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Concept Note on the Importance of Sargassum and the Sargasso Sea for Atlantic Sea Turtles

SARGASSO SEA COMMISSION

INTER-AMERICAN CONVENTION FOR THE PROTECTION AND CONSERVATION OF SEA TURTLES

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Cover Photo: Early juvenile hawksbill turtle (Eretmochelys imbricata) in pelagic Sargassum algae. Photo by Blair Witherington

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SARGASSO SEA COMMISSION

Inter-American Convention for the Protection and Conservation of Sea turtles

The Inter-American Convention for the Protection and Conservation of Sea turtles (IAC) and the Sargasso Sea Commission (SSC) drafted this concept note to highlight the common objectives of their members and to promote the importance of scientific and technical collaboration between the IAC and SSC.

February 2015

The Importance of Sargassum and the Sargasso Sea for Atlantic Sea Turtles

Summary

Globally, sea turtles are one of the most threatened groups of animals. The life histories of the various sea turtle species in the Atlantic Ocean span enormous distances and time as turtles hatch and develop into reproductively mature animals over many decades. Despite being an important stage in development, relatively little empirical research exists on the life histories of early juvenile sea turtles in the first several years of their lives in the Atlantic Ocean. Research indicates that during these "lost years" sea turtles remain in the open ocean and rely on drift habitats dominated by the brown algae *Sargassum*, which serve as refuge from predators and provide sources of food. One of the areas with the most substantial and persistent occurrences of *Sargassum* in the Atlantic Ocean is the Sargasso Sea. Five of the six species of sea turtles that occur in the Atlantic have been recorded there, and for at least three of these species, the loggerhead (*Caretta caretta*), green turtle (*Chelonia mydas*), and hawksbill (*Eretmochelys imbricata*), there is evidence that the Sargasso Sea is an important habitat, especially for early life stages. A fourth species, the leatherback turtle (*Dermochelys coriacea*), uses the Sargasso Sea as an important migratory pathway in its annual migrations between temperate and tropical waters. The shallow-water habitats around the island of Bermuda the only land mass in the Sargasso Sea provide habitat for immature green turtles and hawksbills that have transitioned from the oceanic to the neritic environment. These turtles eventually migrate to feeding grounds and nesting beaches in the Caribbean and Atlantic that are up to several thousand kilometers away. Conservation of the Sargasso Sea will benefit sea turtles as well as many other species but will require regional and international cooperation across the region, including areas beyond national jurisdictions. Further research and collaboration are necessary to build knowledge about how the Sargasso Sea supports sea turtle populations in the Atlantic.

The Sargasso Sea

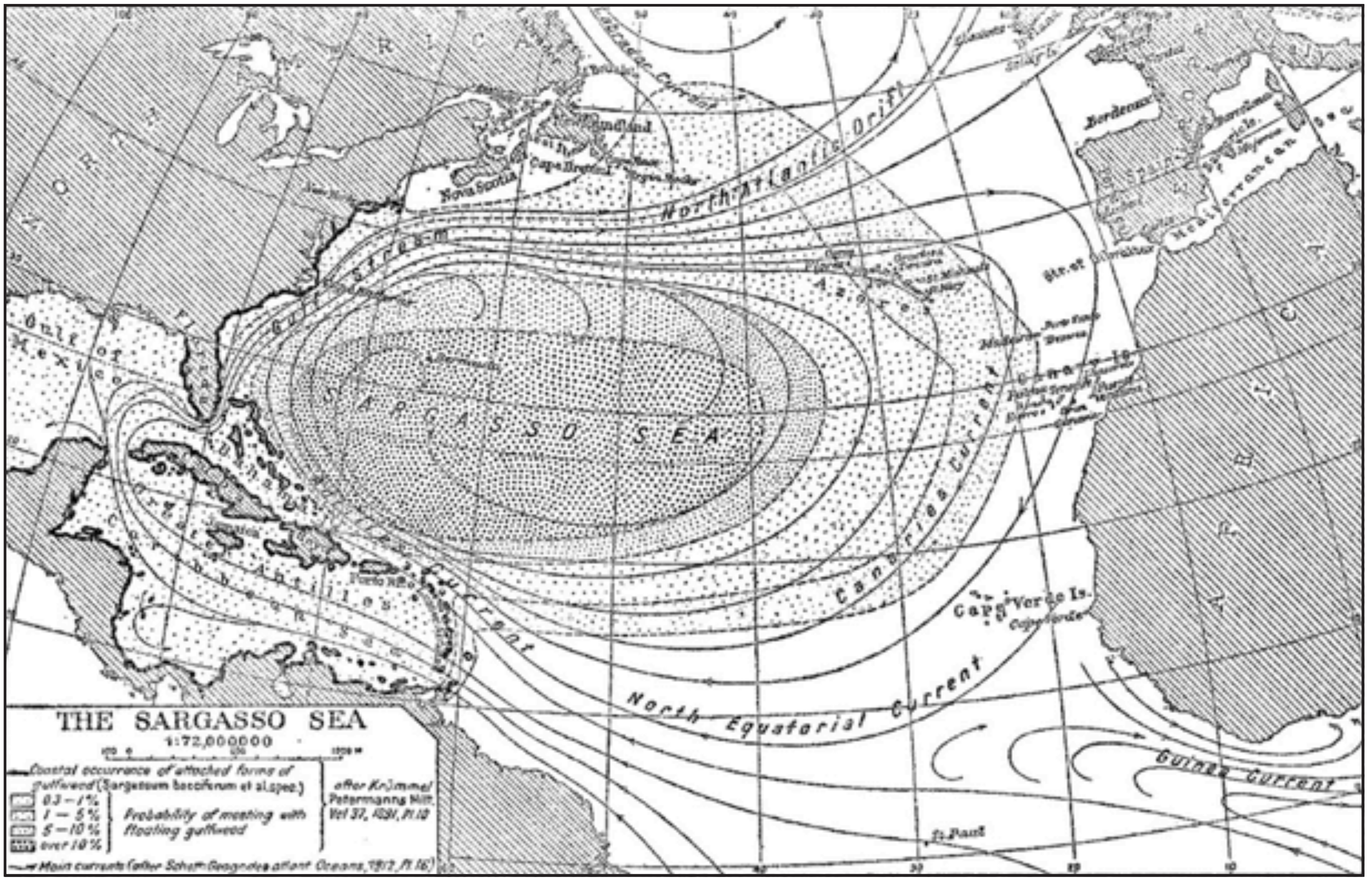

Figure 1: The prevailing currents that form the borders of the Sargasso Sea: the Gulf Stream and North Atlantic Drift to the west and north, the Canaries Current to the east, and the North Equatorial and Antilles currents to the south and southwest (Babcock 1922).

The Sargasso Sea is an area of open ocean situated within the North Atlantic Subtropical Gyre, bounded on all sides by clockwise flowing currents- the Gulf Stream and North Atlantic Drift to the west and north, the Canary Current to the east, and the North Atlantic Equatorial and Antilles Currents to the south and southwest (Laffoley et al. 2011) (Fig. 1). The sea is named after its most conspicuous components which are two species of floating brown algae (*Sargassum natans* and *S. fluitans*) that reproduce vegetatively in open water and form thick mats. These mats have been described as “the golden floating rainforest of the oceans” (Laffoley et al. 2011). *Sargassum* may originate in the Gulf of Mexico and Eastern Caribbean, drifting up the eastern seaboard of the USA in the Gulf Stream with significant amounts becoming trapped in the gyre by eddies spinning off the Gulf Stream into the Sargasso Sea (Laffoley et al. 2011). Large blooms of *Sargassum* have been identified in both regions by satellite remote sensing (Gower and King 2008; Gower et al. 2013). Satellites have recently also shown large quantities of Sargassum off the NE coast of S. America around the Amazon and Orinoco outfalls (see tp://optics.marine.usf.edu/cgi-bin/optics_data?roi=C_ATLANTIC&current=1)). Within the Sargasso Sea, drifting *Sargassum* may be sustained by productive Gulf or Caribbean waters and by direct nutrient inputs provided by species inhabiting the *Sargassum* communities (Lapointe et al. 2014). Although pelagic *Sargassum* occurs elsewhere in the Atlantic Ocean, the Sargasso Sea represents the largest unimpeded area for its persistence (Laffoley et al. 2011). The mats of *Sargassum* create a vital marine ecosystem for diverse communities of species by providing habitat and refuge from predators, spawning areas, food, and migration routes (Laffoley et al. 2011).

The world's open oceans are generally characterized by relatively low biodiversity, but because of the *Sargassum* weed, the Sargasso Sea provides a notable exception (Hemphill 2005, Luckhurst 2007, Laffoley et al. 2011). The floating *Sargassum* supports a diverse community of species, many of which are specifically adapted for life in the floating canopy. Ten species are endemic to floating *Sargassum* – the Sargassum crab (*Planes minutes*), Sargassum shrimp (*Latreutes fucorum*), Sargassum angler fish *Histrio histrio*, Sargassum pipefish (*Syngnathus pelagicus*), Sargassum anemone (*Anemonia sargassensis*), the Sargassum slug (*Scyllea pelagica*), the Sargassum snail (*Litiopa melanostoma*), the amphipods *Sunampithoe pelagica* and *Biancolina brassicacephala*, and the platyhelminthes *Hoploplana grubei* (Laffoley et al. 2011).

In addition to these endemic species, *Sargassum* supports many other invertebrate and fish species. At least 127 species of fish and 145 invertebrate species have been associated with the presence of *Sargassum* (Laffoley et al. 2011). Within the *Sargassum* mats, flying fish and a suite of economically and ecologically important fish spawn and live as juveniles, including swordfish (*Xiphius gladius*), juvenile and sub- adult jacks (*Carangidae*), juvenile and sub-adult mahi-mahi (Coryphaenidae), filefish and triggerfish (Balistidae), and driftfish (Stromateidae) (Dooley 1972, Sterrer 1992, Luckhurst 2007). This rich diversity of species forms the center of a food web that extends to a number of large predatory species such as the tiger shark (*Galeocerdo cuvier*)—an important predator of sea turtles that range throughout the world's oceans and migrate through the Sargasso Sea. (Vaudo et al. 2014). The Sargasso Sea is the only spawning ground of both the American eel (*Anguilla rostrata*) and European eel (*Anguilla anguilla*) (Schmidt 1923, Kleckner et al. 1983, Friedland et al. 2007) and porbeagle sharks (*Lamna nasus*) may give birth to their young there (Dulvy et al. 2008, Campana et al. 2010).

Atlantic Sea Turtle Biology and Ecology

Six species of sea turtles occur in the Atlantic Ocean: loggerhead (*Caretta caretta*), green turtle (*Chelonia mydas*), hawksbill (*Eretmochelys imbricata*), Kemp's ridley (*Lepidochelys kempii*), olive ridley (*L. olivacea*) and leatherback (*Dermochelys coriacea*). During their lives, sea turtles complete a series of developmental stages that may include several transitions between oceanic and neritic (< 200 meters) habitats before they reach maturity. Bolten (2003) outlines three life-history patterns for sea turtles, two of which are represented among Atlantic sea turtles. Loggerheads, green turtles, hawksbills and Kemp's ridleys progress through a life cycle that includes hatching, a frenzied swim to open water, an early juvenile stage, a neritic juvenile stage, followed by a neritic adult stage (Bolten 2003). There are deviations to this basic pattern depending on the species, e.g., adults may re-enter oceanic habitats during reproductive migrations or, in some cases, for overwintering or feeding (Reich et al. 2007, McClellan and Read 2007). The life-history pattern for olive ridleys is less well known but is thought to follow the above pattern for hard-shelled turtles in the Atlantic. Leatherbacks fit a second life-history model, in which they spend both their developmental and adult stages primarily in the open ocean. However, recent satellite telemetry data have broadened that view to also include the use of continental shelf and slope waters (James et al. 2005a). There are numerous accounts of the habitat and behavior of young turtles in the open ocean. Formerly known as the “lost year”, this stage has been hypothesized to represent a period of at least 2 but perhaps 10 or more years during which young turtles remain in the surface waters of the open ocean. It has been variously called the pelagic, oceanic, epipelagic or surface-pelagic life stage (see discussion of terminology in Witherington et al. 2012). To simplify the terminology for this paper, we have used the term “early juvenile” to represent both days-old post-hatchlings and slightly older/larger juveniles that forage almost exclusively at the surface or in the water column (equivalent to “surface-pelagic life stage” of Witherington 2012).

As soon as hatchlings reach the ocean and begin their frenzied swim to the open sea, there is evidence that all of the hard-shelled sea turtles in the Atlantic (loggerhead, green, hawksbill, and Kemp’s ridley) actively seek out floating objects in the ocean, including *Sargassum* (Carr 1986, Witherington 2002, Smith and Salmon 2009, Witherington et al. 2012). *Sargassum* has been well documented as refuge and foraging habitat for the early juveniles of these species (Carr and Meylan 1980, Carr 1987, Schwartz 1988, Manzella and Williams 1991, Shaver 1991, Witherington 2002, Witherington et al. 2012). Of 1884 early juvenile turtles of four species observed during vessel transects in the eastern Gulf of Mexico and Atlantic Ocean off Florida, 89% of them were within 1 meter of floating *Sargassum* (Witherington et al. 2012).

Sargassum may also enhance the thermal benefit of living at the surface in the open sea, as early juveniles are often observed to do. Mansfield et al. (2014) proposed that turtles might receive a thermal benefit from living in surface waters trapped within *Sargassum* mats and warmed by solar radiation. Seven of 17 satellite-tracked, captive-reared, early juvenile loggerheads released off the Atlantic Coast of Florida left the Gulf Stream and entered the Sargasso Sea (Mansfield et al. 2014).

In the oceanic habitat, young turtles are primarily omnivorous and opportunistic feeders that exploit prey aggregated within drift habitats. Their diet consists of animals and plants associated with *Sargassum* (Witherington et al. 2012) and their stomach contents also include detritus including plastics, wood, and insects. It has been hypothesized that the availability of prey and the cover provided by these pelagic drift habitats enhances survival during the early juvenile stage when predation is very high (Musick and Limpus 1997).

A major shift in the life history of loggerheads, green turtles, hawksbills, and Kemp's ridleys in the Atlantic is the habitat transition from the surface-pelagic to the neritic zone (<200 m depth) and the start of benthic feeding. During this stage, early juvenile turtles move to shallow areas and often establish resident populations of immature individuals (Meylan et al. 2011). This shift occurs at different times in the development of the various hard-shelled species. Meylan et al. (2011) describe a benthic developmental stage in the Atlantic and Caribbean immediately following the pelagic stage for each of these four species. As individuals transition to the neritic juvenile stage, they rely more directly on benthic resources and habitat for their subsequent development. Thus, this physical shift of habitat is associated with a shift in diet. Stable isotope analysis of scute samples from neritic juvenile green turtles show that they spend 3–5 years primarily as carnivores in pelagic habitats before making a rapid ontogenetic shift in diet and habitat to the neritic zone (Reich et al. 2007).

As developing turtles move to the neritic zone, the different species take up their more specialized diets (e.g., sea grasses and algae for green turtles, sponges for hawksbills, and mollusks and crustaceans for loggerheads (Meylan 1988, Hopkins-Murphy et al. 2003, Arthur et al. 2008). Evidence suggests that these initial benthic habitats may be geographically separate from subsequent developmental habitats and from adult foraging grounds, especially for green and hawksbill turtles. Loggerhead turtles also appear to transition to a benthic developmental stage, although the separation of juveniles from adults in these habitats is less pronounced, possibly as a consequence of their more relaxed life-history model (Casale et al. 2008). During this time, loggerheads are likely to switch from more immature-dominated to more adult-dominated foraging areas when feeding near shore (Meylan et al. 2011).

The Sargasso Sea and Atlantic Sea Turtles

Five of the six species of sea turtles that occur in the Atlantic Ocean have been recorded in the Sargasso Sea. These are the loggerhead, green turtle, hawksbill, Kemp's ridley and leatherback. The sixth species, the olive ridley (*Lepidochelys olivacea*), may be present in the Sargasso Sea on rare occasions but it has a more southerly distribution. The Sargasso Sea is important to sea turtles as habitat for early juveniles, which have dispersed from their nesting beaches and, depending on the species, live for a variable number of years in the open ocean. The Sargasso Sea lies along the dispersal routes for Atlantic turtles hatching on the coasts of North America, Africa, the Mediterranean, and the Caribbean (Musick and Limpus 1997, Putnam et al. 2013). Most of the evidence for the use of the Sargasso Sea by early juveniles comes from studies of green turtles, hawksbills, and loggerheads (Carr 1987, Musick and Limpus 1997, Meylan et al. 2011, Mansfield et al. 2014). Approximately 75% of the loggerheads that stranded in Bermuda (the only land mass associated with the Sargasso Sea) between 1983 and 2007 measured <42 cm straight carapace length (M. Outerbridge, personal communication). The Sargasso Sea also serves as habitat for other life stages of these species, including overwintering areas and migratory pathways. Juvenile and sub-adult green turtles and hawksbills use the shallow-water habitats of Bermuda as developmental habitat (Meylan et al. 2011)

The importance of the Sargasso Sea to leatherbacks remains poorly known although recent satellite tracking has clearly established that the area is used extensively during annual migrations between temperate and tropical latitudes (James et al. 2005a). This species is not known to associate with *Sargassum* to the same extent as the hard-shelled turtles. In addition to using the Sargasso Sea as a migratory pathway, leatherbacks may also be taking advantage of productive boundary currents and eddies for feeding (James et al. 2005b, Fossette et al. 2010). Leatherbacks are only rarely recorded as strandings in Bermuda, but at least one of sub-adult size (116.8 cm SCL) has been recorded. Jennifer Gray, personal communication). Kemp's ridley is not a common turtle in the Atlantic Ocean or in the Sargasso Sea. It occurs primarily in the Gulf of Mexico and along the Atlantic seaboard of the United States. The principal nesting site of this critically endangered species is in the state of Tamaulipas, Mexico (NMFS et al. 2011). Early juvenile Kemp's ridleys have been observed using *Sargassum* as habitat in the Gulf of Mexico, but this behavior has not been observed elsewhere in the western Atlantic (Manzella et al. 1991, Witherington et al. 2012). Only four Kemp's ridley records are known from Bermuda, including strandings documented by the Bermuda Aquarium's stranding network in 2006 and 2007 (50.4 cm and 14.8 cm straight carapace lengths) and two museum records from the 1940s (Mowbray and Caldwell 1958, Bacon et al. 2006, M. Outerbridge personal communication). The 14.8 cm animal constitutes a rare record of an early juvenile Kemp's ridley in the Sargasso Sea.

Role of Bermuda

As the only land mass within the Sargasso Sea, Bermuda offers a unique window on the role of the Sargasso Sea for sea turtles. Five species occur there, two of which, the green turtle and loggerhead, have been recorded as nesting (Bacon et al. 2006). Bermuda was once an important nesting site for green turtles; however, the population was greatly over-exploited and no nesting by this species has been recorded since the early 1900s. Only two loggerhead nests have been documented in Bermuda in recent decades.

Bermuda's extensive sea-grass beds and reefs serve as habitat for green turtles and hawksbills that have left the open ocean and moved into neritic habitats. A mark/recapture program carried out on the Bermuda Platform since 1968 has shown the importance of Bermuda waters as developmental habitat for these two species (Meylan et al. 2011). Young green turtles show high fidelity to specific grass beds and may remain in Bermuda for up to 20 years as they grow to large sub-adults. Genetic data indicate multiple nesting beach origins for both the green turtles and hawksbills that use Bermuda as developmental habitat. Figure 2 shows where young green turtles that have been tagged after capture in Bermuda waters have been subsequently recovered. The principal sites are feeding grounds in Cuba and Nicaragua, with smaller numbers throughout Central and South America and the Caribbean. To date, three green turtles captured as immature animals at sea in Bermuda have been recorded on nesting beaches - one in Quintana Roo, Mexico, and two at Tortuguero, Costa Rica (Meylan et al. 2014). These movements to feeding grounds and nesting beaches represent journeys of several thousand kilometers. Additional evidence of the connectivity of sea turtles in Bermuda (and the Sargasso Sea) with the wider Caribbean is likely to emerge as more tagged turtles reach reproductive age.

Figure 2. Geographic distribution of tag returns of immature green turtles (Chelonia mydas) originally captured in Bermuda waters in the Sargasso Sea (updated from Meylan et al. 2011). Stars indicate the locations where three Bermuda-tagged turtles were subsequently recorded nesting (Meylan et al. 2014). Gray arrows indicate direction of prevailing currents.

Green turtles and hawksbills smaller than those captured on the seagrass beds and reefs around Bermuda are occasionally recovered by the stranding network of the Bermuda Aquarium, Museum and Zoo and are presumed to be early juveniles living in the pelagic environment within the Sargasso Sea. Loggerheads and, more rarely, leatherbacks and Kemp's ridleys have also been documented by the stranding network.

Conservation

Conservation of the Sargasso Sea will add to the existing measures to promote the recovery of sea turtle populations. Throughout the world, sea turtles receive varying levels of protection against threats such as poaching, direct take, pollution, coastal development and fisheries by-catch. Sea turtles are protected internationally through a number of conventions including the Inter-American Convention for the Protection and Conservation of Sea Turtles (IAC), the Convention on International Trade in Endangered Species (CITES), the Convention on Migratory Species (CMS), and the Convention for the Protection and Development of the Marine Environment of the Wider Caribbean Region (Cartagena Protocol). The IUCN Red List of Threatened Species also classifies each of these species as threatened (IUCN Red List 2013.2). The United States recently designated extensive areas of *Sargassum* habitat off its Atlantic coast and in the Gulf of Mexico as Critical Habitat for the loggerhead turtle (NMFS 2014). It is also important to promote international cooperation with other northeastern Atlantic regional organizations including OSPAR, the Natura 2000 network, and other initiatives within the EU Marine Strategy Framework Directive.

Future Research and Collaboration

The broad scale of movements and the use of multiple habitats by sea turtles of various life stages throughout the Caribbean, Atlantic, and Sargasso Sea highlight the necessity for regional and international coordination for the conservation of these threatened species. It is clear that the majority of sea turtle development during the "lost years" occurs in areas beyond national jurisdiction, and especially within the Sargasso Sea. Managing sea turtle populations within an internationally cooperative framework, such as the Inter-American Convention for the Protection and Conservation of Sea Turtles and the Sargasso Sea Alliance-now the Sargasso Sea Commission, is essential to ensure the effective conservation of Atlantic sea turtle populations.

With appropriate funding, future research that could be undertaken to promote the conservation of sea turtles in the Sargasso Sea includes:

- Conduct dedicated vessel-based transects and captures in the Sargasso Sea to determine the density of sea turtles and expand knowledge of habitat use by the various life stages of the five species that occur there.

- Use platforms of opportunity, especially targeting sailing vessels that cross the Atlantic every spring and summer (a “citizen science programme”), to record and observe distributions, numbers and sizes of sea turtles.

- Use satellite remote sensing to map and quantify Sargassum in the Sargasso Sea to enable estimates of available habitat for juvenile turtles.

- Use satellite telemetry, flipper tags, genetic studies and oceanographic drift models to explore dispersal routes and migratory pathways of sea turtles in the Sargasso Sea.

- Expand the collection of data on sea turtles that strand in Bermuda.

- Record and quantify threats to sea turtles in the Sargasso Sea including debris, entanglement, accidental capture in fisheries, disease.

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