five factors that the Secretary must think about when determining whether a species should be listed or when reviewing a petition for a certain species to be listed must be revised. Although climate change could be read into factors A, C, and E, it would be much more effective to either revise (E) to explicitly include climate change as the “other natural or manmade factors” or to add a sixth factor, (F), that is dedicated only to considering climate change. This would eliminate the current

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110 See supra Part III(A).
111 Id.
112 Id.
113 Id.
need to try and come up with a reason that could eventually get challenged in court. This would also take some of the pressure off of the agencies who must implement the law. As it stands, the agency’s decision to list a species due to being threatened by climate change can be challenged in court for making an “arbitrary and capricious” decision, as seen in *Alaska Oil & Gas Ass’n*. Having to defend against similar cases if the agency began listing the many species that are threatened by climate change would be costly for the agency, further draining the already small pool of resources it has available. Adding a climate change factor would eliminate those legal challenges and potentially allow for the uplisting to endangered of both the Loggerhead and Green Sea Turtle.

The inclusion of either a review process of how funding is distributed or an independent commission to review the distribution of funds to listed species would benefit species that receive minimal funding. Despite not having adequate funding, what little money the agencies do have is distributed disproportionately, with some species receiving as little as $60 for their species recovery funding.\(^\text{114}\) By creating an independent review board of ESA species recovery funding allotments to ensure that funding is distributed more equitably, more listed species will actually get the attention and care they need to mitigate or adapt to the effects of climate change.

A huge part of ensuring the species have adequate time to recover under the protections of the ESA would be creating a way to insulate the agency’s actions from the effects of political changes in the executive branch. This would require either restructuring entirely how agencies work to give them more independence over their decision-making or utilizing a number of bypasses to avoid presidential observation, or three, changing the ability of the agency to later modify their own rules. The first solution is impractical because it would require overturning years of established administrative law and is likely politically impossible as well. There are several ways that agencies can avoid executive review including not engaging in regulatory action, producing more guidance

\(^\text{114}\) Delach et al., *supra* note 81, at 1002.
documents than rules, and creating non-significant rules. However, this solution is not practical either because the environmental regulatory agencies need the ability to enforce their regulations to protect endangered fauna and flora, which under the ESA, requires review from the executive branch. Furthermore, insulating agencies from outside political influence could be unwise depending on the goals of whichever presidential administration is in power during the formation of the more permanent and insulated rules.

Currently, the Secretary has the discretion to choose whether to include climate change in the biological opinions that the Department is required to produce. This has led to a huge deficiency in listings and considerations for critical habitat and permitting once listed. As of 2008, 87% of recovery plans did not include climate change. If there were a mandate that requires consultation with climate change experts to include climate change in every biological opinion, it would be very beneficial to climate-impacted species that are currently not offered enough or even any protection under the ESA.

B. Changing the MTPA

The second prong of addressing climate change would be asking the Florida legislature to give more authority to the FWC and DEP to have more discretion and enforcement power to regulate activities that worsen climate change. If the legislature were to include a larger and more expansive definition of take for the sea turtles as a collective, rather than just takes of individual animals, then all of Florida’s sea turtles could be afforded a protection similar to that of the ESA. Because the state has its own resources, knows its waters, beaches, and the local sea turtles’ needs better than the federal government, this would allow more specialized and targeted care for the continued survival of the species. Finally, if the legislature gave the FWC more power to regulate the habitat, it could make rules to protect the sea turtles’ food supply.

116 Delach et al., supra note 81, at 999.
117 Id.
118 Id.
The MTPA currently allows mitigating factors, like having an active marine turtle nest relocation program with the ability to administer such a program, as part of the permitting process for beach restoration, renourishment, and inlet sand transfer projects.\textsuperscript{119} However, if these mitigating factors are present, the MTPA restricts the DEP by ordering that they “must not restrict the timing of the project.”\textsuperscript{120} This part of the statute is troubling in light of climate change. As the climate and beaches change, the turtle nesting seasons that were initially reliable, have become more unpredictable, beginning earlier. If a permit for a project to restore the beach with the ability to administer a mitigation program happens in February and since the time the permitting process began turtles have begun early nesting on the beach, the DEP has no power to restrict the project’s timing. This law would have made sense when climate change wasn’t pushing sea turtles to nest earlier and the state had an interest in quickly restoring beaches. In light of the current impacts to sea turtles and the threats they will continue to face, this law needs to be amended to give the DEP more discretion and control over the projects.

One argument against expanding federal regulation is that states can fill in the gaps with their own regulation. If the ESA and federal regulations are not amended to include the impacts of climate change more thoroughly, the MTPA could be used as a backstop for the flaws in the ESA. The current MTPA does not fix any of the issues that exist in the ESA. In addition to the aforementioned solutions, if the FWC and DEP were given more power to enforce and regulate, then adding a take prohibition clause that is more like the ESA’s definition would give the agencies more control over existing and future sea turtle takes. Currently, the MTPA instructs that the DEP “give special consideration to beach preservation and beach nourishment projects that restore habitat of endangered marine turtle species.”\textsuperscript{121} Based on this wording, it is not far-fetched that the Florida legislature can also instruct the DEP to give special consideration for other things, like climate change. The DEP could be instructed to give special

\begin{flushleft}
\textsuperscript{120} Id.
\textsuperscript{121} Id.
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consideration to climate change when handling permitting that affects marine
turtles, state actions that may affect them, or individual activities that could
worsen the already dire situation. However, unfortunately, there is only so much
the state statutes can do as federal regulations are so fundamental in the protection
and funding of endangered species. Therefore, federal change is still necessary
and using state statutes as gap fillers for the failures of federal regulations is
ultimately no more effective than a band-aid on a bullet hole.

VI. CONCLUSION

If the proposed changes to the ESA and Florida statute were implemented, Florida’s sea turtles would have a better fighting chance of adapting to and mitigating the effects of climate change. If Congress included climate change as the sixth factor in 16 U.S.C. § 1533(b)(1)(A), then the Loggerhead and the Green Sea Turtle would be afforded the same level of protection as the other three sea turtle species. If the MTPA were revised to give more power to the FWC and the DEP to regulate the habitat of sea turtles outside of individual takes and beach renourishment projects, Florida would be able to work together with the federal government to ensure that the sea turtles successfully adapt to or are protected from climate change.

While sea turtles have existed for millions of years and have successfully lived through huge changes in the earth’s climate, these changes in the coastal development and the unprecedented speed at which the climate is changing are not like what they have endured in the past. Current legal remedies for climate-threatened species, like Florida’s five sea turtles, are insufficient in their current form, in their implementation, and in their ability to be influenced by politics. To solve these issues, Congress needs to step in and ensure that climate change will be a definite factor in every Secretary consideration for listing species.

Additionally, the ESA needs to have an overhaul of the way it allocates funding to listed species so that 62% of the funding never goes to a mere 10% of the species again. These changes would provide more accountability of the agencies and the Secretaries to the way they are using taxpayer money, ensure future protection for the climate-threatened species, and put a stop to the uneven enforcement of the ESA. The Florida legislature also needs to step up and allow the agencies, like FWC and DEP, to have more control and more enforcement capabilities to ensure the future survival of the five sea turtle species. The current absence of climate change or the ability to mitigate climate change in statute and therefore, the inability of Florida’s agencies to act, needs to be addressed and remedied before Florida’s sea turtles go extinct.
REVIEW OF THE LITERATURE ON THE SEAWEED INDUSTRY AND FOOD SAFETY ISSUES

Lilian Elekwachi,1 Daniel Hirschkop,2 & Michael F. Tlusty3

I. INTRODUCTION

The emerging seaweed aquaculture industry in the United States presents novel legal considerations, including how to regulate the sale of seaweed in its whole form as a food product to address potential food safety risks. There is currently no federal guidance on the food safety risks of seaweed in its whole form, leaving states unsure how to proceed with their own laws and regulations, impeding the growth of the industry.

In 2021, the National Sea Grant Law Center (NSGLC) hosted a virtual collaborative learning workshop for state regulators on seaweed food safety. Discussions during that workshop revealed that a primary barrier to the development of food safety regimes for seaweed aquaculture is a lack of knowledge among regulators and policy-makers about the potential hazards associated with seaweeds and seaweed products.4 To begin to fill this knowledge gap, the NSGLC partnered with researchers at the University of Massachusetts Boston to conduct a literature review of the food safety hazards of seaweed production.

The objective of the literature review was to compile and index the primary, peer-reviewed literature related to seaweed food safety hazards. The review was focused on identifying literature on the potential contaminants of cultivated and wild collected seaweed, as well as potential regulatory, policy, and voluntary standards that address ways to minimize or control contamination. The literature survey is presented as a searchable web-based platform, where papers

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4 The proceedings from the workshop are available at http://bit.ly/3UsyrQF.
This report presents a summary of the findings of the literature review. To provide context to the food safety hazards of seaweed production, this report begins with an overview of the state of the industry both globally and in the United States. The report then discusses the food safety hazards identified in the literature which include chemical, microbial, physical, allergenic, and climate hazards. The report concludes with ideas regarding additional research needs.

II. GLOBAL INDUSTRY OVERVIEW: STATUS AND TREND

The seaweed industry is a vital global industry, which reached a total market value of USD 16.5 billion for cultivated species in 2020, with China, Indonesia, and the Republic of Korea the major exporters, and China, Japan, and the United States of America the leading importers. The main production comes from aquaculture, which produced 35.1 million tonnes wet weight (ww), or about 97%, of the total 36 million tonnes produced in 2020. Aquaculture production remains almost entirely marine macroalgae. Wild collection currently stands at ~0.9 million tonnes, which is about half its 1969 volume, when aquaculture and wild collection were equal halves of the total production.

There has been a wide geographical disparity in seaweed aquaculture production with Asia being responsible for 99.5% of the global total, producing 34.9 million tonnes live weight in 2020. This is a slight increase of 0.4 million tonnes over 2019’s aquaculture production, when 99.1% of total production was through aquaculture and the remaining 0.9% through wild collection. Similarly,
in Oceania and Africa, a large portion (85.3% and 81.3% respectively in 2019) of their seaweed production comes from aquaculture, although these continents are minor contributors to world seaweed production, producing only 161.5 tonnes combined in 2019.\textsuperscript{11} On the other hand, while the Americas and Europe were also minor contributors to global seaweed production in 2019 (487 tonnes for 1.4% share of world production and 287 tonnes for 0.8% share of world production respectively), their production was achieved mostly through wild collection (96.1% and 95.3% respectively).\textsuperscript{12} Notably, a single country accounts for a majority of production in each of these last two regions. In the Americas, Chile produced 87.5% of the total, making it the 6\textsuperscript{th} largest producing country globally at 426 tonnes wet weight. In Europe, Norway produced 163 tonnes wet weight, or 56.9% of the European total, making it the 9\textsuperscript{th} largest producing country.\textsuperscript{13}

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{distribution_of_world_aquaculture_production_of_algae_by_major_producers_2005-2020}
\caption{Production distribution of world aquaculture of algae by producing country in live weight\textsuperscript{14}}
\end{figure}

\begin{itemize}
\item \textsuperscript{11} Id.
\item \textsuperscript{12} Id.
\item \textsuperscript{13} Id.
\item \textsuperscript{14} FAO, supra note 6. The FAO has made this figure available under the Creative Commons Attribution-NonCommercial-ShareAlike 3.0 IGO licence (CC BY-NC-SA 3.0 IGO; https://creativecommons.org/licenses/by-nc-sa/3.0/igo).
\end{itemize}
Seaweed is broadly classified into three taxonomic groups: brown seaweeds, also known as kelps, (around 2,000 species under *Phaeophyceae*), red seaweeds (over 7,200 species under *Rhodophyta*), and green seaweeds (more than 1,800 macroalgae species under *Chlorophyta*).\(^{15}\) Cultivation of red seaweeds is primarily *Kappaphycus/Eucheuma, Gracilaria*, and *Porphyra* (nori), whilst brown seaweed is concentrated in growing kelp (*Laminaria/Saccharina*) and wakame (*Undaria*), which are cold water genera.\(^{16}\) In 2020, the top 8 farmed species of seaweeds were either red or brown types and represented 93.7% of total global aquaculture production.\(^{17}\) Japanese kelp *Laminaria japonica* alone accounted for 35.5% of the total, while the second and third most produced species were various red seaweeds from *Eucheuma* and *Gracilaria*, representing another 38% of the total combined.\(^{18}\) Global seaweed cultivation market size is projected to reach up to US $30.2 billion by 2025, a substantial increase from current levels, and the North American market is expected to witness market growth of 11.2% in value during the forecast period of 2021-2027.\(^{19}\)

Red seaweeds accounted for 52.6% in tonnes and 47.6% in value of global production as of 2019, recording a total of 18.3 million tonnes that year.\(^{20}\) The annual percentage growth of red seaweed aquaculture was 10.3% between 1950 and 2019, which is higher than the global annual growth rate of seaweed aquaculture at 7.9%.\(^{21}\) While red seaweed is taking the lead in terms of tonnage produced, brown seaweed cultivation is not far behind. As of 2019, brown seaweed cultivation accounted for 47.3% in tonnes and 52% in value of global production, experiencing an 10.9% annual growth rate in volume during the same time period.\(^{22}\) Global production of green seaweed is very small and on a

\(^{15}\)Anushree Priyadarshini et al., *Economic Status of Seaweed: Production, Consumption, Commercial Applications, Hazards, and Legislations, in 20 Recent Advances in Micro and Macroalgal Processing: Food and Health Perspectives* (Gaurav Rajauria & Yvonne V. Yuan eds., 2021), [https://doi.org/10.1002/9781119542650.ch20](https://doi.org/10.1002/9781119542650.ch20).

\(^{16}\)Id.

\(^{17}\)FAO, *supra* note 6.

\(^{18}\)Id.

\(^{19}\)MARKETSANDMARKETS, *Seaweed Cultivation Market Size, Share, Trends, and Forecasts to 2025* (2020).

\(^{20}\)Cai et al., *supra* note 8.

\(^{21}\)Id.

\(^{22}\)Id.
downward trend since the early 1990s. Only 16,698 tons were produced in 2019, which accounted for just 0.5% of all seaweed production by volume. Five species are primarily cultivated: *Caulerpa spp*; *Monostroma nitidum*; *Enteromorpha [Ulva] prolifera*; *Capsosiphon fulvescens*; and *Codium fragile*.23

![Graph: World production of major aquaculture species (including species groups)](image)

**Figure 2: Top 8 aquaculture species for seaweeds in live weight, 2000-2020**24

All three types of seaweed are very beneficial, especially as human food and animal feed.25 While some seaweeds are consumed whole, most are processed into a variety of products - e.g., fresh, dried, extracted liquids, canned, flaked, powdered, or salted.26 Seaweed products are commonly used in soups, salads.

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23 *Id.*
24 FAO, *supra* note 6. The FAO has made this figure available under the Creative Commons Attribution-NonCommercial-ShareAlike 3.0 IGO licence (CC BY-NC-SA 3.0 IGO; [https://creativecommons.org/licenses/by-nc-sa/3.0/igo](https://creativecommons.org/licenses/by-nc-sa/3.0/igo)).
25 Priyadarshini et al., *supra* note 15.
sushi, and snacks, as well as thickening agents.\textsuperscript{27} Seaweed is also commonly found in dietary supplements due to their nutritious bioactive compounds and micronutrients.\textsuperscript{28} For example, \textit{Palmaria palmata} and \textit{Porphyra tenera} are extremely rich sources of protein.\textsuperscript{29} Brown seaweeds provide vital bioactive compounds that can promote overall good health. Research suggests that brown seaweed helps to control sugar levels and minimizes risk of obesity and high cholesterol, is rich in antioxidants, and helps to build a strong immune system.\textsuperscript{30} Seaweed is also used for medicines, fertilizers, biofuels, and cosmetics, amongst other uses.\textsuperscript{31}

Research indicates seaweed aquaculture has numerous environmental benefits. Seaweed production does not have to compete for fresh water, agricultural land, or fertilizer inputs and does not threaten the commons for other extractive resource uses.\textsuperscript{32} Seaweed production also has a relatively low carbon footprint.\textsuperscript{33} Seaweed requires no inputs to grow, other than sunlight and marine nutrients; it absorbs carbon dioxide efficiently from its environment and pulls more greenhouse gas from water than eelgrass, mangroves, and salt marshes combined based on biomass; and it may help in mitigating methane emissions when used as a feed supplement in cattle farming.\textsuperscript{34} Seaweed aquaculture also has

\begin{footnotesize}
\begin{itemize}
\item \textsuperscript{27} Cai et al., \textit{supra} note 8; Priyadarshini et al., \textit{supra} note 15.
\item \textsuperscript{28} Cai et al., \textit{supra} note 8.
\item \textsuperscript{29} Mona M. Ismail et al., \textit{Therapeutic Uses of Red Macroalgae}, 25 \textit{MOLECULES} 4411 (2020), \url{https://doi.org/10.3390/molecules25194411}.
\item \textsuperscript{31} Buschmann et al., \textit{supra} note 26.
\item \textsuperscript{32} Unlocking Kelp’s Potential as a Major Biofuel Source, \textit{SCIENCE DAILY} (March 2, 2021), \url{https://www.sciencedaily.com/releases/2021/03/210302094053.htm#:~:text=Summary%3A,biofuel%20harvested%20from%20the%20ocean}.
\item \textsuperscript{33} Cai et al., \textit{supra} note 8; Priyadarshini et al., \textit{supra} note 15.
\item \textsuperscript{34} Seaweed Aquaculture: Seaweed Farming, the Fastest-Growing Aquaculture Sector, can Benefit Farmers, Communities, and the Environment, NOAA FISHERIES (Sept. 28, 2020) [hereinafter NOAA], \url{https://www.fisheries.noaa.gov/national/aquaculture/seaweed-aquaculture}; Breanna M. Roque et al., \textit{Red Seaweed (Asparagopsis taxiformis) Supplementation Reduces Enteric Methane by Over 80 Percent in Beef Steers}, 16 \textit{PLOS ONE} 1 (2021), \url{https://doi.org/10.1371/journal.pone.0247820}.
\end{itemize}
\end{footnotesize}
promising potential as a bioremediation technology for removing nutrients such as nitrogen and phosphorus, which are major factors driving algal blooms that deplete oxygen in oceans and can kill aquatic animals. Seaweed also provides new habitats for fish, helps to maintain good water quality through absorption of micronutrients, and supports coastal areas to minimize the effects of wave energy. Seaweed is also a potentially great source of renewable energy from biofuel and a more sustainable raw material compared to other sources of biofuels.

While there is a concern that seaweed grown on lines may potentially entangle large marine animals (e.g., whales, turtles), current systems are looking at using tensioned lines to minimize the possibility of entanglement. Current research is also focused on real-time reporting for weak links that can indicate entanglement or system stress in poor weather.

III. OVERVIEW OF THE U.S. SEAWEED MARKET

The U.S. seaweed industry has received a lot of attention in recent years and is acknowledged as a very important industry from an economic, social, and environmental standpoint. As of 2019, the U.S. was producing 3,394 tonnes wet weight of edible seaweed, with the majority of production coming from

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35 NOAA, supra note 34; Priyadarshini et al., supra note 15.
37 ScienceDaily, supra note 32.
Seaweeds in the U.S. are mostly harvested for food uses, with a small part being used as fertilizer, in medicine, and for other industrial uses.\textsuperscript{42} In the past, eleven species were produced: dulse (\textit{Palmaria palmata}); sugar kelp (\textit{Saccharina latissima}); horsetail kelp or \textit{digitata} (\textit{Laminaria digitata}); \textit{alaria} or winged kelp (\textit{Alaria esculenta}); rockweed or knotted wrack (\textit{Ascophyllum nodosum}); bladderwrack (\textit{Fucus vesiculosus}); sea lettuce (\textit{Ulva lactuca}); laver (\textit{Porphyra umbilicalis}); Irish sea moss (\textit{Chondrus crispus}); and worm weed (\textit{Ascophyllum nodosum}). Recently, the most harvested species are sugar kelp, dulse, \textit{alaria}, laver, and Irish moss.\textsuperscript{43}

Growers in the U.S are exploring integrating the culturing of seaweed, alongside fish and mollusk culture. This integrated multi-trophic aquaculture (IMTA) system is proven to increase both economic and environmental sustainability, as the waste from one aquatic species serves as fertilizer and food for another, thereby lessening the environmental impacts associated with aquaculture production while increasing the diversity of crops produced.\textsuperscript{44}

The majority of commercial production takes place in New England, the Pacific Northwest, and Alaska.\textsuperscript{45} The states of Alaska and Maine are the most significant producing states in the U.S. market and have the highest growth potential for seaweed development, accounting for more than 85\% of total edible

seaweed production in the U.S. The development of seaweed aquaculture in these states has focused mainly on cultivation of several species of kelps, including *Macrocystis pyrifera, Saccharina latissima,* and *Alaria marginata,* with a significant amount of interest in bull kelp (*Nereocystis luetkeana*) in Alaska.

In 2019, Alaska seaweed aquaculture farmers harvested over 136,000 pounds (61.7 tonnes) of seaweed, including sugar, ribbon and bull kelps, doubling the state’s first commercial harvest in 2017. In 2022, that number again increased dramatically to over 872,000 pounds (395.5 tonnes).

The U.S has the second largest coastline (95,000 miles) in the world, and it is very suitable for seaweed farming. In fact, the large coastlines of both Alaska and Maine are still largely untapped when it comes to seaweed production. The U.S. could become a leading producer of seaweed in the world, if resources are maximized sustainably. Currently, seaweed production is limited by a short growing and harvest season (winter and spring), although this does have a seasonal alignment with the primary fisheries’ shoulder seasons, when fishermen are not as busy harvesting groundfish, lobsters, or shellfish. Processing infrastructure is also limited to a small set of processors, who often also sell seed spools. Harvesters who do not have contracts with them usually have little or no

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51 PICONI ET AL., *supra* note 42.
access to seeds. Access to seed supply could be increased if others, such as shellfish hatcheries, became more involved in providing seed. These limiting factors have led to a substantial amount of imported seaweeds from countries with more well-developed seaweed industries.

Growth of the U.S. seaweed industry for food is projected to grow based on increasing harvesting and processing capacity. This growth could be maximized if the constraints that are keeping the seaweed industry are addressed— for instance, increasing manpower, farming and processing infrastructure, and market demand for location production and developing more effective scalable products.

![Figure 4: World Aquaculture Production 1991-2020 in live weight](https://creativecommons.org/licenses/by-nc-sa/3.0/igo)

52 FAO, *supra* note 6. The FAO has made this figure available under the Creative Commons Attribution-NonCommercial-ShareAlike 3.0 IGO licence (CC BY-NC-SA 3.0 IGO; https://creativecommons.org/licenses/by-nc-sa/3.0/igo).
IV. OVERVIEW OF THE FOOD SAFETY HAZARDS OF EDIBLE SEAWEED

U.S. seaweed cultivation has the potential to become an incredibly vigorous sector that can generate massive benefits.\textsuperscript{53} Human consumption of seaweed is growing steadily, more than the other uses.\textsuperscript{54} The versatility and variety of many seaweeds suggest that they can be used in a broad range of food products, adding healthy, low calorie, nutrient dense opportunities for food manufacturers and distributors.\textsuperscript{55} Seaweed aquaculture for human food is projected to drive the growth of the industry as numerous efforts are in place to expand harvest and processing capacity by developing infrastructure to meet the growing demands.\textsuperscript{56}

However, consuming seaweed may present food safety hazards. Seaweed may encounter several hazards during its journey through production and the supply chain. Food safety hazards refer to substances or agents that can cause harm or health problems for people who consume them. These can happen when the food is exposed to substances that are hazardous, which acts as a contaminant to the food.

Studies have identified contaminants, such as arsenic, cadmium, lead, mercury, and \textit{Salmonella}, as major hazards in edible seaweed species and microalgae; with brown seaweed species having the highest concentration of contaminants.\textsuperscript{57} Studies have also noted the following as emerging hazards,

\textsuperscript{53} PICONI ET AL., supra note 42.
\textsuperscript{54} J.L. Banach et al., \textit{Food Safety Hazards in the European Seaweed Chain}, 19:2 COMPREHENSIVE REV. FOOD SCL AND FOOD SAFETY 332 (2020), \url{https://doi.org/10.1111/1541-4337.12523}; Ferdouse et al., supra note 30; PICONI ET AL., supra note 42.
\textsuperscript{55} Buschmann et al., supra note 26.
\textsuperscript{56} PICONI ET AL., supra note 42.
\textsuperscript{57} Concepción Almela et al., \textit{Heavy Metal, Total Arsenic, and Inorganic Arsenic Contents of Algae Food Products}, 50 J. AGRIC. FOOD CHEM. 918 (2002), \url{https://doi.org/10.1021/jf0110250}; Banach et al., supra note 54; Maria Bouga & Emilie Combet, \textit{Emergence of Seaweed and Seaweed-Containing Foods in the UK: Focus on Labeling, Iodine Content, Toxicity and Nutrition}, 4 FOODS 240 (2015), \url{https://doi.org/10.3390/foods4020240}; Qing Chen et al., \textit{Distribution of Metals and Metalloids in Dried Seaweeds and Health Risk to Population in Southeastern China}, 8 SCI. REP. 3578 (2018), \url{https://doi.org/10.1038/s41598-018-21732-z}; J.L. Banach et al., \textit{Food Safety During
though with limited data: allergens, polycyclic aromatic hydrocarbons, toxic metabolites, pesticide residues, dioxins and polychlorinated biphenyls, brominated flame retardants, pharmaceuticals, marine biotoxins, macro- and microplastics, other pathogenic bacteria, rare earth elements, norovirus, and hepatitis E virus.\(^{58}\)

Consuming certain seaweed species may expose individuals to certain food safety hazards, such as heavy metals and microcystin contamination, and health challenges from excessive consumption of certain elements, such as iodine.\(^{59}\) For example, inorganic arsenic (iAs) has the capacity to induce cancer in human and other living tissues.\(^{60}\) Young children, frail or elderly people, and others with weakened immune systems are the most susceptible to hazards and exposure can be fatal for these populations.\(^{61}\) Exposure to food-borne contaminants can also lead to severe illness, such as endocarditis, arterial infections, and arthritis.\(^{62}\)

Poor sewage systems increase the accumulation of heavy metals in seaweed, but most areas contain levels that pose minimal health risks.\(^{63}\) Other factors that may contribute to seaweed food safety include, but are not limited to, location of the cultivation sites (sites adjacent to legacy coal fired power plants have greater heavy metal contamination), the strain of the species of seaweed,

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\(^{58}\) Banach et al., \textit{supra} note 54.

\(^{59}\) Bouga & Combet, \textit{supra} note 57.


\(^{62}\) \textit{Id.}

\(^{63}\) Cherry et al., \textit{supra} note 30.
seasonal variation and climate change, handling, method of harvest and post-harvest management, and processing methods.\textsuperscript{64}

Analysis from Spanish seaweed samples have shown that cadmium and inorganic arsenic are higher than legally permissible in other countries.\textsuperscript{65} The U.S. has not established food safety limits for most seaweed food products, but standards do exist for certain seaweeds when used as a food additive. FDA has recently stated that seaweed will be treated as a raw agricultural commodity in its whole form,\textsuperscript{66} and therefore regulated under the Federal Food Drug and Cosmetic Act and the Food Modernization and Safety Act and its Current Good Manufacturing Practice, Hazard Analysis, and Risk-Based Preventive Controls for Human Food Rule.\textsuperscript{67}

V. LITERATURE REVIEW FINDINGS

To summarize the findings from this literature review, seaweed hazards are grouped into five categories: chemical, microbiological, physical, allergenic, and climatic.

A. Chemical Hazards

Chemical hazards are non-biological toxic substances known to negatively impact human health in a variety of ways. These impacts include, but are not limited to, irritation and sensitivity at a minimum and carcinogenicity at a


\textsuperscript{65} Almela et al., supra note 57; Concepción Almela et al., \textit{Total Arsenic, Inorganic Arsenic, Lead and Cadmium Contents in Edible Seaweed Sold in Spain}, 44:11 \textit{FOOD & CHEM. TOXICOLOGY} 1901 (2006), \url{https://doi.org/10.1016/j.fct.2006.06.011}; Cubadda et al., supra note 60.

\textsuperscript{66} Catherine M. Janasie, \textit{Federal Food Safety Framework: Where does Seaweed Fit In?}, 18:2 \textit{J. FOOD LAW & POL’Y} 74, 77 (2022), \url{https://scholarworks.uark.edu/cgi/viewcontent.cgi?article=1320&context=jflp}.

\textsuperscript{67} 21 C.F.R. § 117.
maximum. Chemical hazards can also be introduced through processing due to reactions between naturally occurring compounds in seaweed and additives, ingredients, or packaging materials, e.g., acrylamide, ethyl a carbamate, and furan.

Chemical hazards summarized below include: (1) heavy metals, minor element, and rare earth elements; (2) Iodine; (3) Polycyclic Aromatic Hydrocarbons (PAHs); (4) Micro- and Nanoplastics; (5) Agrochemicals; (6) Pharmaceutical and Personal Care Products; (7) Marine Biotoxins; and (8) Persistent Organic Pollutants (POPs).

As discussed in more detail below, some seaweed species or products may exceed recommended intake levels of heavy metals and other contaminants. Existing regulations vary substantially by country and noticeably, are completely absent in Canada and the United States (except for when some seaweeds are used as an additive). The European Union (EU) has codified some maximum residue limits (MRLs). Some countries such as France, as shown in Figure 5, have also set their own recommended or legal maximums, which may or may not be as stringent. China, the world’s largest seaweed producer, has some of the stricter limits for arsenic, lead, and cadmium.

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69 Health Canada, Chapter 4: Food Safety Hazards, in IMPORTED & MANUFACTURED FOOD PROGRAM INSPECTION MANUAL (Archived), CANADA FOOD INSPECTION AGENCY (2022).
### Table 1: Max Recommended Levels for Trace Elements and Iodine in Seaweed

<table>
<thead>
<tr>
<th>Element</th>
<th>Max Recommended Level (mg.kg⁻¹ dry matter (DM))</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inorganic Arsenic</td>
<td>3</td>
</tr>
<tr>
<td>Cadmium</td>
<td>0.5</td>
</tr>
<tr>
<td>Mercury</td>
<td>0.1</td>
</tr>
<tr>
<td>Lead</td>
<td>5</td>
</tr>
<tr>
<td>Tin</td>
<td>5</td>
</tr>
<tr>
<td>Iodine</td>
<td>2000</td>
</tr>
</tbody>
</table>

Figure 5: Maximum values for trace elements and iodine in seaweed used as a vegetable or condiment recommended by the Conseil Supérieur d'Hygiène Publique de France (CSHPF).  

#### i. Heavy Metals

Heavy metals are a high-density group of metallic chemical elements that are very toxic and can negatively affect people's health, even at a low concentration. The most known heavy metals in edible seaweeds are arsenic (As), cadmium (Cd), lead (Pb), and mercury (Hg), each of which are discussed below. Chromium (Cr) and Thallium (Tl) are additional potential heavy metals of concern. Several researchers have shown that seaweed species easily bioaccumulate heavy metals at a very low level. However, the level at which the species becomes contaminated primarily depends on the chemical composition of the specific species.

Generally, all seaweeds are up to 70-90% water in its whole fresh form, but the levels of polysaccharides, which easily bind to metals, differ between brown, red, and green macroalgae. In addition, brown seaweeds are made up of

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72 ANSES, supra note 69.
73 Id.
a great amount of alginate, which is also known to work as a binder. This increases the chances of the seaweed trapping heavy metals, leading to the high concentrations seen in brown seaweed species. As a result, the concentrations of inorganic metals, especially arsenic, found in edible brown seaweed species are usually very high compared to red and green seaweed species, and its consumption may exceed three times the World Health Organization (WHO) tolerable daily intake levels. For example, one study found consuming 3 grams per day of the *Hizikia fusiform* samples could represent up to 15% of the WHO arsenic and cadmium tolerable daily intake levels.

The concentration of heavy metals in seaweed varies amongst species, growing area, season, seaweed growth rates, and within species, from one part of the seaweed to another. For instance, the part of the seaweed that is exposed or in contact with the production water tends to absorb more contaminants compared to parts that do not have direct contact with water. Environmental characteristics, such as temperature, salinity, location, and sunlight also have an impact on the level of contamination. The contaminant exposure is seen more in perennial seaweeds, and regular consumption may lead to toxicity of heavy metals in humans. Another study in Korea measured 426 dried seaweed products for heavy metals (arsenic, lead, mercury, and cadmium) and discovered that daily consumption of 8.5 g dry weight of the seaweed product resulted in consumption of between 0.2% to 6.7% of tolerable weekly intake of these metals.

a. **Arsenic (As)**

Arsenic is a naturally occurring metal found in groundwater, sediments, and soil. It can be introduced into the marine environment through natural causes.

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74 NAT’L INST. OF NUTRITION & SEAFOOD RSCH., POTENTIAL RISKSPOSED BY MACROALGAE FOR APPLICATION AS FEED AND FOOD – A NORWEGIAN PERSPECTIVE (2016).
75 Almela et al., supra note 65.
76 Id.
77 ANSES, supra note 69.
78 NAT’L INST. OF NUTRITION AND SEAFOOD RSCH., supra note 73.
80 Hwang et al., supra note 64.
such as rock weathering and geothermal activity, as well as by industrial emissions, fertilizers, and pesticides. Arsenic in seaweeds is classified into three categories: toxic or inorganic arsenic (class 1 carcinogens), nontoxic (arsenobetaine), and potentially toxic (fat-soluble arsenic, arsenosugars, and other organoarsenicals).  

However, most arsenic found in seaweed species are predominantly arsenosugars, which are potentially toxic and have been reported to resist cooking and digestion processes. Rather, they directly enter the hepatic portal system, which is the venous system that returns blood from the digestive tract and spleen to the liver. There are considerable differences between individuals in the excretion rate of arsenosugars, which can range from 4% up to 95%. This high variability of arsensugar metabolism means the toxicity of arsenosugars can also vary depending on the individual. Thus, it is difficult to generalize about the safety or hazards of consuming arsensugar rich foods without characterizing the metabolic fate of arsenosugars in the body.  

When arsenosugars are metabolized, they break down into at least twelve different metabolites, the toxicities of which are also unknown.

Seaweed species can accumulate arsenic up to 50,000 times higher than the arsenic content in the surrounding water. Brown seaweeds have been found to accumulate the highest concentrations of arsenic, followed by red seaweed and green seaweed respectively. Food products made from hijiki (a brown seaweed) have the highest amount of total arsenic. Rose et al. documented hijiki species with inorganic arsenic concentration ranging from 67-96 mg/kg, significantly above the hazard level specified in the EU limit of 3 mg/kg. Other seaweed species investigated were all found to have inorganic arsenic concentration levels that are less than 0.3 mg/kg, which were considered as minor hazards. A

81 Cherry et al., supra note 30.
82 Id.
83 Id.
86 FOOD & AGRIC. ORG., supra note 83.
significant amount of total inorganic arsenic could be removed from seaweed through thorough washing, soaking, cooking, boiling, heating, processing, and treating with sodium chloride.\textsuperscript{88}

b. Cadmium (Cd)

Cadmium is a heavy metal naturally found in soil, rock, coal, and mineral fertilizer, and when mined, can escape into the environment (e.g., air, water). Cadmium contamination in seaweed happens through natural processes and from anthropogenic activities.\textsuperscript{89} Reports have noted seaweed as having very high cadmium concentrations compared to other types of food.\textsuperscript{90} Reports also found cadmium in edible seaweeds ranges from below detection limits of 0.001 μg/mL, up to 9.8 mg/kg dry weight (dw).\textsuperscript{91}

The most influential factors in the accumulation rate of cadmium in seaweeds are the strain of species and seasonal variation. In one study, brown seaweeds were recorded as having the highest cadmium concentration rate in general,\textsuperscript{92} and mean cadmium concentrations were reported as 0.10 ± 0.06 mg/kg dw (brown seaweed, \( n = 22 \)) and 0.30 ± 0.34 mg/kg dw for red seaweed (\( n = 18 \)).\textsuperscript{93} However, seasonal variation plays a role in concentration levels. Red seaweed species are reported to accumulate more cadmium in winter, compared to brown and green species.\textsuperscript{94} The accumulation of cadmium metal differs from one species to another. For example, at a consumption rate of 3.3 to 12.5 grams/day, \textit{Laminaria digitata} contains .024 to 0.90 mg of cadmium, which

\textsuperscript{88} Banach et al., supra note 57.
\textsuperscript{89} Banach et al., supra note 54.
\textsuperscript{91} Banach et al., supra note 54.
\textsuperscript{93} Banach et al., supra note 54.
corresponds to 40% to 150% of the tolerable daily intake, while *Laminaria japonica* contains 0.45 to 0.80 mg/kg, which exceeds the maximum limits for seaweed products according to legislation in France (0.5 mg/kg of dw) and Australia/New Zealand (0.2 mg/kg of dw).\(^95\)

c. **Lead (Pb)**

Lead is a heavy metal found mostly in paints and petrol. The geographical location of the seaweed plays an important role in the accumulation rate of lead.\(^96\) Higher lead concentrations are reported in locations with high anthropogenic activities, although the range, from <0.05 mg/kg (limit detection) dw to 2.44 mg/kg, is considered a low-risk hazard.\(^97\) Lead contamination can also happen throughout the supply chain (transporting, processing, handling, and packaging), but accumulation occurs at a lower rate.

Several studies recorded different species to have accumulated a higher lead concentration than others. Brown seaweed (*U. pinnatifida*) was noted for a higher bioaccumulation of lead of several edible seaweed products investigated.\(^98\) Green seaweed (*Ulva lactuca*) accumulates more lead in summer, followed by red seaweed (*Pyropia columbina*) due to seasonal variation.\(^99\) The increase in temperature during summer months is reported to cause an increase in metabolic activities, which makes the intake of lead higher.

d. **Mercury (Hg)**

Mercury is a heavy metal that can occur naturally and through anthropogenic activities.\(^100\) As they grow, seaweeds can uptake mercury from the environment in its methylmercury form, its most toxic form. The concentration level of mercury varies among the species type and location of cultivation. Brown

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\(^{95}\) Cherry et al., *supra* note 30.  
\(^{96}\) Chen et al., *supra* note 57.  
\(^{97}\) Almela et al., *supra* note 66.  
\(^{98}\) Id.  
\(^{99}\) Desideri et al., *supra* note 91.  
\(^{100}\) Banach et al., *supra* note 54.
seaweed species, such as *U. pinnatifida* and *Sargassum fusiforme*, are found to have the highest mercury accumulations.\(^{101}\) Mercury concentrations are usually around 0.001 to 0.050 mg/kg dry weight, with average of 0.011 mg/kg. These levels exceed the EU MRL for mercury of 0.01 mg/kg for pesticide residues on food products, including algae.\(^ {102}\) Geographical differences play an important role in the accumulation rate of mercury in seaweeds.\(^ {103}\)

\textbf{e. Minor and Rare Earth Elements}

Minor elements are elements generally found in trace amounts in seaweeds. Minor elements can either be essential (needed in the growth process) or non-essential (toxic metals). Rare earth elements on the other hand are metallic elements that are similar in nature, mostly occur together, and are difficult to separate from one another, including cerium, lanthanum, neodymium, yttrium, and scandium. These elements are classified as potential hazards when consumed.\(^ {104}\) The major factors affecting accumulation rate of these hazards include, but are not limited to, geographic area, season, species type, and taxonomic genus.\(^ {105}\)

\textit{ii. Iodine (I)}

Iodine is an essential mineral that is only supplied through diet and is needed in the human body to make thyroid hormones that help in growth, development, and regulation of normal metabolism.\(^ {106}\) Iodine is found in food and water and can be soluble (iodide) or less soluble (iodate). However, while iodine

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\(^{101}\) Id.

\(^{102}\) Hwang et al., supra note 64. The relevant EU regulation is Reg. (EU) 2018/73.

\(^{103}\) Chen et al., supra note 57.

\(^{104}\) Banach et al., supra note 54.

\(^{105}\) Chen et al., supra note 57; Ote Miedico et al., *Characterisation and Chemometric Evaluation of 21 Trace Elements in Three Edible Seaweed Species Imported from South-East Asia*, 64 J. FOOD COMPOSITION & ANALYSIS 188, (2017), [https://doi.org/10.1016/j.jfca.2017.09.004](https://doi.org/10.1016/j.jfca.2017.09.004).

\(^{106}\) EFSA Panel on Additives and Products or Substances used in Animal Feed, *Scientific Opinion on the Safety and Efficacy of Iodine Compounds (E2) as Feed Additives for all Species: Calcium Iodate Anhydrous and Potassium Iodine, Based on a Dossier Submitted by HELM AG*, 11 J. EUR. FOOD SAFETY AUTH. 3101 (2013), [https://doi.org/10.2903/j.efsa.2013.3101](https://doi.org/10.2903/j.efsa.2013.3101).
is important, exceeding the allowable intake can be very toxic, causing thyroid gland inflammation and thyroid cancer.

Seaweed is known to accumulate a considerable amount of iodine, though this varies among species.\textsuperscript{107} Consumption of high amounts of seaweed can pose a potential health risk, as it is considered an iodine-rich food.\textsuperscript{108} Iodine in seaweed is usually 100 times more than iodine levels seen in other terrestrial vegetables.\textsuperscript{109} The level of iodine concentration depends on factors such as production and processing.\textsuperscript{110} Also, seasonality can contribute to iodine accumulation in seaweeds. In one study, iodine concentrations in seaweed along the west coast of Italy showed a pattern with seasonality, with concentrations above average in winter and below average in summer.\textsuperscript{111} While further studies are needed, this temperature-related flux in concentrations could be due to reactive oxygen species that form in seaweed while under heat stress levels, which cause a reaction with the antioxidant properties of iodine, resulting in release into the water column.\textsuperscript{112}

Research shows that iodine concentrations in kelp/kombu can exceed 1,500 mg/kg, meaning an intake of just 0.5g/day of this seaweed would result in the consumption of 0.75mg of iodine. This amount exceeds the nutrient tolerable upper intake level (UL) 0.6 mg/day for adults for iodine established by the Scientific Committee on Food (SCF) and adopted by the EU. Such consumption could increase the risk of adverse effects.\textsuperscript{113} Kelp has the highest iodine

\begin{thebibliography}{99}
\bibitem{108} Id.
\bibitem{109} Ana R. Circuncisão et al., \textit{Minerals from Macroalgae Origin: Health Benefits and Risks for Consumers}, 16 \textit{MARINE DRUGS} (2018), \url{https://doi.org/10.3390/md16110400}.
\bibitem{111} Udo Nitschke et al., \textit{Variability in Iodine in Temperate Seaweeds and Iodine Accumulation Kinetics of Fucus Vesiculosus and Laminaria Digitata (Phaeophyceae, Ochrophyta)}, 54 J. \textit{PHYCOLOGY} 114 (2018), \url{https://doi.org/10.1111/jpy.12606}.
\bibitem{112} Frithjof C. Küpper et al., \textit{Iodine Accumulation Provides Kelp with an Inorganic Antioxidant Impacting Atmospheric Chemistry}, 105 \textit{PROC. NAT’L ACAD. OF SCI.} 6954 (2008), \url{https://doi.org/10.1073/pnas.0709959105}.
\bibitem{113} Banach et al., \textit{supra} note 54.
\end{thebibliography}
concentration and content in food and food supplements, which have been flagged as a risk for pregnant and breastfeeding women and individuals with thyroid disorders. Kelps or large brown seaweeds of the order Laminariales, such as *L. digitata*, *L. hyperborea*, *S. latissima*, and *A. esculenta*, contain a higher amount of iodine, and research done in Japan reported kelp consuming populations with higher iodine-induced hypothyroidism. Seaweed supplements, especially those from kelp, are not recommended for pregnant women due to amount of iodine found in them, which can cause impaired neurological development and endocrine disorders in children through placental transfer. Further, mercury may interfere with iodine metabolism. It was found that prenatal mercury exposure was inversely associated with thyroid hormone levels in women who took iodine supplements during pregnancy.

iii. *Polycyclic Aromatic Hydrocarbons (PAHs)*

Polycyclic Aromatic Hydrocarbons (PAHs) are a class of chemicals naturally found in coal, crude oil, and gasoline, and can also be produced when gas, oil, coal, forest, garbage, and other organic matter are burned, binding to form particles in the air and leading to environmental contamination. The following factors contribute to PAH accumulation in seaweed: species, biology,

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115 Banach et al., *supra* note 54.
116 N. Konno et al., *Association Between Dietary Iodine Intake and Prevalence of Subclinical Hypothyroidism in the Coastal Regions of Japan*, 78:2 J. CLINICAL ENDOCRINOLOGY & METABOLISM 393 (1994), [https://doi.org/10.1210/jcem.78.2.8106628](https://doi.org/10.1210/jcem.78.2.8106628).
119 NAT’L BIOMONITORING PROGRAM, CTR. FOR DISEASE CONTROL AND PREVENTION, *POLYCYCLIC AROMATIC HYDROCARBONS (PAHs) FACTSHEET* (2022), [https://www.cdc.gov/biomonitoring/PAHs_FactSheet.html](https://www.cdc.gov/biomonitoring/PAHs_FactSheet.html).
concentration level around the production site, and nature of the pollutant.\textsuperscript{120} Other accumulation factors include anthropogenic activities around the production site, oil spillage, and processing such as smoking and drying.\textsuperscript{121} The green seaweed \textit{Ulva compressa} accumulates more PAHs compared to red and brown species. One study found naphthalene (NAP) and benzo[a]pyrene as the major PAH pollutants across all species, with mean concentration levels of 68.57 and 56.14 parts per billion (ppb), respectively.\textsuperscript{122} However, the accumulation rate is not considered to be a major contamination risk, as most of the studies found PAHs levels in seaweed to be below the hazard quotient (HQ) and cancer risk index (CRI) metrics established by the U.S. Environmental Protection Agency, and therefore safe for human consumption.\textsuperscript{123}

iv. \textit{Micro- and Nanoplastics}

Micro- and nanoplastics are common materials known to invade terrestrial and marine environments, due to how common they are and how quickly they can travel. They are increasing steadily in most aquatic environments and are an emerging area of study in marine ecosystems. Micro- and nanoplastics can attach to algal surfaces through electrostatic binding to cellulose in the algal tissue.\textsuperscript{124} Seaweed can easily retain exposed microplastic on its surface.\textsuperscript{125} In the same

\textsuperscript{120} Gehan M.E. Zokm et al., \textit{Seaweed as Bioindicators of Organic Micropollutants Polycyclic Aromatic Hydrocarbons (PAHs) and Organochlorine Pesticides (OCPs)}, 29 ENV’T SCI. & POLLUTION RSCH. 34738 (2022), \url{https://doi.org/10.1007/s11356-022-18634-z}.
\textsuperscript{121} Banach et al., \textit{supra} note 54.
\textsuperscript{122} Zokm et al., \textit{supra} note 119.
\textsuperscript{124} Priyanka Bhattacharya et al., \textit{Physical Absorption of Charged Plastic Nanoparticles Affects Algal Photosynthesis}, 114 J. PHYSICAL CHEMISTRY 16556 (2010), \url{https://doi.org/10.1021/jp1054759}.
\textsuperscript{125} Lars Gutow et al., \textit{Experimental Evaluation of Seaweeds as a Vector for Microplastics into Marine Food Webs}, 50 ENV’T SCI. & TECHN. 915 (2016), \url{https://doi.org/10.1021/acs.est.5b02431}.
study, snails that naturally feed on this alga did not distinguish between clean algae and algae with microplastics. Plastics are often made with additives that are potentially toxic, and microplastics can accumulate toxic and carcinogenic substances, such as polychlorinated biphenyls (PCBs). Ulva is a genus of macroalgae that commonly blooms in temperate coastal waters and is found on both the east and west coasts of the United States. Ulva spp. collected at locations across the New Bedford Harbor Superfund Site was found to contain PCB levels equal to or exceeding FDA tolerance levels. Not only did this study find that these seaweeds could accumulate high levels of PCBs, but that the PCBs were passed through the food web to mummichogs, a keystone fish species in the area.

v. **Agrochemicals**

Agrochemicals are chemicals used in agriculture, such as herbicides, pesticides, and fertilizers. These can enter the seaweed food chain through different means, including, but not limited to, runoff from agricultural fields and treatments used to treat plants around the production sites. Seaweeds may also be intentionally used as a bioremediation to remove contaminants like pesticides in water. Contamination with pesticides and chemotherapeutic agents can also come directly from aquaculture activities. Benzoylphenylurea, carbamates, avermectins, and organophosphorus compounds are widely employed in aquaculture and associate to particulate matter and seaweeds owing to their hydrophobicity. The reported concentrations of this hazard fall mostly below MRLs of 0.01 mg/kg as defined by the consolidated version of EU Regulation

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127 Donald Cheney et al., *Bioaccumulation of PCBs by a Seaweed Bloom (Ulva Rigida) and Transfer to Higher Trophic Levels in an Estuarine Food Web*, 611 MARINE ECOLOGY PROGRESS SERIES 75 (2019), [https://doi.org/10.3354/meps12840](https://doi.org/10.3354/meps12840).

128 Banach et al., *supra* note 54.


(EC) No. 396/2005, although there is not enough data on the occurrences of this hazard.\textsuperscript{131}

IMTA can add to agrochemical load depending on the species co-farmed with seaweed. Aquaculture wastewater sometimes contains remnants of chemicals from feed additives, inorganic and organic fertilizers, hormones, flocculating agents, liming agents, antibiotics, medication, pesticides, disinfectants, and therapeutants that were used during the fish farming processes.\textsuperscript{132} Seaweed in IMTA may bioaccumulate these toxic compounds in the process of bioremediation, and the accumulation could become a potential hazard if the seaweed is consumed.

\textit{vi. Pharmaceuticals and Personal Care Products}

Human and animal pharmaceuticals and personal care products (PPCPs) from sewage discharge systems have been found in seaweed farms, especially those located around residential areas and where human activities mostly occur. The presence of PPCPs was commonly attributed to sewage effluent, aquaculture, waste disposal, horticulture, or animal husbandry.\textsuperscript{133} A study found several pharmaceuticals around seaweed producing sites, including antibiotics β-blockers and drugs for psychiatric treatments, and exposure causes accumulation of the substances.\textsuperscript{134} However, research conducted on the occurrence of PPCPs in the seaweed cultivating environment is limited, even though they are being flagged as emerging hazards.

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\textsuperscript{131} Banach et al., \textit{supra} note 54.
\textsuperscript{133} Banach et al., \textit{supra} note 54.
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vii.  **Marine Biotoxins**

Marine biotoxins are harmful toxins that are produced by harmful microalgae or through naturally occurring chemical reactions.\(^\text{135}\) Dinoflagellates, which can produce toxins that can accumulate in seaweed, were found in seaweed cultivation sites.\(^\text{136}\) Filamentous cyanobacteria, which is known to produce toxins that are poisonous to humans, were also discovered around seaweed cultivation sites.\(^\text{137}\) Some marine biotoxin agents were found to be associated with seaweeds, including palytoxin (PTX), domoic acid (DA) and analogs, ciguatoxins, and cyclic imines (CIs).\(^\text{138}\) However, the literature on this hazard is very limited.

viii.  **Persistent Organic Pollutants (POPs)**

Persistent Organic Pollutants (POPs) are pollutants that accumulate in the environment over a period of time. If seaweed is being cultivated in a contaminated site, it tends to suck up the accumulated hazard. The influencing factors are the cultivating environment and the seaweed species itself.\(^\text{139}\) Reports have noted *Ulva rigida* (a green seaweed species) to increasingly take up POPs from cultivation areas.\(^\text{140}\) However, there is a limited amount of research on this pollutant in macroalgae.

B.  **Microbial Hazards**

Microbial hazards are hazards from microorganisms present in air, food, water, soil, animals, and the human body, and can occur during cultivation,

\(^{135}\) Banach et al., *supra* note 54; *FOOD & AGRIC. ORG.*, *supra* note 83.
\(^{136}\) *FOOD & AGRIC. ORG.*, *supra* note 83.
\(^{138}\) Banach et al., *supra* note 54.
\(^{139}\) *Id.*
growth, harvest, transportation, processing, handling, and storage of seaweed. Exposure to these hazards causes foodborne illnesses and can be toxic. The list of microbial hazards is not as lengthy as chemical hazards. Possible microbial hazards in seaweed include pathogenic bacteria, norovirus, prions, and parasites such as trematodes. Microbial hazards can occur through the various supply chains, including harvest, production, processing, transportation, and packaging.

i. **Pathogenic Bacteria**

Major factors influencing pathogens in seaweed include the cultivation site, handling, storage, heat treatment, poor hygiene, and sanitation around the cultivation site and processing facilities, as well as the people handling the seaweed, and proximity to wildlife populations such as a refuge.

The risk of human exposure to pathogenic bacteria is higher when contaminated seaweed is consumed raw. However, drying was found to reduce bacterial load to some extent. Studies show that major foodborne disease pathogens, such as those from *Vibrio parahaemolyticus* and *Vibrio vulnificus*, are easily accumulated around coastlines, where seaweeds are usually farmed or harvested. While studies on these are limited, *Escherichia coli*, *Vibrio spp.*, and *Salmonella enterica* were found in several seaweed species. In the U.S., an assessment was performed on sugar kelp in Maine bays, which found low levels of *E. coli*, *V. parahaemolyticus*, and *V. alginolyticus* in samples at all study sites. The study also found *S. enterica* on sugar kelp from 83% of sampling events.

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141 [FOOD & AGRIC. ORG.](https://doi.org/10.1089/food.2013.1665) * supra note 81.
142 Banach et al., * supra* note 54; Banach et al., * supra* note 57.
143 Banach et al., * supra* note 54; Banach et al., * supra* note 57; [FOOD & AGRIC. ORG.](https://doi.org/10.1089/food.2013.1665) * supra* note 83.
144 FAO, * supra* note 83.
147 Banach et al., * supra* note 54.
during the study.\textsuperscript{148} \textit{V. vulnificus}, which poses a significant threat to human health along the U.S. Gulf coast, was found in seaweed samples along the coast of Japan.\textsuperscript{149} 

Processing contaminated seaweed through heating does not always eliminate the risk exposure and can even add more hazardous bacteria to already existing ones.\textsuperscript{150} \textit{Bacillus licheniformis} and \textit{Bacillus pumilus}, two toxin producing, spore-forming bacteria, were detected following a heat-treatment of seaweed.\textsuperscript{151} While bacterial levels reported in the above studies were relatively low, the presence alone indicates that care should be taken when developing management, processing, and storage practices for the harvest of seaweed along coastlines.

\textit{ii. Viruses}

Viruses, such as norovirus and hepatitis E virus, have been found in edible seaweed species, and exposure can occur during cultivation, harvest, or processing.\textsuperscript{152} Norovirus is among a gastroenteritis group of viruses that spread quickly, commonly known to inflame the stomach and intestine lining and cause severe diarrhea and vomiting in infected patients. Hepatitis E virus is commonly found in the stool of an infected person and can spread even in microscopic quantities. The main route of these viruses in seaweed is foodborne, mostly from pig and wild boar.\textsuperscript{153} The first recorded norovirus outbreak in South Korea was in two different schools where seasoned green seaweeds were eaten. Although multiple norovirus genotypes were detected in the students’ food samples, a

\begin{flushleft}
\textsuperscript{148} Olivia N. Barberi et al., \textit{Assessment of Bacterial Pathogens on Edible Macroalgae in Coastal Waters}, 32 J. APPLIED PHYCOLOGY 683 (2019), \url{https://doi.org/10.1007/s10811-019-01993-5}.

\textsuperscript{149} Zahid H. Mahmud et al., \textit{Occurrence, Seasonality and Genetic Diversity of Vibrio vulnificus in Coastal Seaweeds and Water Along the Kii Channel, Japan}, 64:2 FEMS MICROBIOLOGY ECOLOGY 209 (2008), \url{https://doi.org/10.1111/j.1574-6941.2008.00460.x}.

\textsuperscript{150} Banach et al., \textit{supra} note 54; Banach et al., \textit{supra} note 57.

\textsuperscript{151} Banach et al., \textit{supra} note 54.

\textsuperscript{152} Banach et al., \textit{supra} note 54; Banach et al., \textit{supra} note 57.

\textsuperscript{153} Banach et al., \textit{supra} note 54.
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significant amount of this virus was linked to the seaweed. However, very few reports have noted viruses, and therefore limited information is available about them in edible seaweeds.

C. Physical Hazards

Physical hazards are objects or materials that are introduced to seaweed unintentionally and when consumed, can pose considerable risk to human health. Physical hazards include small pebbles and pieces of shells, metal, plastic, and glass that are generally greater than 0.3 inches in size, although foreign objects smaller than this may cause trauma and injury in special risk groups like infants or the elderly. These material fragments can easily be found in harvested seaweeds. They can also be introduced during production, transportation, processing, storage, or packaging.

D. Allergenic Hazards

Allergenic hazards are a type of hazard found in foods, where some people have an allergic reaction to specific proteins which may be present in the food. An allergic reaction can cause mild symptoms or a major reaction. Major allergenicity influencing factors for edible seaweed include seaweed type and cultivation site. Although there is currently limited information about the allergenicity of proteins present in seaweed, at least one study has identified food allergens in green seaweed \textit{Ulva}. Other studies have found that there are protein structures in dried nori similar or identical to immunoreactive components related to immunoglobulin E-mediated allergies, which are also found in crustaceans. Therefore, people who react to crustacean species are likely to also be allergic to nori seaweed \textit{(Porphyra spp.)}. A study of seaweeds cultivated in

\begin{footnotes}
\footnote{J.H. Park et al., \textit{First Norovirus Outbreaks Associated with Consumption of Green Seaweed (Enteromorpha spp.) in South Korea}, 143 \textsc{Epidemiology \& Infection} 515 (2015), \url{https://doi.org/10.1017/S0950268814001332}.}
\footnote{FOOD \& AGRIC. ORG., \textit{supra} note 83.}
\footnote{Id.}
\footnote{Banach et al., \textit{supra} note 54.}
\footnote{Tomohiro Bito et al., \textit{Bioactive Compounds of Edible Purpler Laver Porphyra sp. (Nori)}, 65 J. AGRIC. \& FOOD CHEMISTRY 10685 (2017), \url{https://doi.org/10.1021/acs.jafc.7b04688}.}
\end{footnotes}
Long Island Sound, as well as other areas with the presence of fouling organisms including crustacean shellfish known to contain the protein tropomyosin, suggested the potential for ingestion-related allergic reactions.\textsuperscript{159} Immunoglobulin E-mediated patients were also found to react to some red seaweeds species, such as \textit{Porphyra}, \textit{C. crispus}, and \textit{P. palmate}.\textsuperscript{160}

\textbf{VI. Climatic Influence on Food Safety Hazards of Edible Seaweed}

Climatic changes that occur because of shifting temperatures and weather patterns, and changes in seawater chemistry, can significantly complicate and/or amplify already present hazards. Anthropogenic climate change, being the major driving force due to burning of fossil fuels, deforestation, landfills, the effects of overpopulation, and other human related activities, can lead to dramatic changes in localized, nearshore areas where the vast majority of seaweed aquaculture takes place. Seaweeds play an important ecological role in coastal habitats, yet they can still become vulnerable to both physical and chemical changes in the marine environment.\textsuperscript{161} Major threats from climatic changes include, but are not limited to, the development and escalation of harmful algal blooms (HABs) and marine heat waves, both strongly influenced by rising temperatures in production waters. HABs are colonies of toxic algae that grow quickly, resulting from warmer water temperatures, excess nutrients, and sunlight. HABs act as a water contaminant and can cause human health hazards. Such blooms can lead to shifts in the typical species composition of coastal ecosystems.\textsuperscript{162} Literature supports the idea that extreme weather events and warming due to climate change could be increasing


\textsuperscript{160} Jason Thomas et al., \textit{Seaweed Allergy}, 7 \textit{ALLERGY & CLINICAL IMMUNOLOGY} 714 (2019), https://doi.org/10.1016/j.jaip.2018.11.009.

\textsuperscript{161} Christopher D. G. Harley et al., \textit{Effects of Climate Change on Global Seaweed Communities}, 48 \textit{J. PHYCOLOGY} 1064 (2012), https://doi.org/10.1111/j.1529-8817.2012.01224.x.

blooms of Sargassum sp. in the Caribbean. A rise in temperature was also noted to aggravate the escalation of a HAB called red tide in Florida’s southwest coast.

In another study, a marine heatwave was found to impact resistance, bleaching, changes in abundance, species invasions, and local to regional extinctions. A rise in arsenic accumulation was higher in Fucus spiralis and Ascophyllum nodosum seaweed species in elevated sea surface temperatures. A preliminary report discovered an increase in water temperature can make fish and seaweed absorb more mercury. Another report found increased iodine accumulation in seaweed used for carbon sequestration, thereby increasing the hazard level.

VII. CONCLUSIONS

While seaweed is an important part of the global food system and can provide nutritional benefits, there are a number of food safety concerns. From a science and sampling perspective, information exists only for those contaminants that researchers actively test for. There are significant deficiencies in monitoring seaweed for potential food safety risks, and it would benefit governments to create a standardized sampling program, as well as to share data regarding food safety testing.

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166 FOOD & AGRIC. ORG., supra note 83.
167 Park et al., supra note 144.
Furthermore, in the United States, federal guidance is required to set limits for the food safety risks discussed within this paper. Given the large number of contaminants that exceed regulated safety limits in other countries, the U.S. should likewise set safety limits. Existing regulations vary substantially by country within Europe, with some MRLs codified by the EU. However, countries like France have also set their own recommended or legal maximums which may or may not be as stringent. China also has a number of guidelines in place for food safety considerations for seaweed consumption. It is important for the U.S. to follow suit and create safety limits for seaweed consumption given the emphasis on increasing seaweed cultivation during Blue Economy discussions, as well as through U.S. federal grants programs such as those run by the Department of Energy’s Advanced Research Projects Agency-Energy.

169 Beatrice Crona et al., *Four ways blue foods can help achieve food system ambitions across nations*, 616 Nature 104 (2023), https://www.nature.com/articles/s41586-023-05737-x.