Understanding the Plastics Problem to Inform Solutions

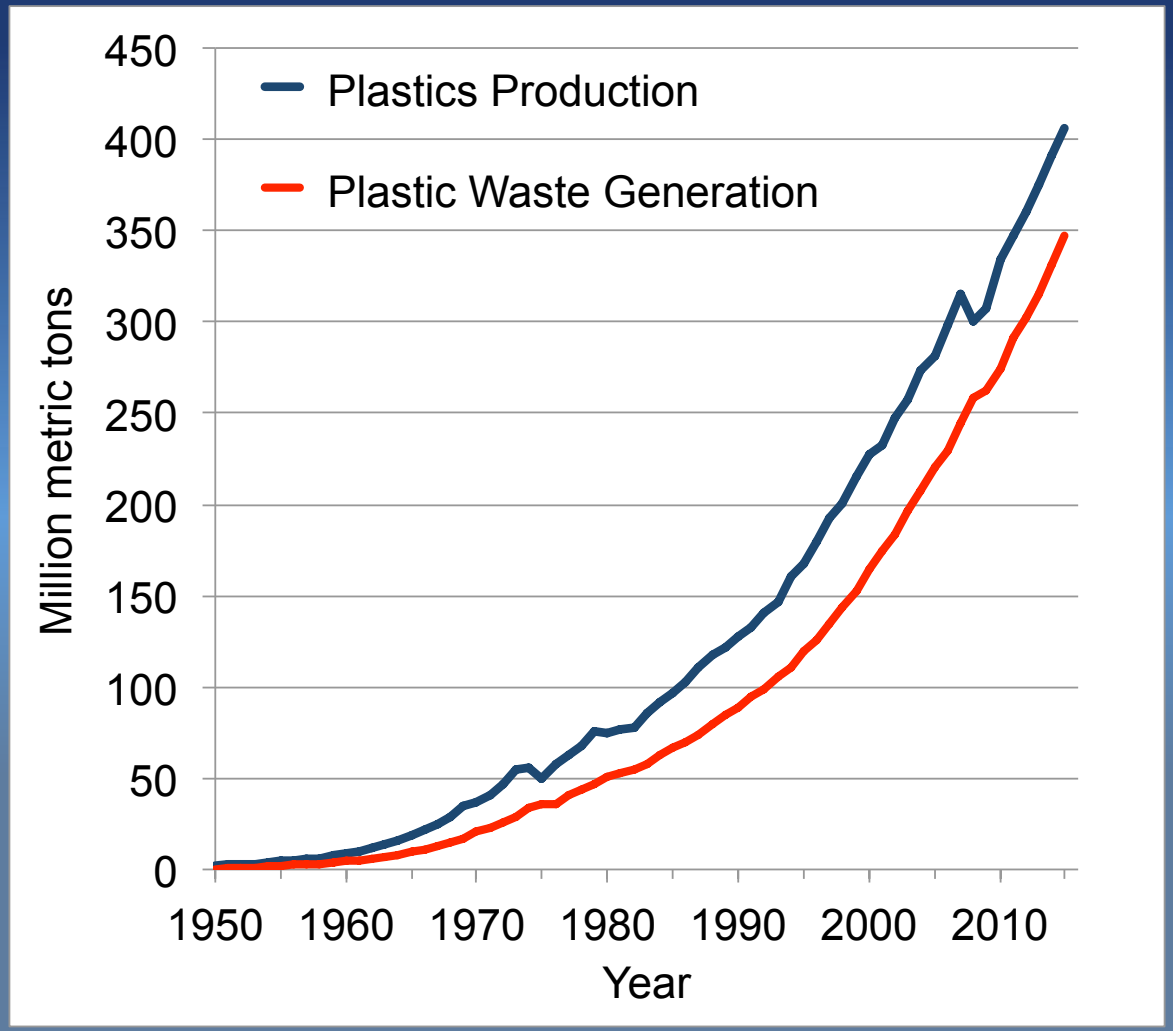
Kara Lavender Law, PhD

Sea Education Association
Woods Hole, MA, USA

S·E·A
www.sea.edu

Chesapeake Bay Commission
17 November 2022

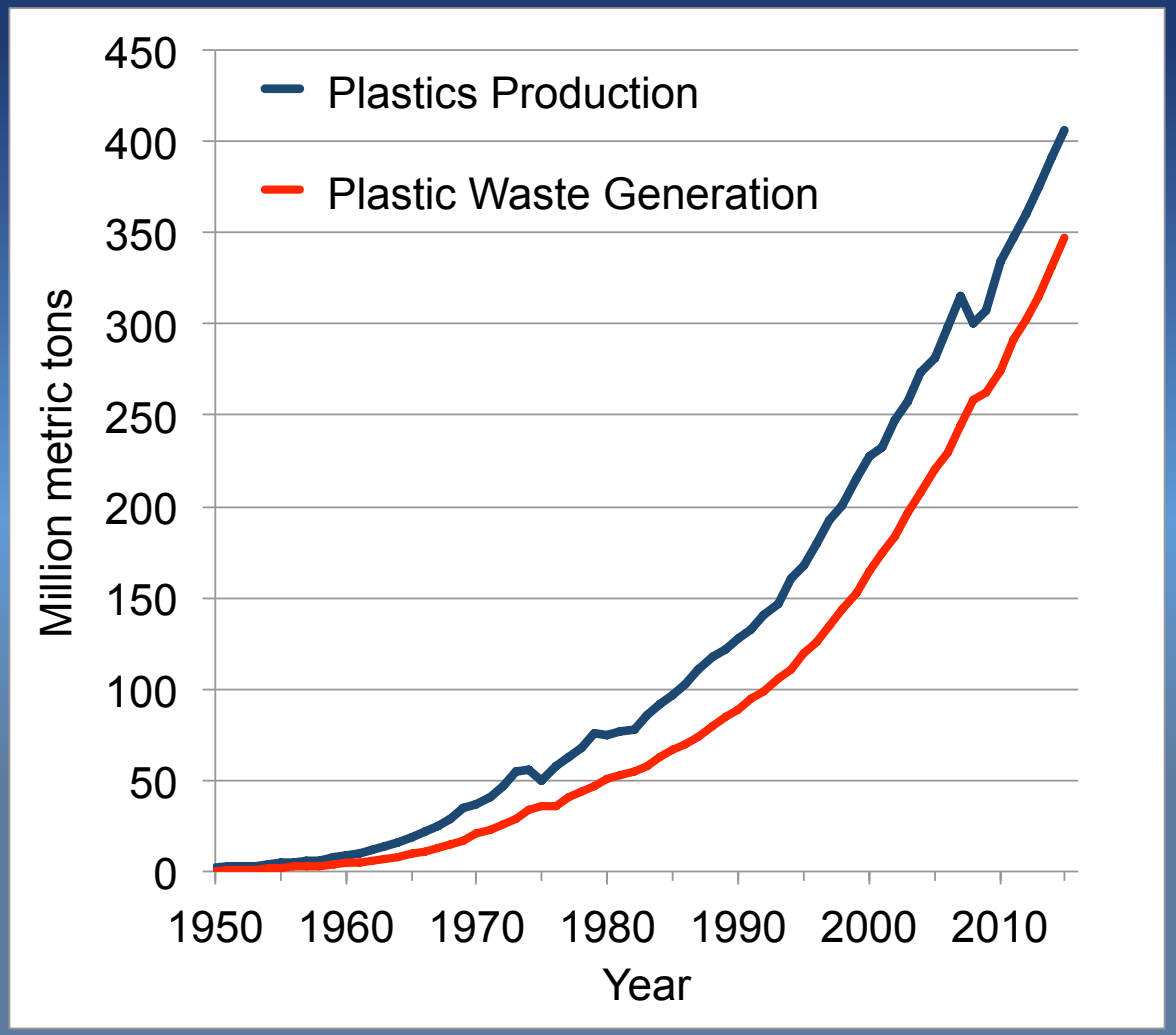
The rapid rise of plastics




Credit: Mr Mrs Marcha

Geyer *et al.*, *Sci. Adv.* 2017
Production, use and fate of all plastics ever made

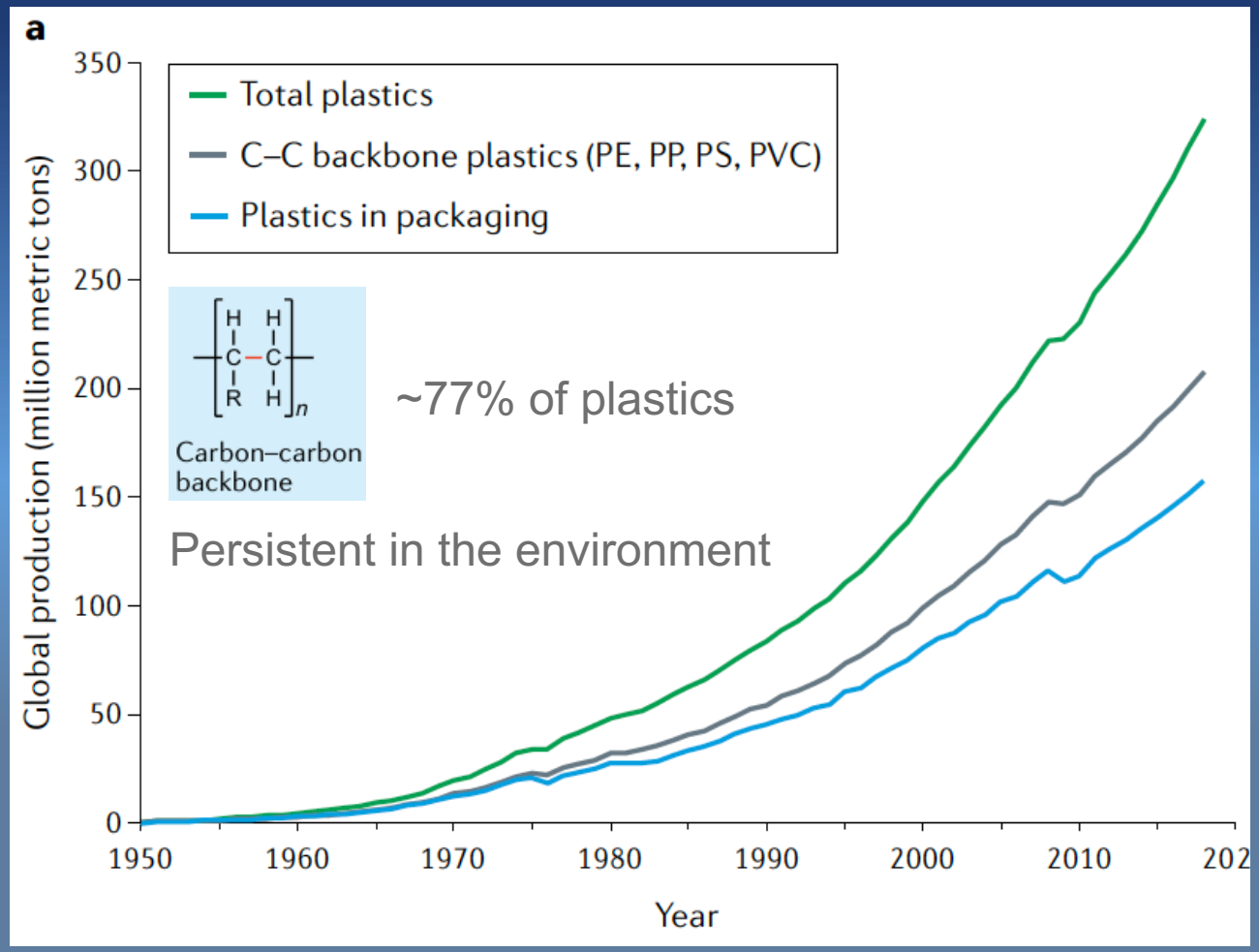
The rapid rise of plastics



- 8.3 B metric tons produced
- 70% have become waste
- 90% are still in existence

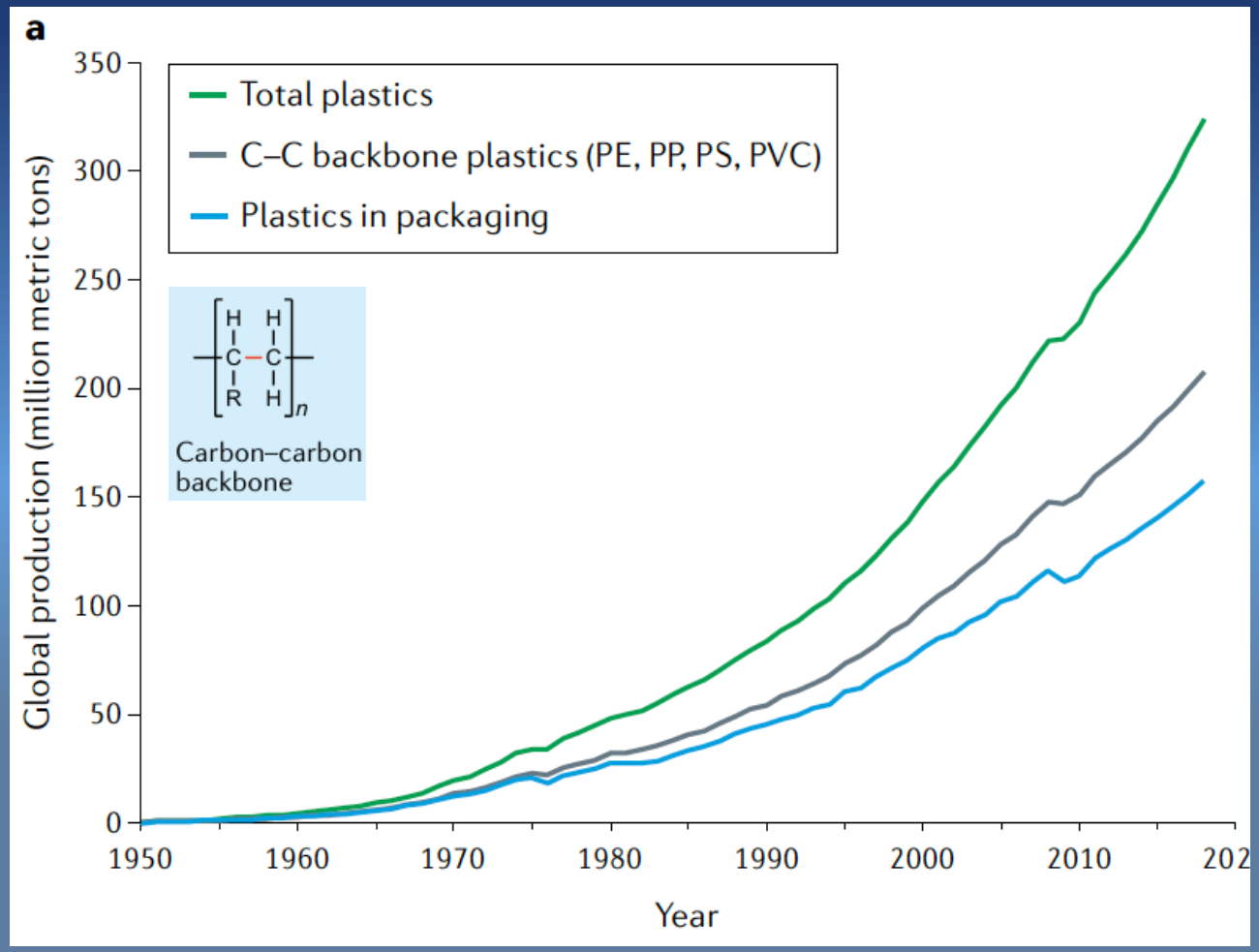
Geyer *et al.*, *Sci. Adv.* 2017
Production, use and fate of all plastics ever made

The plastics we use most



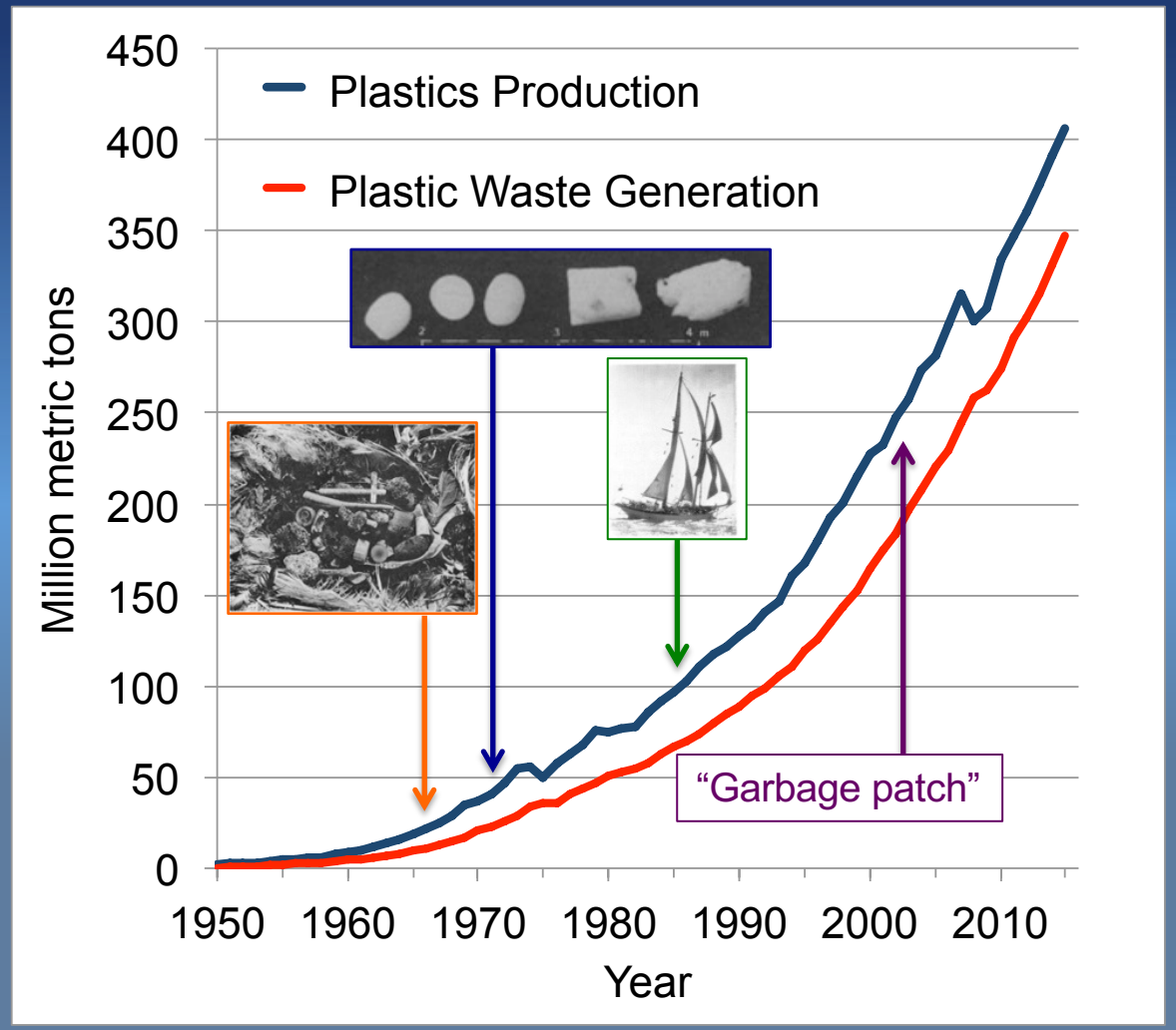
Law & Narayan, *Nat. Rev. Mats.* 2022.
Reducing environmental plastic pollution by designing polymer materials for managed end-of-life.

Packaging and single-use plastics



Law & Narayan, *Nat. Rev. Mats.* 2022.
Reducing environmental plastic pollution by designing polymer materials for managed end-of-life.

Detecting plastics in the ocean



Laysan Albatrosses swallow indigestible matter.—That marine birds swallow indigestible materials is well documented. Simpson (1965) discusses the ingestion of pumice by the Brown Skua (*Catharacta skua lonnbergi*) and Bierman and Voous (1950) present information on stomach stones found in Antarctic petrels. Additional records of pumice in birds' stomachs are reported by Sutherland (1964) for the Slender-billed Shearwater (*Puffinus tenuirostris*) and by Gill (1967) for the Antarctic Prion (*Pachyptila desolata*). George Watson (pers. comm.) found pumice in the stomachs of petrels (*Oceanites*), the Cape Pigeon (*Daption capensis*), and the White-chinned Petrel (*Procellaria aequinoctialis*). Fisher (1903: 788) states that candle nuts (*Aleurites moluccana*) found on Laysan Island "were almost undoubtedly ejected by albatrosses." No quantitative report on the variety of indigestible materials ingested by the Laysan Albatross (*Diomedea immutabilis*) has been recorded previously.

An inspection of the Hawaiian Islands National Wildlife Refuge from 8 to 28 September 1966 gave us an opportunity to examine the hard materials in the remains of young Laysan Albatrosses that had died in the June–July 1966 fledging period. On 24 September we collected specimens from 100 carcasses on Southeast Island, Pearl and Hermes Reef (27° 46′ 45″ N, 175° 48′ 45″ W). On a circuit of Southeast Island, the maximum dimensions of which are approximately 900 by 300 meters, we counted a total of 386 dead albatrosses above the high-water mark. Most of the birds were on the beach or in the vegetation (primarily *Tribulus* and *Portulaca*) near it. A few were scattered farther inland. Remains of some at the tideline that had been broken into fragments by wave action were not enumerated, but after examining all beaches and inland areas we estimated at least 450 to 500 Laysan

Plastics on the Sargasso Sea Surface

Abstract. *Plastic particles, in concentrations averaging 3500 pieces and 290 grams per square kilometer, are widespread in the western Sargasso Sea. Pieces are brittle, apparently due to the weathering of the plasticizers, and many are in a pellet shape about 0.25 to 0.5 centimeters in diameter. The particles are surfaces for the attachment of diatoms and hydroids. Increasing production of plastics, combined with present waste-disposal practices, will undoubtedly lead to increases in the concentration of these particles. Plastics could be a source of some of the polychlorinated biphenyls recently observed in oceanic organisms.*

While sampling the pelagic *Sargassum* community in the western Sargasso Sea, we encountered plastic particles in our neuston (surface) nets. The occurrence of these particles on the sea surface has not yet been noted in the literature [we also collected petroleum lumps, which have received attention (*1*, *2*)].

SCIENCE, VOL. 175

Kenyon and Kridler (1969)

Carpenter *et al*. (1972)

Wilber (1987)

Moore (2003)

Plastic in the North Atlantic

"I just want to say one word to you—just one word."
"Yes sir."
"Are you listening?"
"Yes sir, I am."
"Plastics."
"Exactly how do you mean?"
"There's a great future in plastics. . ."

Mr. McGuire to Ben
The Graduate, 1969

by R. Jude Wilber

R/V Westward

Neuston Net

The problem of plastic debris in the marine environment is cause for increasing concern today among scientists. Over the last 10 years, the North Atlantic and other oceans have been polluted with plastic debris through careless handling, accidental loss, and indifferent dumping. Although many of the biological effects of plastic in the ocean are unassessed, the negative effects of this debris on seals, birds, and sea turtles are well documented. Strangulation is often the result of seals and birds trapped in plastic netting. But, marine animals also ingest small plastic pellets. The damage done to certain marine communities from this kind of debris is unknown, although the proof of this awaits further study.

Actually, there may be some positive aspects to the presence of floating plastic in the open ocean.

Epifauna, such as *Membranipora* (a bryozoan)—a small group of colonial encrusting animals) and Lepas (a barnacle), may use plastic as an "alternative substrate." These animals are commonly found on organic flotsam, such as wood and Sargassum. The use of plastic as a substrate by such organisms is at present relatively rare, but relatively rare phenomenon in the open ocean.

It is virtually impossible to tow a neuston* net through the surface waters of the Sargasso Sea and not catch plastic debris of some sort.

One of the most common items so sampled are small (1 to 5 millimeters) polyethelene pellets known as "nibs" to the plastics industry. Typical beaches in places such as Bermuda, the Bahamas, and Florida are literally covered with billions upon billions of such pellets mixed with other plastic debris and natural organic flotsam in the upper wrack lines.**

This picture of the current status of plastic in the Atlantic has emerged during the last three years as part from studies conducted by the scientists and students of the Sea Education Association, Woods Hole, Massachusetts, aboard the research vessel *Westward*. In 1984, we began a survey of plastic pollution along Westward's routes of operation in the open ocean and along the shorelines of islands

* *Neuston refers to both the uppermost surface layer of a body of water as well as that group of organisms that occupy this environment. Neuston nets are designed to sample the air/water interface and drawn to 25 centimeters below it.*

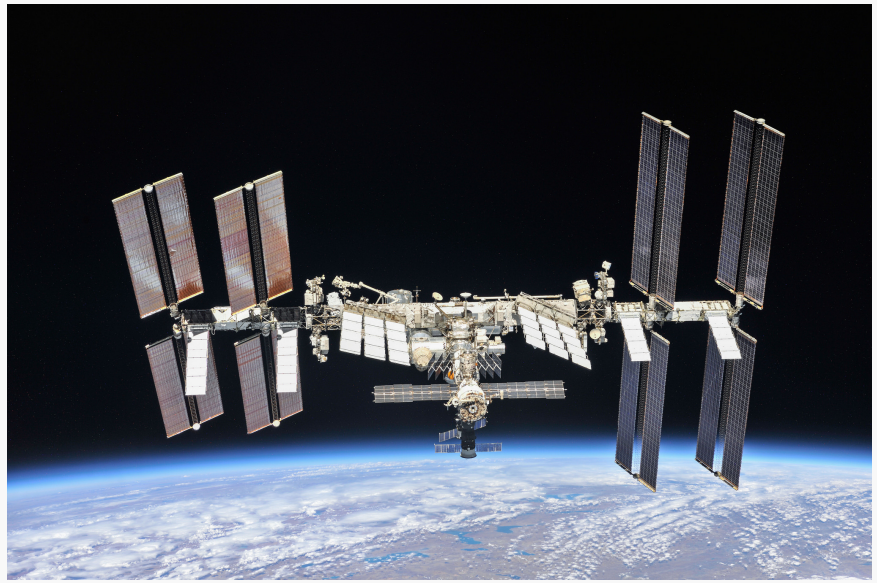
** *Wrack refers to marine plant life that is cast up on shores through the action of waves and tides. The uppermost wrack line is the line of debris deposited by very high tides and/or storm waves.*

“Garbage Patch”

Fact or Fiction?

The actual view of the “garbage patch” from space

Photo taken August 5, 2021



Images courtesy of M. McArthur and NASA


View from a ship in the “garbage patch”


Plastics at SEA
North Pacific Expedition 2012
31° 19.8' N
140° 20.4 W

Traditional measurements of ocean plastics

Microplastics

Microplastics: abundant & widespread

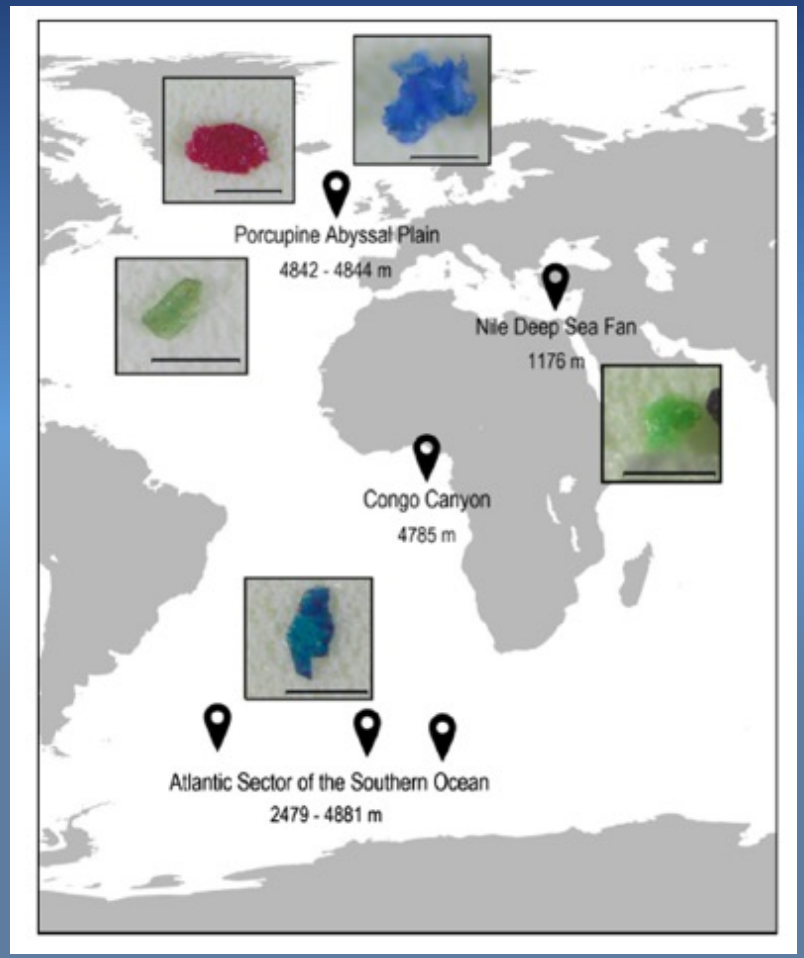
Beaches

Nicholas Mallos/Ocean Conservancy

Water column

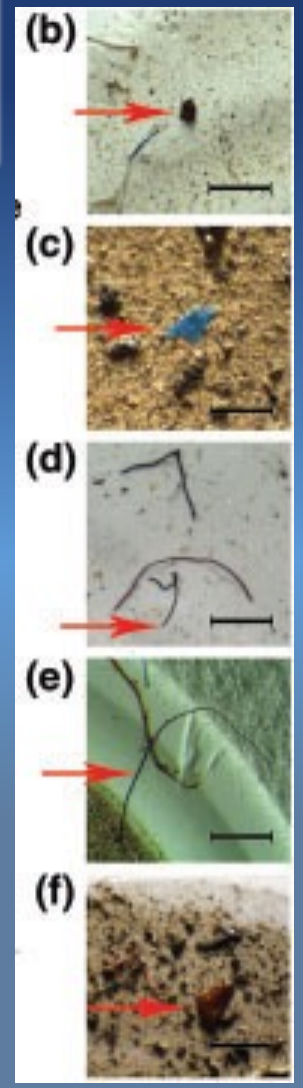
Giora Proskurowski/SEA

Deep-sea sediments



Van Cauwenberghe *et al.*, 2013

Arctic sea ice



Obbard *et al.*, 2014

Contamination ⟶ Impact?

“Blonde Bomber”
The Marine Mammal Center, Sausalito, CA

??

By J RAWLS
https://commons.w

U.S. contribution of plastic waste to the environment

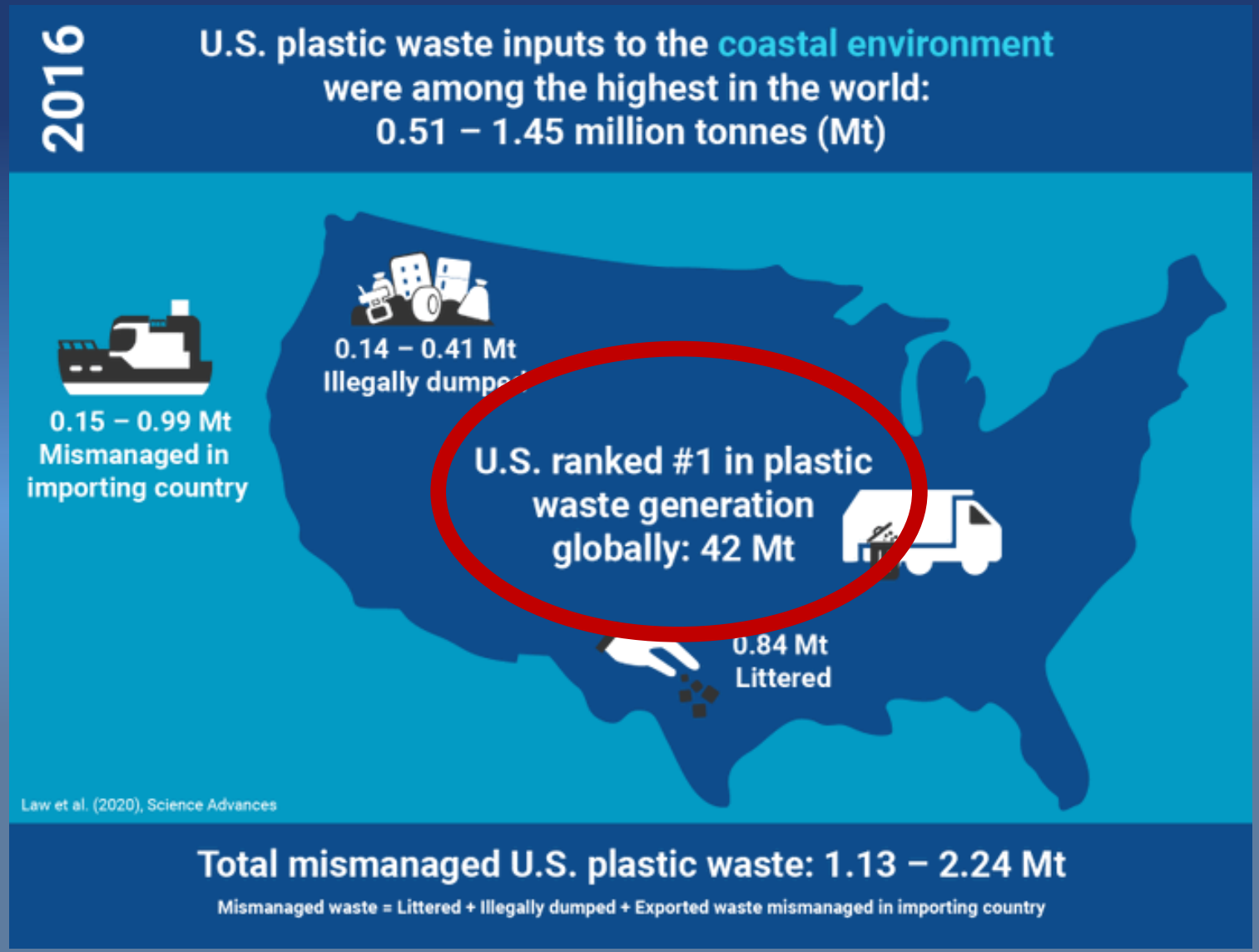


Photo: Jenna Jambeck

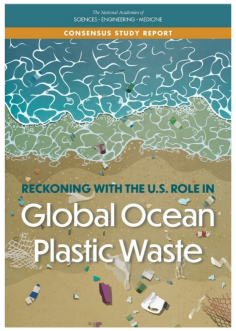
Law *et al. Sci. Adv.* 2020
The United States' Contribution to Plastic Waste to Land and Ocean

Problem:

Plastics pose a threat to environmental health

Proximate Solution:

Prevent plastics from entering ecosystems, biota, humans

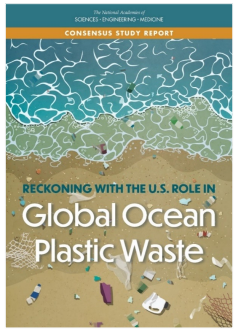


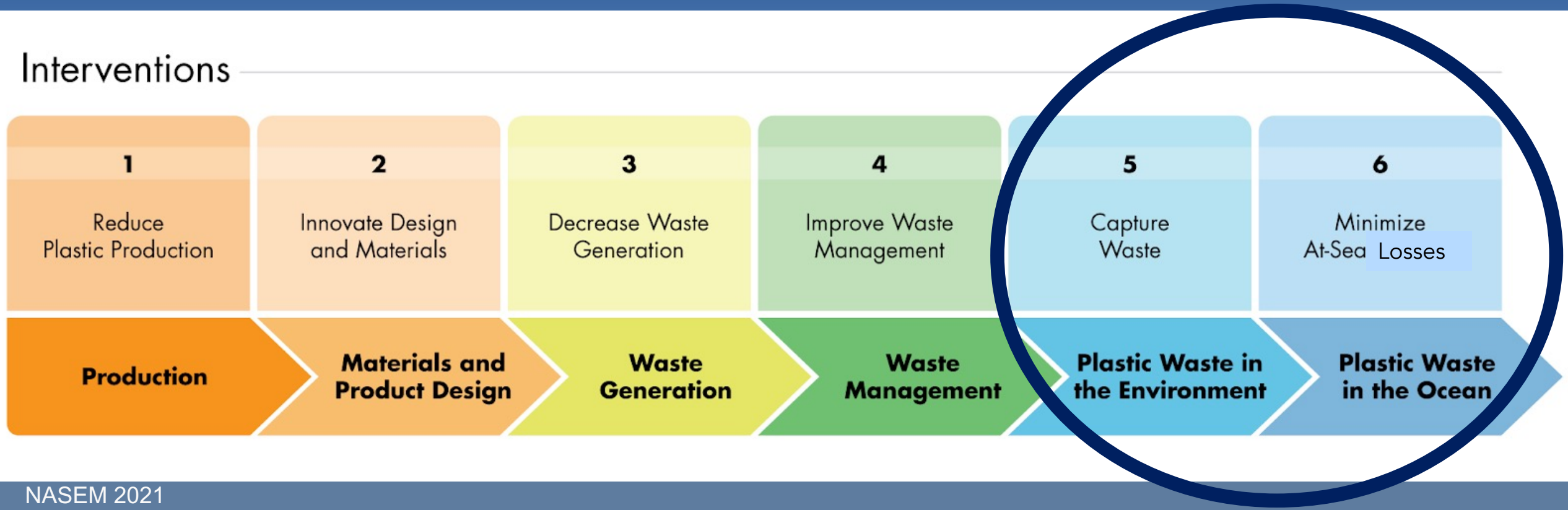
Problem:

Plastics pose a threat to environmental health

Proximate Solution:

Prevent plastics from entering ecosystems, biota, humans



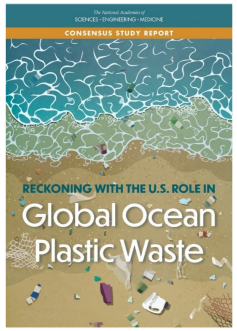


Problem:

Plastics pose a threat to environmental health

Proximate Solution:

Prevent plastics from entering ecosystems, biota, humans



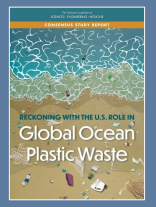
Acknowledgements

Jessica Donohue
Emelia DeForce
Deb Goodwin
Skye Morét-Ferguson
Giora Proskurowski
Erik Zettler
Chris Reddy (WHOI)

> 10,000 SEA students

NCEAS Marine Debris Working Group

SCOR FLOTSAM Working Group



2020-2021 U.S. NASEM Committee

March Marine Initiative

RICHARD LOUNSBERY FOUNDATION
EST. 1959