Man-made Objects on the Surface of the Central North Pacific Ocean

In August 1972, on the Scripps Institution of Oceanography's expedition C'BOG I in the Central North Pacific, there was a rare combination of clear warm weather and calm seas which tempted the scientific personnel to spend their leisure time on the bow of the ship. From this vantage point it was obvious that the sea surface is littered with a startling array of man-made objects, even 600 miles from the nearest major civilization (Hawaii) and outside the major shipping lanes.

A junk log was established and maintained (not continuously) for four days, during which time the ship travelled from 34° 29′ N, 145° 36′ W to 35° 00′ N, 155° 00′ W, and then south to 31° 00′ N, 155° 00′ W. Record was kept of the duration of watch, ship's speed and viewing conditions, and an effort was made to categorize each object, even though exact identification was often uncertain.

The results of this log are presented in Table 1. During 8.2 viewing hours during which time the ship travelled 156 km, and in approximately 12.5 km², a total of 53 man-made objects was recorded. Twelve of these were glass fishing floats, approximately 5 to 14 inches in diameter, which may claim some historic or aesthetic place on the sea surface. The remaining 41 objects were encountered with an average frequency of one every 12 minutes. At least two-thirds of these were plastic.

Succumbing to the temptation to extrapolate from our sample of six plastic bottles, we have calculated an average concentration of 0.5 bottle km^{-2} (95% confidence interval, assuming a Poisson distribution: 0.2–1.0 bottle km^{-2}) and a total of 35.4 million plastic bottles (14.2×10^6–70.8×10^6) currently adrift in the North Pacific Ocean (as well as 5.9 million red rubber sandals). A more conservative estimate may be derived from the observed ratio of plastic bottles to fishing floats, of which there are an estimated ten million afloat in the Pacific Ocean[1]. Our ratio predicts five million plastic bottles.

Table 1 Tentative Identification of Man-made Objects adrift in the Central North Pacific Ocean

Plastic		Glass		Miscellaneous	
Bottles	6	Fishing floats	12	Rope	1
Fragments	22	Bottles	4	Old balloon	1
Total	28	Total	16	Finished wood	1
				Shoebrush	1
				Rubber sandal (red)	1
				Paper items	3
				Coffee can	1
				Total	9

On two of the plastic bottles, algal growth was evident. A third was covered with gooseneck barnacles. Floating plastic, like a glass fishing float, provides a long-lived substrate for transport of sessile animal species as well as algal and bacterial growth; whether the increased availability of such "micro-arks" might alter distributional patterns or attract local concentrations of associated pelagic organisms is an open question.

In the growing concern over global pollution, the accumulation of plastic products has received little attention. Widespread concentrations of plastic pellets have been reported in the Sargasso Sea[2]. Although plastic objects may directly injure wildlife[3], the inert nature of plastic means that it is unlikely to enter the food chain and threaten human welfare. As a pollutant, its effect is chiefly aesthetic, which is difficult to evaluate and easy to ignore. We find it alarming that "disposable" items now litter even the most remote surfaces of the oceans.

The production of plastics has evolved rapidly during the past twenty years—annual production of plastic bottles now exceeds 3×10^9. The development of degradable plastics may bring some relief[4], but unless we find adequate means of disposing of our plastic products soon, we can anticipate that the "Wynkin, Blynkin and Nod" of our children will set sail into a plastic sea, accompanied by all the "no-deposit—no-return" products of our technology.

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Induced Nucleophilic Substitution in Benzo[a]pyrene

Cavalieri and Calvin have proposed[1,2] that the carcinogenic action of benzo[a]pyrene (BaP) may arise from aryl hydroxylase induced binding to nucleophilic cellular components. Their theory proposes that attack by electrophilic oxygen, produced in the hydroxylase system, occurs at the 6 position of the hydrocarbon to give a carbonium ion, localized primarily at the 1 and 3 positions, which can undergo attack with nucleophilic cellular components. Alternatively, initial attack could occur at 1 or 3, followed by nucleophilic reaction at 6.

Some evidence for the theory has been obtained by using iodonium ion as a model for the hydroxylase system. Benzo[a]pyrene and iodine dipyridine nitrate react to give either the 6-iodo or 6-pyridinium derivative or a mixture depending upon reaction conditions. Effects of solvent, concentrations and ratios of reactants were investigated and are summarized in Table 1. Equimolar quantities of the reagents react within 10 min in chloroform to give 6-iodo-benzo[a]pyrene in nearly quantitative yield. All other reactions listed required up to 24 h to reach completion. Formation of the pyridinium derivative requires a 2 : 1 molar ratio of iodonium reagent to BaP.

Table 1 Effect of Reaction Variables on Product Formation

Concentration of BaP	Molar ratios py/BaP *	(py-I-py)†/BaP	Solvent	Yield, % I-BaP	Yield, % py-BaP
		1	$CHCl_3$	99	Trace
		1	MeOH	95	
		1	DMF	95	
			Pyridine	No reaction	
1 mg ml.$^{-1}$	32	2	1% py/$CHCl_3$	50†	50†
0.5 mg ml.$^{-1}$	64	2	1% py/$CHCl_3$		95
5 mg ml.$^{-1}$	30	2	5% py/$CHCl_3$		95
5 mg ml.$^{-1}$	30	1	5% py/$CHCl_3$		50
1 mg ml.$^{-1}$		2	CH_3CN		10

* Added pyridine.
† Approximate yields.

The formation of the 6-pyridinium derivative may be interpreted as arising *via* the proposed ionic mechanism with initial electrophilic attack occurring at position 1 or 3 rather than at position 6 as occurs in the formation of 6-iodobenzo[a]pyrene. The position of attack might change for steric reasons because different reagents could be involved as indicated by the following equilibria:

$$(\text{py-I-py})^+ \rightleftharpoons (\text{py-I})^+ + \text{py} \rightleftharpoons \text{I}^+ + 2\ \text{py}$$