

Conservation on the High Seas – drift algae habitat as an open ocean cornerstone

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In the race to protect unique and vulnerable ecosystems beyond national jurisdiction, one of the most critical open ocean habitats is potentially being overlooked, despite its presence on the ocean's surface. Open ocean (i.e. pelagic) drift algae habitat is found in most of the temperate and sub-tropical regions of the world's ocean. Drifting on oceanic currents, this habitat provides essential nursery, resting, spawning and grazing habitat for a range of commercially important as well as unusual fishes, invertebrates, sea turtles and seabirds. Often accumulating along frontal boundaries, this habitat demarcates 'oases' of open ocean productivity and diversity. However, pelagic drift algae habitat is facing its share of anthropogenic impacts, including direct harvest for algin production, medicinal extracts and livestock fodder. In the USA, recent measures have been implemented to protect this important habitat, but conservation measures on the High Seas are still lacking. While traditional forms of protected areas might do well to protect drift algae epicentres like the Sargasso Sea, a new concept of marine protected area (MPA) is required to protect the transient nature of most pelagic drift algae concentrations and associated oceanographic processes. Drift algae may, in fact, provide a visual cue for enabling the demarcation of dynamic MPAs, thereby acting as an umbrella for the protection of a broader suite of pelagic habitats.

A CRITICAL MARINE HABITAT is being overlooked in the race to protect unique and vulnerable ecosystems of the planet's high seas. Drifting algae provide an important open ocean habitat for both unusual and commercially important fishes, invertebrates, sea turtles, and seabirds, serving as an irreplaceable nursery and grazing area for many species in stages of their lifecycles. In the global effort to advance a network of high seas marine protected areas (MPAs), attention to unique, vulnerable and largely unknown deepsea ecosystems such as seamounts, hydrothermal vents, deep coral reefs and 'black smokers' should not detract from much needed protection for the surface (or epipelagic) zone.

The open ocean water column is often thought to be nearly devoid of structural habitat complexity, an attribute believed to contribute to high levels of biodiversity within ecosystems such as rainforests and coral reefs. In reality, physical complexity exists in the pelagic water column, but is often manifest in oceanographic features such as oceanic fronts and eddies (spiraling offshoots of great ocean currents), and areas of sharp horizontal temperature, density or salinity gradients (thermo-, pycno- and haloclines). These oceanographic features, which may be persistent or temporary, not only act as boundaries between habitats but also as sources of upwelling, bringing nutrients (and therefore food) to distinct, and often predictable, areas of the ocean's surface waters.

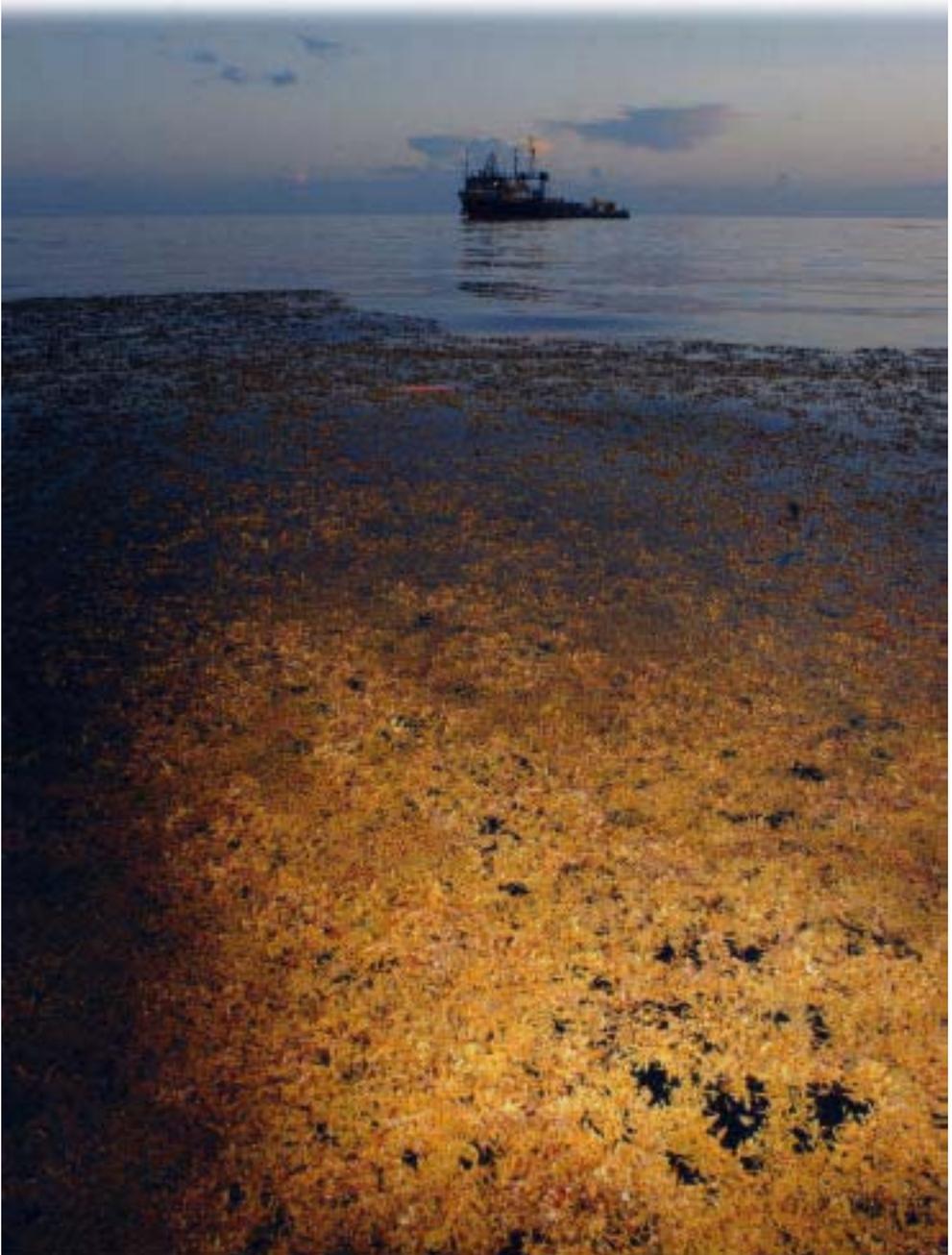
Within the epipelagos, habitat complexity can also be found in a more familiar form: as vegetation, in the form of drift algae. Unfortunately, this drift algae habitat is usually thought of as prime fishing grounds, an unlimited harvestable product, or a nuisance to be avoided and discarded. This article demonstrates not only the ecological value of these habitats, but how placing strict international protections on them may safeguard a greater suite of high seas oceanographic features. They may also provide obvious visual cues for dynamic and transient protected areas (see Norse, this issue).

The ecological importance of pelagic drift algae

Drift algae, like its tropical marine vegetation-dominated counterparts the mangroves and seagrass beds, is a critically important nursery habitat for juvenile fishes and sea turtles, a grazing area for larger predators, and a resting area for seabirds. Drift algae and associated flotsam, such

as seagrasses and vegetation of terrestrial origin, are found in most tropical and temperate regions of the ocean. In shallow water areas where attached marine algae provide the dominant habitat biomass (e.g. kelp beds), some of these algae inevitably become detached and take on a new life, providing structural habitat as they drift around in oceanic currents. Species of kelp (*Macrocystis* spp.), and other brown algae (*Hizikia*, *Myagropsis* and *Cystoseira*), normally attached

Sargassum – pelagic drift algae habitat – a unique and vulnerable ecosystem. Photo: Sylvia A. Earle.

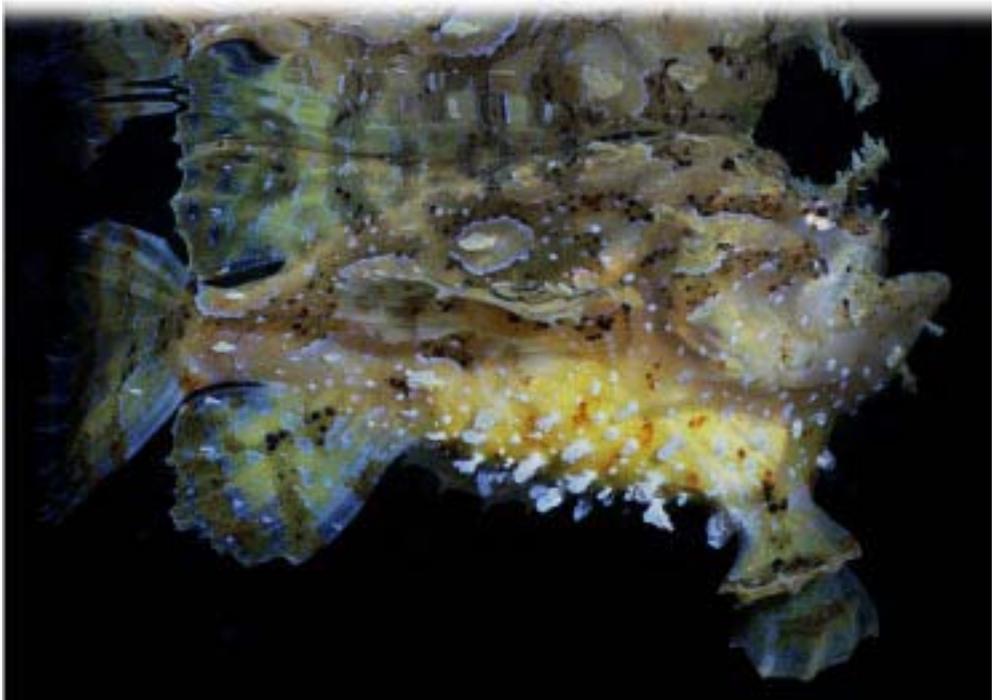


to the seabed, along with seagrasses and vegetative debris of terrestrial origin, are well documented as regularly undergoing this transformation into pelagic habitat (e.g. Hirosaki 1960, Kingsford and Choat 1985). However, one genus of brown algae – *Sargassum* – has taken this role to the next step. In the Atlantic, two species of *Sargassum*, *S. natans* and *S. fluitans*, have become holopelagic – drifting continuously within the North Atlantic gyre system, never attaching to the seafloor during their lifecycle (Parr 1939).

Depending upon the region of the ocean and daily oceanographic conditions such as prevailing winds, drift algae can appear as occasional clumps supporting sparse associated fauna, or as expansive mats several kilometres in length, supporting a complex of associated plants and animals. It also forms windrows (elongated lines of algae on the surface) that are associated with upwelling nutrients and serve as ‘oases’ of abundant life in the open ocean.

Globally, at least 280 species of fish are known to be associated, at some point in their lifecycle, with drift algae (Hemphill *et al.* 2003). Many of these, such as the Atlantic tripletail *Lobotes surinamensis*, and various species of filefish (especially *Stephanolepis* spp.) appear to be nearly completely dependent upon drifting algae for refuge as juveniles. Numerous species of young jacks (*Carangidae*) are especially abundant, indicating that drift algae carries a resident plankton population capable of sustaining these voracious predators (Coston-Clements *et al.* 1991). Even fishes generally associated with coral reefs, such as the sergeant major *Abudefduf saxatilis* and balloonfish *Diodon holocanthus*, can be found with great regularity as juveniles drifting within pelagic *Sargassum* of the Florida Current and Gulf Stream. Pelagic predators such as dolphinfish *Coryphaena hippurus*, a highly sought-after game fish, utilise mats of drift algae as primary hunting grounds and are thought to be entirely dependent upon the algae in portions of its range (Manooch *et al.* 1984). Some fishes, notably flyingfish (*Exocoetidae*), even use drift algae as a substrate for laying their eggs (Breder 1938). And at least two fishes, the sargassum frogfish

Many permanent residents of drift algae, such as this sargassum frogfish *Histrio histrio*, have developed unique colouration and appendages for camouflage within the algae. Photo: Wolcott Henry.



Histrio histrio and the sargassum pipefish *Syngnathus pelagicus*, are endemic to pelagic *Sargassum*.

However, drift algae is not the domain of fish alone. A host of attached plants, fungi, invertebrates and non-fish vertebrates depend on this habitat. At least 100 invertebrates can be found in the Atlantic *Sargassum* complex, living either permanently attached or free-swimming amidst the fronds of drifting algae (Coston-Clements *et al.* 1991). Conspicuous invertebrate inhabitants include swimming crabs, shrimps, nudibranchs, polychaetes and the sargassum snail *Litiopa melanostoma*. As with fishes, numerous crustaceans will utilise the habitat as a nursery, while a few, such as the sargassum swimming crab *Portunus sayi*, will remain permanent residents. Many of these permanent inhabitants have developed unique adaptations, such as unusual shapes and colourations enabling them to camouflage in the drifting plants.

Additionally, non-fish vertebrates, such as four species of turtle – loggerhead *Caretta caretta*, green *Chelonia mydas*, Kemp's ridley *Lepidochelys kempii* and hawksbill *Eretmochelys imbricata* – are known to utilise drift algae as hatchlings. It is here that they forage and seek refuge during their 'lost year' (Carr 1987). Seabirds also rely on drift algae habitat. In the South Atlantic Bight, 26 species of seabird have been observed to feed and roost on *Sargassum* 'reefs'. Three of these – white-tailed tropicbirds *Phaethon lepturus*, masked boobies *Sula dactylatra* and bridled terns *Sterna anaethetus* – are found there in significantly higher abundances than the surrounding open ocean habitat without algae (Haney 1986).

Although much is understood about drift algae habitats, much more remains unknown. This is particularly the case for egg and larval stages of fishes and invertebrates, the life history of hatchling sea turtles, estimates of drift algae biomass, population dynamics, and the effect of drift algae loss on fish and sea turtle populations (Coston-Clements *et al.* 1991). Nearly nothing is known on the impacts of removing either the drift algae itself or living marine resources from within the habitat.

Drift algae, physical oceanography and biodiversity

As previously mentioned, there are various physical oceanographic features that contribute to habitat complexity in the pelagic zone in ways that are different from terrestrial ecosystems. Some of these, such as fronts and eddies, are intricately linked to drift algae habitat. Fishermen and scientists alike know that drift algae can frequently aggregate into windrows in response to wind forcing (Langmuir 1938) or from shear currents along frontal boundaries (Stommel 1965).

Oceanic fronts are the meeting point between two dissimilar bodies of water, and are usually marked by steep gradients in sea surface temperature and chlorophyll. The hydrographic forces that cause the accumulation of drift algae along these fronts also cause the aggregation of many species. These frontal zones, along with warm- and cold-core eddies are especially important for pelagic diversity as they concentrate food supply, enhance local production and increase habitat heterogeneity (Oschlies and Garçon 1998). In short, they are "islands" of high biological productivity with immense concentrations of fish and invertebrate larvae. With such plentiful supplies of food available, they are sought out as 'stepping stones' in the basin-scale migrations of large pelagic tunas, turtles and whales (Etnoyer *et al.* 2004), making them areas of special concern to management and conservation.

Although the quantity of pelagic drift algae varies considerably among different regions of the ocean, when present it provides not only a habitat, but also a strong visual cue to the presence of a frontal system. This would suggest that by protecting the easily visible drift algae, one might also simultaneously protect highly productive convergence front habitat. Although fronts can be located quite easily using satellite technology, this technology is not available on all vessels, and where available, can be rendered ineffective by cloud cover. Drift algae, easily spotted from vessels even in poor weather conditions, could thus potentially serve as an umbrella for protecting a broader suite of pelagic habitats.

Progress in conservation of pelagic drift algae

Drift algae habitat is under increasing anthropogenic pressure from four distinct activities:

1. commercial take of drift algae;
2. commercial and recreational fishing in direct association with algal mats;
3. pollution; and
4. vessel traffic through drift algae habitat.

In recent years, drift algae, particularly *Sargassum*, has been subject to direct human take. *Sargassum* is rich in a number of elements, including calcium, potassium, sodium and iodine (Laihao *et al.* 2001). It is used in many parts of the world as food, livestock fodder, fertiliser, medicine, tea, and is extracted commercially for the production of algin and sodium alginate (Wang and Chiang 1994, Kaladharan and Kaliaperumal 1999). In addition to current take, the UN Food and Agriculture Organisation (FAO) (Naylor 1976) has highlighted the potential for development of 'standing stocks' of *Sargassum*, *Cystoseira* and *Macrocystis* in the waters of the Sargasso Sea, southern Italy, Yugoslavia, the Patagonian Sea, the North American Pacific Northwest, California, the Humboldt Region (Chile/Peru), and the entirety of the Indian Ocean coastal areas, particularly Tanzania, Oman, India, Sri Lanka, Australia and the islands of Kerguelen.

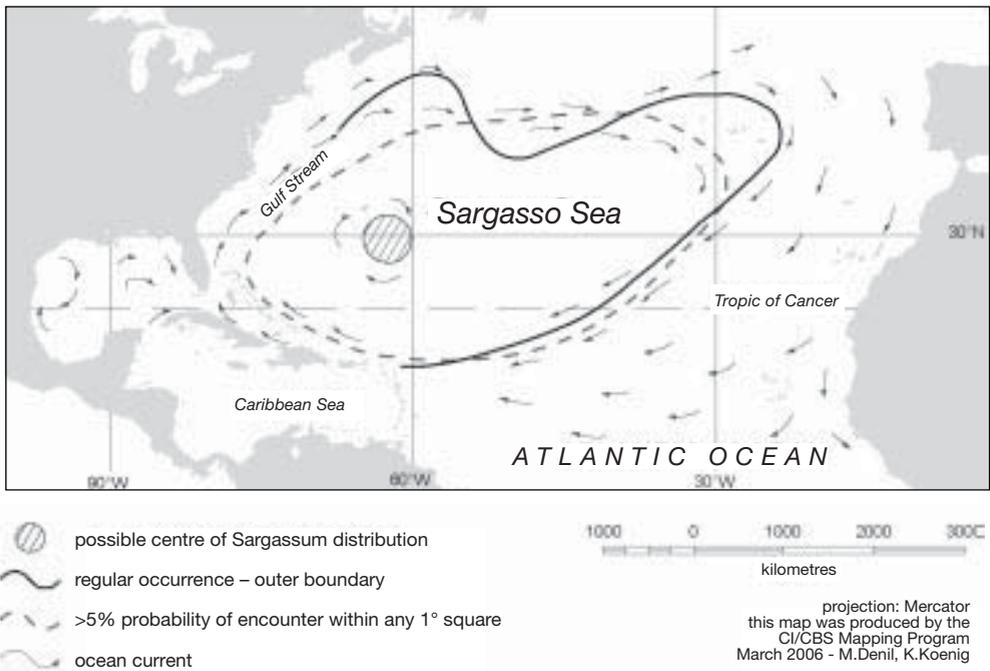
In terms of attached populations of marine macro-algae, conservation legislation has been adopted in a number of countries including Japan, Denmark, California (US), France and Chile, as a result of harvesting pressure. In terms of drift algae, most existing measures for its conservation have originated from the south-eastern United States, since, although encountered within national jurisdiction in many regions of the world, it seldom reaches the great biomass encountered here. The National Coalition for Marine Conservation (NCMC 2005), a US-based advocacy group, claims that many in the fishing community feel that the abundance of large game fish such as marlin, sailfish and tuna is directly associated with the abundance of *Sargassum* habitat and are prepared to take measures to protect it. In fact, *Marlin* magazine (Ferrell 2001) has stated that the habitat 'might just represent the most important offshore environment on earth'.

In 2003, the US National Marine Fisheries Service issued a rule to implement a *Sargassum* Fisheries Management Plan (FMP) (Department of Commerce 2003). The plan establishes areas closed to harvest, sets quantity and time limits on harvest elsewhere, and requires an observer be present onboard any vessel taking *Sargassum* (SAFMC 2002). Other US regulations that consider the conservation of *Sargassum* habitat include the Fisheries Management Plans for Billfish and other Highly Migratory Species, which identify offshore concentrations of *Sargassum* as 'essential fish habitat' – protected under the Magnuson-Stevens Fishery Conservation and Management Act (US Public Law 104–208) (NCMC 2005a).

In 2005, international concern for drift algae was expressed via a resolution of the International Commission for the Conservation of Atlantic Tunas (ICCAT). The resolution calls for the protection of pelagic *Sargassum*, recognising the importance of this open ocean habitat as critical nursery and feeding grounds for marlin, swordfish and tuna. It also charges ICCAT's scientific committee with assessing the ecological value of *Sargassum* to tunas and other highly migratory species. Member countries are asked to report to the Commission on any activities that may impact pelagic *Sargassum* within the convention area, with particular emphasis on the Sargasso Sea, the centre of distribution and abundance for Atlantic *Sargassum* that circulates between 20° and 40° N latitude and between 30° W longitude and the western edge of the Florida Current/Gulf Stream.

Steps are being taken within ICCAT toward the conservation of the Sargasso Sea. However, ICCAT, as a fisheries management organisation, has jurisdiction over pelagic *Sargassum* as a habitat only with relation to impacts caused by commercial fishing activities. Threats posed by commercial take of the algae, recreational fishing, pollution or vessel traffic must still be addressed.

The Sargasso Sea. Source: Adapted from Dooley, 1972.



The way forward? A potential framework for conservation

Since Regional Fisheries Management Organisations (RFMOs) are not the appropriate mechanism for protecting high seas marine habitats from a broader range of threats and human uses beyond fishing, there exists only a very limited set of international legal instruments that may govern the growing number of potential impacts on drift algae habitat. First and foremost is the 1982 UN Convention on the Law of the Sea (UNCLOS), the basic international mechanism for governing all activities on the ocean. Provisions of UNCLOS most relevant to this issue are those in Part VII relating to co-operation in the conservation of marine living resources of the high seas (Articles 116–119) and the obligation in Part XII to protect and preserve the marine environment.

Another international legal instrument, the Convention on Biological Diversity (CBD), invokes general obligations for the conservation of biodiversity. Some particularly relevant aspects of the CBD are those found in Articles 3–5, i.e. the obligations of parties to conserve biodiversity with respect to activities under their control beyond limits of national jurisdiction.

As many commercially important fish species are associated with drift algae habitats, the UN Fish Stocks Agreement (FSA), and its provisions for international co-operation, biodiversity protection and ecosystem-based and precautionary approaches to the conservation and management of straddling and highly migratory fish stocks, is also applicable. Additionally, Article 5(f), which calls on States to minimise impacts on associated endangered species, is of particular relevance to the use of drift algae as a nursery habitat for hatchling sea turtles.

MPAs can offer a comprehensive and integrated approach to protecting drift algae and associated oceanic fronts and eddies. The concept of MPAs beyond national jurisdiction has been under discussion since the 1991 meeting 'Wild Ocean Reserves', hosted by the US National Oceanic and Atmospheric Administration (NOAA). The meeting explored this new approach to conserving unique ocean resources by refining the High Seas reserve concept, outlining economic and management issues, and identifying mechanisms and considering implications of

international law for establishing such reserves. Since then, there has been a series of good work analysing both the 'where' and the 'how', including the IUCN/WWF/WCPA strategy for a network of High Seas MPAs (Gjerde and Breide 2003).

Likewise, options for governing and establishing MPAs beyond national jurisdiction, have undergone considerable analysis and evolution. At the *Defying Ocean's End* Conference, held in Los Cabos, Mexico in 2003, the concept of a 'policy enclosure' of the high seas commons emerged as a highlight of the meeting's outcomes (Gorina-Ysern *et al.* 2004). Moving away from a single-sector or single-fishery approach, this 'World Ocean Public Trust' would provide a framework based on UNCLOS for biodiversity conservation beyond national jurisdiction. Under the World Ocean Public Trust, all ocean uses would be sustainable, the *ecosystem approach* and *precautionary approach* would be applied, and the conservation of biodiversity would be maintained as a priority on at least equal footing with other potential ocean uses (Gorina-Ysern 2004). At a recent meeting, under UN auspices, on conservation and sustainable use of marine biological diversity beyond areas of national jurisdiction, a variation on the World Ocean Public Trust concept was finally put forward for discussion by the Natural Resources Defense Council, WWF, Conservation International, Greenpeace, and the Marine Conservation Biology Institute. A new UNCLOS implementing agreement, under which high seas MPAs would be a component, was proposed.

At the *Ad Hoc Open-ended Informal Working Group to study issues relating to the conservation and sustainable use of marine biological diversity beyond areas of national jurisdiction* held in New York at UN headquarters on 13–17 February 2006, many States, led by the European Union, recognised that additional mechanisms may be required to address the long-term protection of high seas ecosystems and biodiversity. The European Union has also formally proposed a new Implementing Agreement to UNCLOS to promote the integrated management of human activities and the establishment of marine protected areas.

A tree trunk floating in the open ocean has assumed the role of drift algae, attracting a mixed school of chubs *Kyphosidae*, jacks *Carangidae*, and triggerfishes *Balistidae*. Photo: Sterling Zumbunn, Conservation International.



With such momentum, the establishment of a comprehensive network of high seas MPAs may indeed become a reality. However, can this same mechanism address habitats such as oceanic fronts, which are ephemeral in both space and time? The traditional protected area concept cannot be easily applied to this type of process without establishing them on a geographic scale that may defy practical implementation and political will. However, known patterns or regions of oceanic fronts and eddies could be protected as dynamic or transient protected areas.

To accomplish this, a process could be implemented to identify and establish large-scale multiple use management areas in oceanic regions of high convergence activity such as the persistent frontal zones of the North Pacific Transition Zone and the area of warm-core ring frequency of the South Atlantic Bight, and adjacent areas of the Gulf Stream. Under non-frontal oceanographic conditions it could be business as usual, with sustainable uses proceeding without interruption. However, the transient fronts and eddies of the management area would receive a higher grade of protection. Compliance and enforcement of such a regime could be simplified by automatically conveying drift algae and associated flotsam the highest degree of protection as this would often, although not always, protect the front by default.

The biggest problem with this approach is that sub-tropical and temperate frontal systems are not always blessed with abundances of drift algae. Drift algae abundance is variable both regionally and temporally, as heavy wind conditions might blow drift algae onward despite the presence of a strong oceanic front. The abundance of *Sargassum* in the Western North Atlantic far exceeds typical drift algae present in the eastern Pacific. However, despite low abundances, sparse windrows of *Macrocystis* and associated flotsam are generally present on strong fronts such as the ones that regularly occur near the Channel Islands (Wallace J. Nichols *pers. comm.*). The key to regulating this discrepancy could be in the spatial degree of protection, for example, regulating activities within a certain distance of drift algae.

The strict protection of drift algae and the regulation of activities within a certain distance of it could thus protect a significant number of fronts and eddies. However, this still would not cover them all. There would still be some need to protect and regulate fronts themselves, independent of and in unison with the presence of drift algae habitat. Fishermen already utilise commercial satellite-based sea surface temperature (SST) and chlorophyll maps to focus fishing efforts. Enforcing agencies can do the same. Nevertheless, heightened protection for drift algae habitat would protect the very cornerstone of the pelagic ecosystem, while offering a visual cue that could aid in regulation and enforcement of a broader protection scheme.

References

- Breder, C.M. Jr. 1938. A contribution to the life histories of Atlantic Ocean flyingfishes. *Bull. Bingham Oceanogr. Coll., Yale Univ.* 6(5):1-126.
- Carr, A. 1987. New perspectives on the pelagic stage of sea turtle development. *Conserv. Biol.* 1(2): 103-121.
- Coston-Clements, L., Settle, L.R., Hoss, D.E. and Cross, F.A. 1991. Utilization of the Sargassum habitat by marine invertebrates and vertebrates – a review. *NOAA Technical Memorandum NMFS-SEFSC-296*, 30p.
- Department of Commerce. 2003. Fisheries of the Caribbean, Gulf of Mexico, and South Atlantic; Pelagic Sargassum Habitat of the South Atlantic. 50 CFR Part 622.
- Federal Register* 68(192): 57372. <http://ribbs.usps.gov/files/fedreg/usps2003/03-24619.PDF> (accessed February 10, 2005).
- Dooley, J.K. 1972. Fishes associated with the pelagic sargassum complex, with a discussion of the sargassum community. *Contrib. Mar. Sci.* 16:1-32.
- Etnoyer, P., Canny, D., Mate, B. and Morgan, L. 2004. Persistent pelagic habitats in the Baja California to Bering Sea (B2B) ecoregion. *Oceanography* 17(1): 90-101.
- Ferrell, D.F. 2001. Sargassum: Weed of Life. *Marlin: The International Sportsfishing Magazine*. July 31, 2001. <http://www.marlinmag.com/article.jsp?ID=17095> (accessed 10 February 2006).
- Gjerde, K. and Breide, C. 2003. Towards a Strategy for High Seas Marine Protected Areas. Proceedings of the IUCN, WCPA and WWF Experts Workshop on High Seas Marine Protected Areas, 15-17 January 2003, Malaga, Spain. <http://www.iucn.org/themes/marine/pdf/GjerdeBreideHSMMPA.pdf>
- Gorina-Ysern, M. 2004. World ocean public trust: high seas fisheries after Grotius –towards a new ocean ethos? *Golden Gate University Law Review* 34(3): 645-714.
- Gorina-Ysern, M., Gjerde, K. and Orbach, M. 2004. Ocean Governance: A New Ethos through a World Ocean Public Trust. In: L.K. Glover and S.A. Earle, (eds.). *Defying Ocean's End: An Agenda for Action*. Island Press, Washington, D.C. Pp. 197-212.

- Haney, J.C. 1986. *Pelagic seabird ecology and its relationship to environmental heterogeneity in the South Atlantic Bight*. Ph.D. Dissertation, Univ. of Georgia, Athens, Georgia.
- Hemphill, A.H., Arena, P.T. and Spieler, R.E. 2003. Seasonal dynamics of ichthyofauna closely associated with pelagic *Sargassum* in Broward County, Florida, USA: preliminary results. In: L. Creswell (ed). *Abstract Volume: 56th Annual Meeting of the Gulf and Caribbean Fisheries Institute*. Tortola, BVI., P. 48 (Poster Presentation).
- Hirosaki, Y. 1960. Some ecological observations on fishes in Sagami Bay appearing together with drifting seaweeds. *J. Fac. Sci. Hakkaido Univ. Ser. VI, Zool.* 14: 435-443.
- ICCAT. 2005. *Resolution by ICCAT on Pelagic Sargassum*. International Commission for the Conservation of Atlantic Tunas. <http://www.iccat.es/Documents/Recs/compendiopdf-e/2005-11-e.pdf> (accessed 10 February 2005).
- Kaladharan, P. and Kaliaperumal N. 1999. Seaweed industry in India. *Naga, The ICLARM Quarterly* 22(1): 11-14.
- Kingsford, M.J. and Choat, J.H. 1985. The fauna associated with drift algae captured with a plankton-mesh purse seine net. *Limnol. Oceanogr.* 30(3): 618-630.
- Laihao, L., Liudong, L., Xianqing, Y., Peiji, C., Yanyan, W. and Shi qiang D. 2001. Nutritive composition of *Sargassum* and trial-producing of tea in paperbag from it. *J. Zhanjiang Ocean University* 21(1): 3-42.
- Langmuir, I. 1938. Surface motion of water induced by wind. *Science* 87: 119-123.
- Manooch, C.S., III, Mason, D.L. and Nelson, R.S. 1984. Food and gastrointestinal parasites of dolphin *Coryphaena hippurus* collected along the southeastern and Gulf coasts of the United States. *Bull. Jpn. Soc. Sci. Fish.* 50: 1511-1525.
- Naylor, J. 1976. Production, trade and utilization of seaweeds and seaweed products. *FAO Fisheries Technical Papers - T159*. 73pp. http://www.fao.org/documents/show_cdr.asp?url_file=/docrep/005/AC860E/AC860E11.htm (accessed 10 February 2005).
- NCMC. 2005. *NCMC Seeks International Protection for Sargassum Habitat*. National Coalition for Marine Conservation. May 17, 2005. <http://www.fryingpantower.com/modules.php?name=News&file=article&sid=1822> (accessed on 5 February 2006).
- Oschlies, A. and Garçon, V. 1998. Eddy-induced enhancement of primary production in a model of the North Atlantic Ocean. *Nature* 394(6690): 266-269.
- Parr, A.E. 1939. Quantitative observations on the pelagic *Sargassum* vegetation of the Western North Atlantic. *Bull. Bing. Ocy. Coll.* VI(7): 1-94.
- SAFMC. 2002. Second Revised Final. *Fishery Management Plan for Pelagic Sargassum Habitat of the South Atlantic Region, Including a Final Environmental Impact Statement, Initial Regulatory Flexibility Analysis, Regulatory Impact Review and Social Impact Assessment/Fishery Impact Statement*. South Atlantic Fishery Management Council, 1 Southpark Cir., Ste 306, Charleston, S.C. 29407-4699.
- Stommel, H. 1965. *The Gulf Stream*. Univ. Calif. Press, Berkeley, 248p.
- Wang, W.L. and Chiang, Y.M. 1994. Potential economic seaweeds of Hengchun Peninsula, Taiwan. *Econ. Bot.* 48(2): 182-189.

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