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PLASTICS FILE

A CONCISE GUIDE
to
PLASTICS

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318p.

1957

REINHOLD PUBLISHING CORPORATION
NEW YORK
CHAPMAN & HALL, LTD., LONDON

1. INTRODUCTION

The plastics industry—a young industry—is growing more rapidly than most other American industries and is expanding at an astonishing rate both in the number of different materials commercially available and in the fields of their application. Today, judged by total sales, it comprises one of the few billion dollar industries and its growth has been so rapid in recent years that public acceptance has outstripped public knowledge. Thus, many of the widely disparate materials enjoying the general term "plastics" have a common image in the consumer's mind. This creates a problem in identification as well as in application.

An analogy with the metal industry may help to make this problem clear. Both soft lead and hard tungsten, for instance, are included under the term "metals," but their properties are so well known that few people would refer to either as a metal without some qualification. Yet many people still refer to, say, polyethylene, merely as a plastic. To correct this, manufacturers and plastics engineers are endeavoring to educate users to adopt more specific terminology. In addition, they are trying to acquaint consumers and fabricators alike with the essential properties of the more common materials such as the vinyls and the phenolics. To this end manufacturers have been doing more and better labeling of their end products. These certainly are moves in the right direction and the industry as a whole has made encouraging strides since the introduction of phenolics in 1909. However, some difficulties still exist for the designer first entering the field because variations in physical properties occur within each specific type. Group and type characteristics will be found in Chapter 2. If these meet general requirements, additional information can be secured by noting the applications in Chapter 5 and the comparative tables in Chapter 7. Finally, when selection of a material has been narrowed down the manufacturer should be consulted for recommended detailed specifications.

To illustrate, the cellulosics form a typical group or family of plastics.

As a group they are sturdy materials, readily colored, hard-surfaced and relatively low in price. Within this group are the acetates, the butyrates, ethyl cellulose and the nitrates—each with its distinct properies. Furthermore, each of these may be varied to a considerable extent by the producer. One producer, for instance, lists five different acetates among his products. Others often advertise "materials compounded to meet your specifications." The buyer as well as the user of the end products should know that a urethane product, for example, is not much like a phenolic product, although they are both plastics. To know the right plastic to use for a specific application is, of course, not only highly important to the fabricator but also to the consumer. To impart such knowledge to both fabricator and consumer is the object of this book.

Chapter 2 describes the properties of most commercial plastics. It presents a longer list than needed for the average buyer, as a few of these may be regarded as specialized materials. Some authorities list just 12 household plastics which they say should be better known. These are partly thermoplastic and partly thermosetting as indicated in Tables 1.2 and 1.3.

What Are Plastics?

The generic term "plastics" refers to a group of organic synthetic materials (p. 14) which group itself constitutes the best definition of the term. The American Society for Testing Materials has the following rather complicated description:

"A plastic is a material that contains as an essential ingredient an organic substance of large molecular weight, is solid in its finished state, and at some stage in its manufacture or in its processing into finished articles, can be shaped by flow."

The modern plastics industry may be said to have started in 1930 when diversified products of plastics research laboratories first came into commercial use in appreciable volume. The commercial materials available that year included the nitrates, the phenolics, the acetates, casein, the ureas and the alkyds. Table 1.1 shows the approximate dates when many of today's plastics first became commercially available in the United States.

Plastics are synthetic in the sense that they do not occur naturally. The molecules are composed principally of carbon, hydrogen, nitrogen, and oxygen, which are derived from petroleum, coal, salt, and air and water. Their properties depend to some extent on the size of the molecules of which they are composed. In the early stages of manufacture most plastics are monomers, composed of small single molecules, but under the influence of heat, or of heat and pressure, or of chemical catalysts

these small molecules combine to form long-chain molecules which make up solid or semi-solid structures. This process is called "polymerization." Dissimilar monomers may be jointly polymerized, and the process is then called "copolymerization." Usually no water or other substances are given off during the process. When substances are given off the process is called a "condensation reaction" instead of polymerization.

TABLE 1.1. PROGRESS IN PLASTICS DEVELOPMENT

Approximate Dates Covering Introduction of Some Commercial Plastics

Year	Plastic	Typical Application
1870	The nitrates (Celluloid)	Eyeglass frames
1909	The phenolics	Telephone hand set
1909	Cold molded	Electric heater parts
1919	Casein	Knitting needles
1919	Vinyl acetates	Adhesives
1927	The acetates	Safety glass interlayer
1928	The ureas	Lighting fixtures
1931	The acrylics	Brush backs, displays
1935	Ethyl cellulose	Flashlight cases
1936	Polyvinyl chloride	Raincoats
1938	Vinyl butyral	Safety glass
1938	Polystyrene	Housewares
1938	Polyamides (nylon)	Fibers
1939	Polyamide molding powders	Gears
1939	Melamines	Tableware
1939	Polyvinylidene chloride (saran)	Auto seat covers
1942	Polyethylene	Squeeze bottles
1942	Polyesters	Large forms
1943	Silicones	Motor insulation
1943	Tetrafluoroethylene	Gaskets
1947	Organosols and plastisols	Coatings, films
1947	Epoxies	Molding compound, adhesives
1948	Chlorotrifluoroethylene	Gaskets and valve seats
1953	Urethanes	Sheets and foams
1955	Urethanes	Molding powder

The use of the term "resin" is sometimes confusing. It may be synonymous with "plastic" but it usually refers to the liquid polymers which are the starting materials in the production of molded or fabricated solid or semi-solid products. For example, a bath of liquid polyester for impregnating fabrics for use in the production of a boat or a fender, is referred to as a "resin bath." The term resin is not used in referring to the cellulosics. The most common over-all advantages of plastics as a group are: light weight, good physical properties, good range of color, adaptability to mass production methods, and, often, lower cost.

Some materials which belong to the broad family of plastics are based on inorganic rather than organic molecules, and this further complicates a definition for plastics. Typical of the inorganic group are the silicones. As stated earlier, the best definition of "plastics" is the total list (given in Chapter 2) of materials now generally recognized as such. If one knows these materials he has a pretty good idea of the meaning of the word "plastics" but he still may have a far from complete understanding of the entire plastics industry in which the methods of fabrication and the intermediate shapes and forms play such an important role.

The industry likes to include many products which in the popular mind seem far removed from plastics. Thus, certain types of printing ink, organic coatings, and adhesives are often included as plastics.

Most basic materials for the plastics industry—the resins and molding powders—are produced by a branch of the chemical industry, and thus both industries—plastics and chemicals—are closely associated. Many resins are filled or reinforced or extended by non-plastic materials, chief of which are wood flour used in phenolics and in some of the other thermosetting plastics, and glass fibers and fabrics used in connection with several of the newer thermoplastic resins. These materials, known as "fillers" play an important part in the over-all plastics picture. (See Fillers, Chapter 3.)

At this point the terms thermosetting and thermoplastic should be explained.

Thermosetting is a term applied to resins (plastics) which solidify or set on heating and cannot be remelted. The thermosetting property usually is associated with a cross-linking reaction which forms a three-dimensional network of polymer molecules. Typical of the thermosetting materials are the phenolics and the ureas. In general, thermoset materials cannot be reshaped once they have been fully cured.

Thermoplastic is a term applied to resins (plastics) that may be softened by heat and which upon cooling regain their original properties, even if the process is repeated. Typical of this group are polystyrenes, acrylics, and vinyls.

Some terms often used in connection with plastics are described briefly in Table 1.4.

Plastics, generally speaking, are light weight; for their weight, they are prodigiously strong. There are many plastics (32 commercial varieties,

as listed in Chapter 2) and each has its individual characteristic properties. Thus, by studying the tables in Chapter 7, the properties in Chapter 2, and the applications in Chapter 5, it usually is possible to select the type which may be best for a given job. A recent case in the medical field may emphasize the value of securing the right plastic.

According to a recent announcement the choice of a plastic in one instance probably saved many lives. Charles Holter, seeking a material for a tiny valve used in draining fluid from the brain in treating hydrocephalic babies, tried several plastics which failed for one reason or another. Finally, engineers from Lee Rubber & Tire Company suggested silicone, which proved successful, solving a problem which had baffled surgeons for years.

Because terms for the various plastics differ with the users the following brief forms used in this book* should be noted.

Acrylic—methyl methracrylate or acrylate
Acetate—cellulose acetate
Butyrate—cellulose acetate butyrate
Nitrate—cellulose nitrate or nitrocellulose or pyroxylin
Melamine—melamine-formaldehyde, (sometimes called melamine resins)
Phenolic—phenol-formaldehyde
Urea—urea-formaldehyde
Fluorocarbons—chlorotrifluoroethylene and tetrafluoroethylene

The Extent of the Industry

Plastics start where chemicals leave off and continue through to the finished products. In the earliest stage are the molding powders and resins produced in the main by perhaps 100 chemical or plastics companies. (A total of 103 such companies have been listed.) These may be considered a sort of reservoir of unfinished material waiting to be processed. The molding powders are purchased by molders, extruders and others scattered across the country. The resins are purchased by a still larger group of processors ranging from boat manufacturers on one hand to packaging film producers on the other. Of the molders and extruders nearly 50 per cent are injection molders, 30 per cent compression molders, and 20 per cent extruders. These figures are somewhat arbitrary in the sense that many molders do compression and injection molding and some do extrusion. Transfer and jet molding are included under compression molders. There are others, for example, the cold-molding operators, who use mold-

* Some tables and quoted items may continue to use the longer forms.

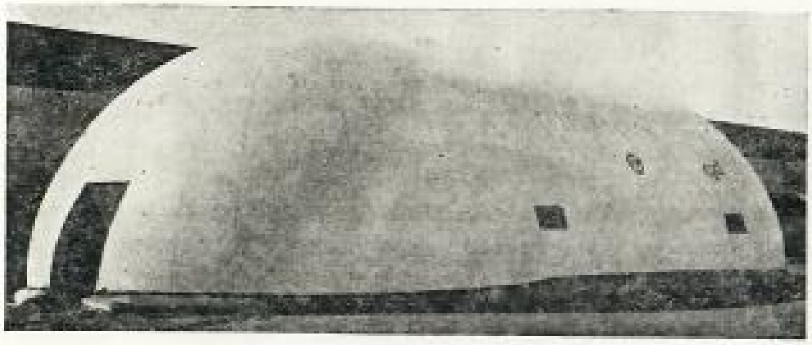

Figure 1.1. This portable warehouse is entirely supported by air. It is made of Fiberthin, a paper-thin tough vinyl-coated nylon fabric produced by the coated fabrics department of U. S. Rubber at Mishawaka, Indiana. The structure is held to the ground by a tube at its base which is filled with water. A small blower keeps up the supporting air pressure, which is low. Passage through the door does not disturb the stability of the structure.

TABLE 1.2. THE COMMON THERMOPLASTICS
(remeltable)

Term	Features	Some Trade Names
Acrylics	crystal-like, warm	Lucite—Du Pont Plexiglas—Rohm & Haas
Acetates	tough, hard, easily colored	Lumarith—Celanese Plastacele—Du Pont Vuepak—Monsanto
Butyrates	tough, good weatherability	Tenite Butyrate—Eastman
Cellulose propionate	no odor, stable, bright finish	Forticel—Celanese
Cellulose nitrate	tough, hard surface, inflammable	Nixon C/N—Nixon Nitration Herculoid—Hercules Powder
Ethyl cellulose	tough, stands hard treatment	Hercocel E—Hercules Powder Nixon E/C—Nixon Nitration
Polyamides (nylon)	strong and extra tough; stands high temperature	Zytel—Du Pont Plaskon—Barrett Division
Polyethylene	light weight and squeezable	Poly-eth—Spencer Alathon—Du Pont
Polystyrene	brilliant, rigid, colorful	Styron—Dow Lustrex—Monsanto
Vinyls	versatile, multi-purpose, colorful	Exon—Firestone Marvinol—Naugatuck

NOTE: Most materials have many trade names associated with them. Names listed here have been selected arbitrarily and are not to be considered as in any way leading or most common. See Chapter 10, p. 272, for other names.

ing powders. Then there are the producers of cast materials and the formulators of organosols and plastisols, to mention but a few of those who produce the many semi-finished materials of the industry. Many of the unit forms of plastics are described in Chapter 3. Molded forms are difficult to classify because some are intermediate or unfinished whereas many are finished materials which are packaged for the ultimate consumer right at the molders plant.

The last and largest group active in the plastics industry comprises the fabricators, and they are so widely diversified that they can scarcely be called a group.

There are other complications. Some of the producers of molding powder are also molders and many of the molders are also fabricators.

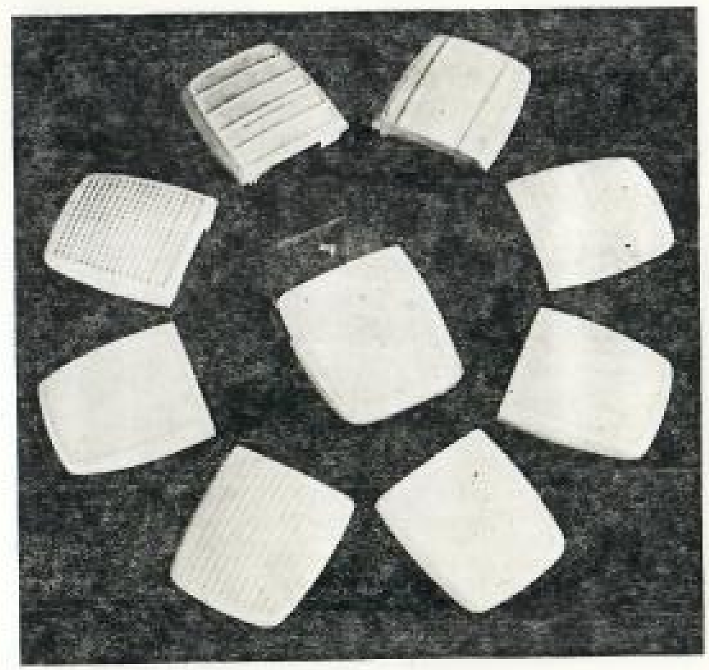

Figure 1.2. Electric razor parts molded of melamine plastics. According to Norman Gray of Schick, Inc., "no other material could give us in one unit a dimensionally accurate chassis on the inside and at the same time a colorful, easy-to-hold handle on the outside." He goes on to say that melamine has proved completely resistant to perspiration, tarnishing, scratching, and the corrosive onslaughts of shaving aids and lotions, in addition to which it possesses the required electrical and mechanical properties. It is produced by transfer molding. Melamine molding compound molds more readily by transfer than urea does.

(Courtesy Bakelite Co.)

Figure 1.3. Using polyethylene film for glazing, simple greenhouses like this have been constructed for as little as $50.00.

TABLE 1.3. THE COMMON THERMOSETTING PLASTICS
(non-remeltable)

Term	Features	Some Trade Names
Casein	the button plastic, variegated effects	Ameroid—American Plastics Corp., New York, N. Y. Galorn—George Morrel Corp., Muskegon Heights, Mich.
Epoxies	coatings, tooling and for reinforced materials	Epon—Shell Chemical C-8 epoxy—Bakelite
Melamines	sturdy, hard, rich, durable	Melmac—American Cyanamid Resimene—Monsanto
Phenolics	extra stronge, durable, good insulator	Resinox—Monsanto Bakelite Phenolic—Bakelite
Polyesters	weather resistant, choice for reinforced material	Laminac—American Cyanamid Vibrin—Naugatuck Chemical
Ureas	hard, smooth surfaced, colorful, stable	Beetle—American Cyanamid Plaskon Urea—Barrett Division

NOTE: The trade names listed here are arbitrary only. For other trade names see the trade name section, p. 272. Epoxies in some forms may be thermoplastic.

No clear line of distinction can be drawn between plastics production and the production of some closely associated materials. Nylon molding powder is a plastic but what about nylon textile fibers? Epoxy resins start as plastics and may end up as coatings or adhesives, and the point where they are no longer plastics has not been defined.

Recently plastics have been claimed to be growing five times as fast as all industry combined. Within ten years the annual production of all plastics materials has jumped from about 1,000,000,000 to close to 4,000,000,000 pounds.

The impressive sales figures given in Chapter 4 which show plastics to be a billion dollar industry do not cover the extensive tool and equipment business which is an essential concomitant. The use of plasticizers for plastics is increasing at a higher rate than that of plastics as a whole.

The Make-up of the Industry*

Today, a minimum of 5,000 companies in the United States are engaged in some plastics activity. These divide into three categories, which sometimes overlap: (1) the plastics materials manufacturer who produces the basic plastics resins or compounds; (2) the processor who converts plastics into solid or semi-solid form; and (3) the fabricator or finisher who further fashions and decorates the product. Exceptions to the above classifications are many. The company which formulates plastics-type coating materials may be considered part of the plastics industry, although he does not deal with a solid or semi-solid product.

The Materials Manufacturer

The primary function here is the formulation of a plastic from basic chemicals. The plastic usually is sold in the form of granules, powder, pellets or flake. However, some of the materials manufacturers go a step further and produce sheets, rods, film, and similar materials from the molding compounds. In 1956 The Society of the Plastics Industry listed 103 companies in this group. Of these, 43 companies have been suggested as the leading materials manufacturers of the industry. (These are listed and described in Chapter 8.) Most of them are chemical manufacturing companies. However, some companies purchase the chemicals from which they formulate the resins and compounds; others purchase resins, limiting their work to the formulation of molding compounds.

* Prepared in cooperation with The Society of the Plastics Industry.

The Processor

Processors of plastics may be divided into six rather distinct classifications:

(1) *Molders* who form end products in molds of the desired shape. These number about 1200.

(2) *Extruders* who, by means of extruding machines, produce sheets, film, wire covering, special shapes and similar materials. A subgroup (not usually referred to as extruders) produces fibers and monofilaments, as explained in Chapter 3. The conventional extruders number about 250.

(3) *Film and sheet makers*. These are considered here as a separate group, although some are included under extruders. This group includes those who make sheets and film either by casting or calendering or by extruding. There are about 60 companies in this group.

(4) *High-pressure laminators*. This group, comprising about 50 companies, forms sheets, rods and tubes from paper, cloth, wood, and other materials, by impregnating the materials with liquid resins and producing the end products by means of heat and high pressure.

(5) *Reinforced plastics manufacturers* who combine liquid resins with such materials as glass fibers, cloth, sisal and hemp fibers, and even such materials as wood flour, to form the final desired shapes by low pressure means. There are about 120 companies in this group.

(6) *Coaters*, numbering about 80, who make use of spread coating, dipping or calendering to coat fabric and paper with plastics.

TABLE 1.4. DEFINITIONS OF SOME PLASTICS TERMS

Accelerator	a substance which speeds up reactions either in polymerizing of resins or vulcanization of rubbers.
A-Stage resin	a thermosetting resin before it is cured or made into molding powder.
Autoxidant	any of a class of compounds added to other substances to retard oxidation.
Binder	the resin in a molding composition is known as a binder. It holds together fillers and other ingredients.
Bleeding	diffusion of color out of plastic part into surrounding surface or part.
Blow molding	shaping thermoplastic materials into hollow form by air pressure and heat. Usually performed on sheets or tubes.
B-Stage resin	intermediate stage between A-Stage and C-Stage. Phenolic molding powders are usually in B-Stage.
Bulk factor	ratio of the volume of a molding powder to that of articles produced therefrom.
Calendering	producing film or sheeting between rotating hot rolls.
Catalyst	a substance which changes the rate of a chemical reaction without itself undergoing permanent change in its composition.
Cold flow	permanent change in dimension of a plastic under stress without heat.
Cold-molded plastics	bituminous or inorganic materials molded at high pressure and room temperature and cured by baking afterwards.
Creep	synonymous with cold flow.
C-Stage	final stage in the reactions of a thermosetting resin. A fully cured stage.
Cure	changing physical properties of a material by chemical reaction—usually to a harder or more permanent form. Sometimes synonymous with set.
Dielectric strength	maximum voltage a plastic material can resist. Test usually is on ⅛ in. thick sheet. Result is expressed in volts per mil.
Estron	acetate rayon.
Extenders	low cost materials used to dilute or extend high cost resins without much lessening of properties.
Hobbing	forming a mold cavity by pressing a hard steel master model into a soft steel blank, which is then hardened and polished.
Inhibitor	a substance that slows down chemical reaction—often used to prolong shelf or storage life.
Jet molding	this and other types of molding are described in Chapter 6.
Latex	water suspension of fine particles of rubber or rubber-like plastics.
Monofilament	a single fiber or filament of indefinite length generally produced by extrusion.
Organosol	finely divided or colloidal dispersion of a resin in a plasticizer, with solvents or other materials. See Plastisol.
Paste resins	another term for organosols.
Plasticizers	materials added to a plastic to improve flexibility or to facilitate compounding.
Plastisols	colloidal dispersion of a resin in a plasticizer without solvent.
Post forming	phenolic laminates and some other thermosetting sheet materials may be formed into simple shapes by heat and pressure after initial care.
Preform	a compressed tablet of molding powder to facilitate handling and weighing in the molding operation.
Slush molding	forming hollow shapes by pouring resin into female mold, allowing to form a shell and then pouring out excess.
Sprue	material left in orifice between entrance and mold parting line in molding. Most common in injection molding.

The Fabricator and Finisher

Because of an overlapping of both activity and of terminology no clear cut division actually exists here. This group includes the miscellaneous companies which, for the most part, take the films, sheets, tubes and rods produced by those known as processors and makes them into finished products. Examples include manufacturers of shower curtains (film), luggage (sheets), flash lights (tubes), and towel racks (rods). Fabricators often do their own casting from molding powders and finishers often take complete moldings from an earlier processor. A division under the heading "finisher" might read "decorator," and still be considered as part of the plastics industry. Some printers working with films, sheets, and other plastics materials fall into this classification, and closely associated with them are the embossers, who produce a textured pattern on a plastic surface (e.g., luncheon mats). While this classification is poorly defined The Society of The Plastics Industry lists about 1500 companies working on rigid plastics sheets and another 1500 engaged in finishing film and non-rigid sheeting.

The Chemical Companies

Most of the primary producers are large chemical companies whose plastics production is actually a relatively small part of their total business. Of the ten leading plastics materials producers only one has plastics sales representing as much as 32 per cent of its total sales. The average proportion of plastics sales to total sales among this group is 17 per cent,

TABLE 1.5. PRODUCTION PER MONTH, MAY 56*

The eight most used plastics (other than coatings)
— in pounds —

Vinyls	64,000,000
Polystyrene	58,000,000
Polyethylene	47,000,000
Phenolics	44,000,000
Ureas and melamines	27,000,000
Coumarone—indene and petroleum polymer resins	21,000,000
Cellulosics	12,000,000
Polyesters	7,000,000

* For more recent figures see Chapter 4.

and the group's annual sales of *all* products (including non-plastics) come to a little more than 7 billion dollars which, at 17 per cent, means that the plastics sales total about 1.19 billion dollars, or about half of the country's total plastics sales. More about the material producing companies will be found in Chapter 8 and more about their production of plastics will be found in Chapter 4.

Identification of Plastics

Except for a few of the more common types, it is difficult to identify plastics by any simple tests. A person with a good sense of smell and some knowledge of chemical odors can identify any of several plastics by holding a match to them. Some precaution should be used, however, because cellulose nitrate is almost explosive when dry and in thin sections. An electric soldering iron is a good tool to use for identification. Before it gets red hot, press it against the unknown sample. If it sinks in, the sample is thermoplastic; if not, it is thermosetting. This locates the sample as belonging to one of the groups shown in Tables 1.2 and 1.3—as being either thermoplastic or thermosetting.

A more extensive examination can be made with a bunsen burner. If the sample won't burn (after 10 seconds at edge of flame) it is a vinyl or a fluorocarbon if it was found to be thermoplastic and probably a urea, a melamine, or a phenolic if it was thermosetting. A fishlike odor is indicative of melamine and a phenol odor is of course a phenolic. The absence of either odor should indicate a urea. If the sample burns with a blue flame that dies after removal, a polyamide is indicated. However, if the dying flame is yellow it may indicate any of the following: a casein if the odor is of burning milk, and the material was thermosetting; a vinyl, if the odor is acrid, for a thermoplastic. If there is an acetic acid odor a flame-resistant type of cellulose acetate is indicated.

If the sample had a dying flame and was found to be thermosetting, it probably was a laminated phenolic. In this case, in addition to the characteristic phenol odor, it would have an odor of burning cellulose or of some other filler material. If the sample continued to burn after removal from the flame and was found to be thermosetting, an allyl is indicated.

The search has now been narrowed to perhaps six thermoplastic materials, but these are the hardest to identify accurately. An odor of burnt sugar points to ethyl cellulose; an odor of rancid butter means a butyrate. A yellow flame and an acetic odor indicate a standard type of cellulose acetate or of vinyl acetate. The vinyl acetate has a darker smoke. An odor of illuminating gas indicates polystyrene.

such as benzoyl peroxide is dissolved in the monomer and heat is applied, the liquid gradually thickens to form a soft gel. With further heating this gel hardens into an insoluble, infusible, clear, colorless solid. The plastic therefore falls in the thermosetting group. One of its leading applications is optically clear sheets. Its properties in sheet form include clarity, low color, high abrasion resistance and solvent and temperature resistance.

A typical sheet material, known as allymer CR-39, has a surface comparable to polished plate glass in luster, smoothness, and chemical resistance. It is superior to plate glass in impact resistance and has but half the weight of glass. Its optical clarity makes it useful as photographic filters. It has less than 50 mils distortion at 265°F. Acrylics generally are fluid at that temperature. The burning rate of the allyls is about one-quarter that of cast acrylic. The abrasion resistance is much greater than that of methyl methacrylate.

Butyrate (Cellulose Acetate Butyrate)*

By reacting purified cellulose with acetic and butyric anhydrides in the presence of sulfuric acid as catalyst and glacial acetic acid as solvent, an interesting thermoplastic material is produced. It has exceptional toughness, good impact strength, and is lighter in weight than cellulose acetate. Other properties include low heat conductivity, high dielectric strength, and good outdoor weathering and aging. Because of the latter it is used for gunstocks and fishermen's floats and tackle. Other applications include automobile tail-light lenses and wallboard molding. The latter is interesting because the material lends itself readily to dry extrusion which permits production in any length. Retaining strips for wallboard may even be nailed in cold weather without splitting, which is a big asset in the building trade.

The ratio of acetic and butyric components may be varied considerably to produce a flexibility ranging from hard to soft, and even to liquids. The latter are used for photographic film, lacquers, protective coating solutions, and protective strip coatings.

A proprietary butyrate known as Tenite Butyrate has about 13 per cent acetyl and 37 per cent butyryl. It has lower water absorption than cellulose acetate and better compatibility with water-resistant and non-volatile plasticizers.

Plasticizers for the Butyrates. Formulating or plasticizing cellulose acetate butyrate powder prior to marketing it as a molding powder is a

* Prepared in cooperation with B. P. Rouse, Jr., Tennessee Eastman Company, Division of Eastman Kodak Company, Kingsport, Tennessee.

simple process, since a variety of plasticizers of excellent compatibility has been developed for use with this material. Many of these plasticizers act as solvents for the cellulose ester and become an integral part of the plastic composition. As a result, the more compatible plasticizers have little or no tendency to exude, bleed, or evaporate under extreme service conditions. Plasticizers of the less volatile types, such as the butyl and higher phthalate esters and esters of adipic, azelaic, and sebacic acids produce butyrate plastics having superior dimensional stability, exceptional toughness, and good impact strength.

A noncompatible type plasticizer may be used to produce plastics which are suitable for a large number of applications. These are generally used in larger quantities and give plastics of a higher impact strength but lower surface hardness. In many cases the dimensional stability of such plastics is adequate.

The plasticizers are added to the cellulose acetate butyrate powder in carefully controlled amounts, usually by a mixing process under regulated heat and pressure for varying periods of time. Although solvent processes can be used they are not common for compounding this type of cellulosic plastic.

Color Range of the Butyrates. In recent years the basic color of butyrate plastics has been improved to the extent that brilliant, water-clear transparent materials are available for many applications. In general, these materials can be colored to any shade, any translucency, or any opacity. Colors are reasonably stable when subjected to elevated temperatures, ultraviolet light, or infrared rays. By the incorporation of ultraviolet light inhibitors greatly improved color and physical properties have been achieved. It should be pointed out that all colors are not equally stable. Some red dyes and pigments, for example, withstand the direct rays of the sun with less color change than others. Greens and blues must be pretested carefully before they are used in colored plastic compositions. It is customary for the manufacturer to carry on a broad testing program which includes accelerated testing in the laboratories as well as extensive outdoor testing in various localities.

The search for more stable coloring dyes and pigments never ceases. Suppliers of dyes and pigments, as well as manufacturers of plastics, are constantly trying to secure additional information on color fastness, heat resistance, weathering, and other color properties by making accelerated tests, such as the Weather-Ometer and Fade-Ometer, and by conducting outdoor tests at various testing stations throughout the country under a variety of climatic conditions. This wealth of information should be examined in cases where an article is to be subjected to unusual conditions, as such precautions can save irreparable mistakes. The best tests, Casein particles may be transformed into a homogeneous plastic mass by adding moisture and applying heat and pressure. This is accomplished in an extruding machine. The extruded plastic is treated with formaldehyde and acquires horn-like properties.

The casein industry originated in Germany about 1910, in England during World War I, and later in America. Originally, only sheets and rods were produced. Its major use then, as today, was for the manufacture of buttons. Considerable time was lost until the plastic was cured by formaldehyde after extrusion. However, both time and material were saved by slicing the rod to the desired diameter and thickness as it was extruded. The curing then takes but a fraction of the time required for a full rod.

The cured plastic will burn, but will not support combustion. It is cream-colored and slightly opaque. It can be prepared transparent or in an unlimited number of opaque, translucent, or transparent colors. Mottled effects with two or more colors, irridescent effects with metal powders, or synthetic pearl are standard procedure.

TABLE 2.4. PHYSICAL PROPERTIES OF CASEIN
(Average Values)

Properties	Casein
Specific gravity	1.35
Tensile strength, psi	7600
Compressive strength, psi	high
Continuous heat resistance, °F	180
Heat distortion temperature, °F	200
Dielectric strength, v. per mil*	400*
Machining qualities	—
Effect of sunlight	colors fade
Per cent water absorption, 24 hr.	10 or more
Resistance to strong acids	poor
Resistance to weak acids	good
Resistance to strong alkalies	poor
Resistance to weak alkalies	poor
Clarity	translucent or opaque

* This is for dry material and has little significance as material takes up atmospheric moisture and is seldom dry.

Some typical uses for casein plastics include, besides buttons, buckles, slides, knitting needles, various fancy goods, knife handles, pens, pencils, etc. However, almost the entire output is consumed by the button industry.

The cured plastic is easily machined; it may be sawed, turned, sanded, drilled and ground. Polishing is accomplished in several ways, but is generally done chemically. The completely finished plastic is placed in hot sodium hypochlorite solution for several minutes, removed, and dried. A high glossy finish is obtained. Polished pieces may be dyed by placing them in a hot bath using acid dyes, but as the dye penetrates the surface to a very slight depth, no mechanical polishing should be attempted after the operation.

Casein is not resistant to water, and a sample immersed in it will gain weight and increase in volume. Electrically, dry casein plastic is a good insulator, but upon exposure to damp air it absorbs water which breaks down its insulating properties.

Cellophane*

While cellophane is not a true plastic it is a close borderline material and should be mentioned briefly. It is made by treating highly purified cellulose with sodium hydroxide. The result is alkali cellulose. By adding carbon bisulfide this is changed to cellulose zanthate, which is thinned, filtered and allowed to stand in tanks to rid it of entrapped air bubbles. It is then ready to be formed into film. This may be done by depositing a thin coating on a fabric belt which carries the coating or film into a bath of ammonium sulfate where it is coagulated and hardened. After washing and some further treatment the regenerated cellulose emerges as a clear, transparent, and self-sustaining film or sheet which if dried would be brittle. To overcome this it is passed through a glycerol bath of which it absorbs about 7 per cent to gain flexibility. Finally, it is treated with plasticizers, resins, and waxes to become the well known commercial cellophane which is used as a protective wrapping material. It may be coated with an appropriate lacquer to make it moisture-proof or heat-sealable. Because of its low cost and wide range of properties it is the most widely used film today.

Cellulose Nitrate

This member of the cellulosic family, also known as nitrocellulose or pyroxylin, is not generally molded. It cannot be injection molded because of its sensitivity to high temperature and in compression molding its easy

* This section prepared in cooperation with Boonton Molding Company.

and a trace of mineral acid, is converted to the unsaturated tricarboxylic acid, aconitic; if a terpene is present the aconitic acid condenses with it. Alkyds useful in varnishes and gasket materials have been prepared by esterifying citric acid with such polyols as castor oil, pentaerythritol, and trimethylol propane.

Unsaturated polyesters suitable for casting and laminating are prepared by esterification of citric acid with allyl alcohol and a glycol. Four moles of citric acid are esterified with 3 moles of a glycol and then with 6 moles of allyl alcohol. The resulting neutral syrups can be homopolymerized to transparent, rigid products with peroxide catalysts. Polymerization rates are lower than those obtained with the glycol maleates but higher than with other allyl resins tested. The polyesters are compatible with methyl methacrylate and vinyl acetate but not with styrene.

Polyethylene

The fifth plastic type in production for 1956 was polyethylene, but in the minds of most students of the plastics market this is the plastics with the brightest future. The total production of polyethylene in 1950 was under 50,000,000 pounds but in 1956 its production had increased almost tenfold to 450,000,000 pounds, and some estimates place its 1960 production at close to 1,000,000,000 pounds.

The polyethylene resins have outstanding electrical properties and excellent water resistance. They also have good resistance to most organic chemicals. They are the lightest of all the plastics with a specific gravity ranging from 0.91 to 0.96. In appearance they are translucent white and have a rather waxlike feel. As materials for fabrication they are about half way between rigid and nonrigid plastics, or half way between polystyrene and plasticized vinyls.

FLOAT

They can be molded, extruded, calendered and applied in films, either from solutions or by flame-spraying. They soften at about 230°F. In film form they have good tensile and tear strength and puncture resistance. As a result of these properties, combined with an absence of taste or odor, they are used extensively for packaging fresh produce, hardware, toys, and many other types of merchandise. Some typical uses for other forms of polyethylene are squeezable bottles, acid-resistant tank and pipe linings, wire insulation, molded containers, bristles, and textiles. One of the largest polyethylene moldings is a 22-gallon can. Other large moldings include dish pans, baby baths and laundry baskets.

Housewives, discouraged with the failure of some plastics, are regaining confidence through their experience with polyethylene, partly due to the

sound design of many recent polyethylene dishes and kitchen utensils. It is claimed that more than half of the annual polyethylene used in housewares will be in pieces ranging from 3 to 12 pounds each. The average price of polyethylene molding powder is 39 cents per pound and the average per pound price of the finished household item is $2.04.

Figure 2.10. Polyethylene film is used as a strawberry mulch by the Ishibashi Brothers on their California ranch. The film is 0.00125 in. thick and 34 in. wide. It has half inch holes along the edges to allow irrigation water to reach the plant roots.

Polyethylene as originally developed in the United States by Bakelite and Du Pont was produced by a high-pressure method. Within recent years the Ziegler and Phillips low-pressure processes have been brought to this country by several United States chemical companies. One of these, Du Pont, states "Polyethylene produced by low-pressure techniques differs from high-pressure polyethylene; it has additional strength, stiffness and resistance to heat distortion and vapor transmission."

A material similar to polyethylene—an olefin polymer based on ethylene—is said to represent a new family and bears the trade name Fortiflex. It is a highly crystalline material with some physical properties similar to those of conventional polyethylene and with some properties that are superior. It is denser, more rigid, harder, and has greater surface gloss—properties which are better for some applications and not as good for others. The Manufacturing Chemists' Association has published data showing Fortiflex to have heat resistance above 225°F and tensile strength more than double that of conventional polyethylene.

The development of Irrathene, irradiated polyethylene, was announced in 1954 by the General Electric Company of Schenectady, New York, and is now in commercial production. Irrathene electrical insulation is produced in the form of tapes and films which retain the excellent elec-

(Courtesy Bakelite Co.)

Figure 2.11. A new 22-gallon trash can molded of polyethylene imparts all of the properties of this material to what has long been one of the most unsightly of all household items. It is noiseless, break resistant, non-rusting, non-denting, lightweight, colorful and easy to clean. Colors are molded in so that they cannot be chipped or washed away. The lid can be unlocked with a simple twist of the wrist. The top diameter of the can is 20½ in. and the height is 27¾ in. Rust is no problem since polyethylene resists water, oil, grease, harsh alkalies and even sharp acids. Even after rough handling by the garbage collector, can springs back into shape without showing a dent, and the usual clatter is eliminated at the same time. The retail price is about $12.95.

trical properties of polyethylene over a wide temperature and frequency range. The material has a high dielectric strength and a low power factor. Non-melting and dimensionally stable at high temperatures it has been recommended for use as a Class A insulating material for a hot-spot rating of 225°F. However, in sealed systems or in the absence of oxygen the material is said to withstand temperatures up to nearly 400°F with little or no change in mechanical or electrical properties over prolonged exposure.

(Courtesy Celanese Corp. of America)

Figure 2.12. Drum liners of polyethylene are becoming increasingly popular. They are tear resistant, highly inert to most chemicals and low in moisture vapor transmission.

Some recent investigations have developed the fact that carbon black dispersed in polyethylene resin is effective in preventing degradation due to sunlight and weathering. Those who wish to know more about this interesting work and its results are referred to Acheson Dispersed Pigments Co.*

* 2250 E. Ontario St., Philadelphia 34, Pennsylvania.

Fillers

Fillers are added to give a plastic specific mechanical and electrical properties and to increase its resistance to various service conditions. Although they often reduce the per pound price, they are seldom used for this specific objective. The percentage of filler is usually between 20 and 50 by weight. Some common fillers and their functions are as follows:

For bulk:

wood flour	jute
asbestos	cotton flock
sawdust	wood pulp
mica	

For reinforcement:

glass fibers	asbestos
cotton fibers	wood flour

For hardness:

metallic carbides	quartz
silicone carbide	mica

For thermal or chemical resistance:

asbestos	sand
graphite	metallic oxides
diatomaceous earth	powdered metals
quartz	

For appearance:

metallic oxides	powdered metals
organic pigments	phosphorescent calcium sulfide

Mold lubricants are sometimes added to facilitate release from the die after a piece is molded. A typical material is calcium stearate.

Materials similar to the fillers just described are often used with laminated and reinforced plastics but they are usually introduced in the form of fabric or mats and are not generally called fillers.

Films and Sheets

An expanding list of plastics capable of producing films and sheets is available to the fabricator and designer. A few of the most frequently used materials are listed below:

acrylics
cellophane
cellulose acetate

ethyl cellulose
polyethylene
polyester
polystyrene
polyvinyl alcohol
polyvinyl chloride
vinyl chloride-vinyl acetate
vinylidene chloride

Films may be divided into three general markets: packaging; industrial (scotch tape, garden mulch, balloons, etc.); and soft goods (raincoats, umbrellas, and shower curtains).

The first three film materials in order of present production are cellophane, polyethylene, and vinyl copolymers. Of these the use of polyethylene as a film material is increasing more rapidly than the other two. For a more complete discussion of film applications see Chapter 5.

TABLE 3.3. FILM PRODUCTION PER YEAR*

Plastic	Pounds
Cellophane	250,000,000
Polyethylene	66,000,000
Vinyl chloride and copolymers	58,000,000
Cellulose acetate	20,000,000
Cellulose nitrate	15,000,000
Ethyl cellulose	1,000,000
Polyvinyl alcohol	500,000

* Average values for 1954, 1955 and 1956.

"Sheeting" is the term applied to continuous material; "sheet" is applied to relatively small pieces of sheeting cut to specific lengths. The term "film" actually refers to thin sheeting, and is an optional term which the American Society for Testing Materials (ASTM) recommends for thicknesses not greater than 0.010 inch. In commercial practice 3 mils (0.003 in.) is usually the upper limit for thickness of film. This is especially true of packaging materials.

Sheeting is made by one of several different methods. The film-forming mass may be cast onto a large wheel or onto an endless metal belt, the thickness of the material being determined by the position of a doctor knife held adjacent to the casting wheel or belt. Casting on a paper carrier is a new process which will be discussed later.

Sheeting may also be produced by calendering, as explained in Chapter 6, but a more common method is by extrusion. One method, introduced by the Tennessee Eastman Company, is to extrude a thin tube and then to slit one side of the tube and lay it out over a suitable spreading device to form a flat film. Sheeting and film are produced from nearly all types of plastics. Chapter 5 discusses some typical applications for sheets made from the following materials:

Cellulose acetate	Nylon
Cellulose acetate butyrate	Polyethylene
Cellulose propionate	Polystyrene
Ethyl cellulose	Polyvinyl butyral
Fluorothenes	Vinyls (polyvinyl chloride and polyvinyl chloride acetate)
Methyl methacrylate	

A comparison of the properties of three of the principal transparent sheeting materials is given in Chapter 2. It will be seen from this that the acrylics are the lightest but also, next to polyester film, the strongest in tension. The acetate sheets can be produced with excellent clarity but their usefulness in some applications is limited because of their high water absorption which is about 3.3 per cent in 24 hours as against 0.2 per cent for the allyls.

The physical properties given in Chapter 2 are indicative of the properties of the film.

Vinyl sheets are available in translucent, transparent, or opaque forms and in an extensive range of colors. They come in varying thicknesses ranging from film which is 3 mils or less to as much as 1 inch. Thicker parts usually are called "slab stock." Sheets may have a press finish or a calender finish and may be rigid or flexible.

All types of vinyl sheets may be cut, stamped, or sheared with standard tools. The flexible types can be bonded to each other or to other materials by heat-sealing methods. Rigid sheets are available from 0.005 to 0.025 in. thick, either cut, with a matté finish, or in continuous rolls having a calender finish. Both flexible and rigid sheets can be formed and shaped with heat. The rigid sheets can be formed around mandrels into complicated, three-dimensional shapes, and they can be machined, much as metal sheets can be formed on standard metal-working equipment. They can be vacuum formed.

Cellulose acetate film is produced in continuous lengths and in thicknesses of 0.001 in. or less up to 0.01 in. or more. The thickness is limited to about 0.01 in. because of the slow drying rate. However, thick sheets may be produced by skiving them from pressed blocks. Standard sheets are 20 x 50 in. and can be given a high polish between plates in a press operation. The gage of film is often expressed in thousandths of an inch

multiplied by 100,000. Thus a film 0.002 in. thick would have a gage number of 200. In addition to cellulose acetate film and sheeting, films and sheets are produced from cellulose acetate butyrate, ethyl cellulose, and cellulose acetate propionate.

The polyamides are excellent film and sheet-forming materials. By adding plasticizers, properties may be produced in nylon films varying from rigid to elastic.

A flexible foamed plastics sheet insulation, called Armaflex, is manufactured by the Armstrong Cork Co., Lancaster, Pennsylvania. It is adaptable to curved or irregular surfaces with little or no fitting and cutting, and withstands temperatures as high as 160°F. Thickness can be built up by applying successive layers. The foamed plastics sheets are available in thicknesses of ⅛ to ¾ inch. Applied with the proper adhesive, the sheets do not require mechanical supports. Their flexibility makes them suitable for insulating large tanks, irregularly shaped vessels, oversize pipes, and refrigeration and air-conditioning equipment.

A new material, known as Rhinolyte, consists of nylon mesh, laminated between two sheets of vinyl. Electronically welded, this light weight material is strong and completely waterproof. It is used for tarpaulins by the construction, agricultural, transportation and other industries. A 20 x 20 ft. heavy-duty tarpaulin weighs only about 37 pounds. It is also reportedly flexible to minus 50°F, and resists chemicals, tearing, and abrasion.

Acrylic sheets. These are usually formed by casting and the process is more difficult than with CR-39 or polystyrene. In curing, which is usually done at from 265 to 300°F, a critical point is reached when excessive heat is given off by the material itself. Ovens with rapidly moving air are provided to eliminate this excessive heat. Casting is usually done between plate glass sheets. The glass sheets are mounted one above the other with spacers around the edge to keep them apart the distance desired for the thickness of the casting. Because of shrinkage the spacers should either be made of elastomers such as plasticized polyvinyl chloride or of metal covered with paper. In the latter case, they must be removed at the right point in the curing cycle to permit shrinkage without having the casting drawn away from the glass sheets which constitute the mold. In casting, the mold is horizontally inclined and a special funnel is used to feed the liquid material in between the glass plates. Sometimes the liquid is prepolymerized to a syrupy condition so as to speed up curing. Even so, the curing time is slow and ranges from one day to one week.

Acrylic sheets are standard for transparent enclosures on aircraft. Edge-lighted sheets are used as radar plotting boards. Other uses include outdoor sign material, industrial window glazing, and safety shields over moving machine parts.

Table 3.4. Typical Sheeting Applications*

Cellulose acetate	
carpet sweeper windows	packaging
containers	photographic film base
instruction sheets	table mats
instrument faces	toys
mechanical shielding	windows in pocket folds
Cellulose acetate butyrate	
automobile tail lights	mechanical shielding
containers	rigid safety guards
instruction sheets	
Cellulose propionate	
drawing instruments	food protectors
Ethyl cellulose	
deep-drawn containers	goggles
electrical tape	sales displays
food packaging	
Fluorothenes	
electrical insulation	high-frequency dielectrics
Methyl methacrylate	
aircraft enclosures	watch crystals
dials	windows
display boxes	
Nylon	
conveyor belts	seat material
furniture strips	vacuum packages
Polyethylene	
electrical insulation tapes	packaging
garment bags	refrigerator items
liners for closures	
Polystyrene	
cable wrapping	electrical insulation
cosmetic packages	shades in fluorescent lighting
decorative objects	table mats
Polyvinyl butyral	
safety glass interlayer	
Vinyls (polyvinyl chloride and polyvinyl chloride acetate)	
acid tank lining	rainwear
boats	suspenders
book binding	umbrellas
curtains	upholstery
luggage	wading pools for children
phonograph record preforms	

* See also Chapter 5.

Table 3.5. Cellulose Acetate Film Areas

Thickness, in.	Gage	Sq. in. per lb.
0.00088	88	25,000
0.001	100	22,000
0.0012	120	18,300
0.0014	140	15,700
0.002	200	11,000
0.003	300	7,300

Foams

Many liquid resins will form foams with the proper introduction of a gas. The use of foams in industry is increasing as pointed out in Chapter 5. In general, foams may be divided into two main groups—rigid and flexible. The leaders in the flexible group are the vinyl type and the polyurethanes. By varying the production technique, the polyurethanes may be used for both flexible and rigid foams but the rigid group has not enjoyed the same activity due to difficulties in handling. Rigid foamed polystyrene has had extensive use in the building industry. It may be either foamed in place or produced in the form of sheets or rectangular slabs. Slabs, 3 or 4 in. thick and 4 x 8 ft. in dimension are used for closet walls and other non-supporting partitions by coating them with cement plaster.

Expandable polystyrene is finding many new interesting uses of which the following are a few examples: insulation, where closed cell structure is an advantage; sandwich construction, where controllable density and low thermal conductivity (K value) are favorable for insulated panels; packaging, where toughness is stressed; and toys and displays, where ability to be molded to intricate shapes is important.

Laminates

Most any material—cloth, paper, or woven glass fibers—may be impregnated with a resin, laid up in layers and then cured by heat and pressure to form a laminate. The terms "high-pressure" and "low-pressure" laminates are commonly used but the distinction between the two types is not clear. When a pressure of 1200 psi or more is used the product generally is called a "high-pressure laminate." Textolite and Formica are typical of the well known high-pressure laminates.

QUEENSLAND TURTLE RESEARCH

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Australia
Telephone 73-2674

Business: National Parks and Wildlife Service
Pallarenda
Townsville. 4810
Australia
Telephone 74-1411

22 Aug 84

Dear George,

Thanks for the Tokelau report.

I have no records of turtles intangled in debris in Aust. unless you count a subadult green which washed ashore
(1) in New South Wales several years ago with a length of fishing line hanging out both its mouth and cloaca. It had
est. 1980 just died when found. It is preserved in the Australian Museum Sydney but not dissected so I don't know what had happened to its gut but I can imagine a big tight knot. Also attached are some references to
(2) Dermochelys tangled in shark lines and lobsterpot lines for your info. I've also had 3 (2 <u>caretta</u>, 1 <u>mydas</u>) tangle
(3) in the anchor ropes to the marker bouys along my reef transecs at Heron Reef — all additional recaptures into the population study. The last record for you is
(4) of a sub adult green that washed in dead tangled in an anchor rope with a light reef anchor attached. The origin/purpose of the anchor is undetermed. This was at Bundaberg about 2 year ago.

The trip to Indonesia was very interesting — I learned a lot even if they didn't. But I know that many of the students benefited. The problem is changing the attitudes of the political decision makers. Attached is a copy of my report to WWF for your ...

I'm off again this weekend for an Australasian Herpetological Conference in Sydney. There looks like being about 5 or 6 sea turtle papers being presented. I'm presenting one on "*Caretta* Temp. dependent sex ratio: intra and inter rookery variation between clutches from different females."

and a second paper on

C. mydas: sex ratio x size class x maturity and current breeding status of a feeding ground population. This latter is based on the laparoscopy work we are following. I'll send you final drafts of papers when they are ready.

Hope all is well with your work.

All the best

Col

L.

SINCE NINETEEN HUNDRED "THE VOICE OF CONSERVATION"

Dr. George Balazs
National Marine Fisheries Service
P.O.Box 3830
Honolulu
Hawaii 96812

August 29 1984

Dear George:

Many thanks for your recent letter. Regarding the entanglement of marine turtles in fishing gear, we did have one of our French Guiana leatherbacks caught in a lobster line in New Jersey. However, perhaps the most useful reference for this is a book you probably have, "This Broken Archipelago" by James D. Lazell, Quadrangle Press, 1976. Lazell found, that, of fifteen Massachusetts area leatherbacks that he had examined, five had been, or still were, entangled in lobster lines around their right front flipper. He goes on to describe a possible scenario as to how it is usually the right flipper that is involved. See pages 191-192 of the book.

request sent 10-11

Nicholas Mrosovsky has probably also gathered data of this kind in systematic fashion for his monograph on the leatherback, which was accepted by Harvard University Press, but the press now seems to be changing its mind in rather unethical fashion ("moving away from single-species monographs", or some excuse of that kind). You might drop him a line.

Incidental mortality of olive ridleys in the Orissa area appears to be a serious problem. Washups of dead turtles are described in the two Indian sea turtle compendia that were published recently, as well as in Hamadryad. These are ascribed to drowning in trawls and gill nets. Kar counted 3000 carcasses at Gahirmatha in 1983, but only 500 in 1984, perhaps reflecting legal controls of commercial fishing in the vicinity of the arribada beach -- a result of the international write-in-and-complain campaign. Apparently the arribada in late January 1984 included an estimated 250,000 nesting turtles on only 5 km of beach -- what a spectacle!. See Hamadryad 9, no. 2, p. 12 for details.

I hope these fragments of information will be of use.

All best wishes,

Peter

Peter C. H. Pritchard Ph.D.

FLORIDA AUDUBON SOCIETY

1101 Audubon Way • Maitland, Florida 32751 • (305) 647-2615

Dear George,   4. Sept 1984.

Reviewing my field notes and interm reports from Oman 1977 – 1980 I can offer the following information on entrappment.

a) Between Feb and April 1977 26 adult green turtles washed ashore dead on 10 Km of beach at the northern end of Masirah. Accidental drowning in Trawl nets was implicated but not proven. 3 large trawlers were active in the region and several turtles had aberasions consistent with capture in a trawl. An executive order by the Fisheries department and local governor banned Trawler activity within 3 miles of the beach east of Masirah in June 1977. ~~da~~ Stranded dead turtles sightigs immediately dropped to about 2/month.

b) In the course of my study I recieved specimens or information on 7 green turtles and 5 hawksbills captured in gill nets set for fish in the shallow coastal waters west of Masirah. Most of these were sub adults, many brought to me alive were tagged and released. These gill nets are either cotton or monofilament approx 3" knot-knot mesh and an average of about 20 m long. They are generally set in water of 2 – 10 m depth.

c) In the course of aerial surveys along the entire Oman coast in 1977 and 1978 and ground surveys in 1978 and 1979. I obrerved approximately 30 green turtles apparently captured in gill nets and discarded as inedible by the coastal villagers in these regions.

In generall then - Yes entrappment occurs.

- Compared to ~~pop~~ turtle populations in the region the effect is small.
- I found no evidence of entrappment in "ghost nets", i.e discarded or lost fishing gear - although I was not aware of this problem at that time and was not looking specifically for it.

A further note on "ghost net" entrappment. The fishermen in Gloucester Mass consider this a small problem. They point out that once a gill net comes loose from its anchoring points it quickly "Balls up" in a compact tangle and doesnt catch anything. They readily admit that properly set nets catch non target species - birds, seals turtles etc and I have heard of, but cannot verify, 2 reports of leatherbacks caught in pound nets in recent years in this area. This is, of course, inshore fishing with relatively short nets. Hope all this helps.

WWF Australia declined to fund my Turtle project for 1986. They claimed it ~~was~~ required "greater definition" and invited me to reapply for a smaller amount in 1986. Perhaps IUCN will take up the slack? Thanks for your help anyway.

Regards Pevan.

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
SEFC, Panama City Laboratory
3500 Delwood Beach Road
Panama City, FL 32407-7499

May 8, 1984 F/SEC5:LHO:rb

Captain Sal Litrico
Port Captain Gulf Coast
SONAT Marine, Inc.
2040 Guy N. Verger Blvd.
Tampa, FL 33605

Dear Captain Litrico:

My interest in Captain Wotherspoon's observations of extensive areas of flotsam and concentrations of marine life has prompted me to seek your permission to accompany him on one of your vessel's trans-gulf trips. We believe these observations are apparently related to the oceanographic conditions responsible for juvenile sea turtle distribution in the Gulf of Mexico. So little is known about the pelagic habits of young turtles that this period of their life has become known as the "lost year." Therefore, any opportunity we have to document their occurrence on the high seas will help fill important gaps in our knowledge. For this reason, Professor Archie Carr, of the University of Florida and I solicit your approval to sail with Captain Wotherspoon this spring or summer (or with any other captain that would be agreeable).

We are willing to sign an insurance waiver in order to remove your company from any liability our presence might incur and will be responsible for all travel arrangements and expenses to and from the vessel. Also, we understand that you may have to schedule our trips separately if necessary. It is also our understanding that our activities must not adversely effect the normal operation of the vessel.

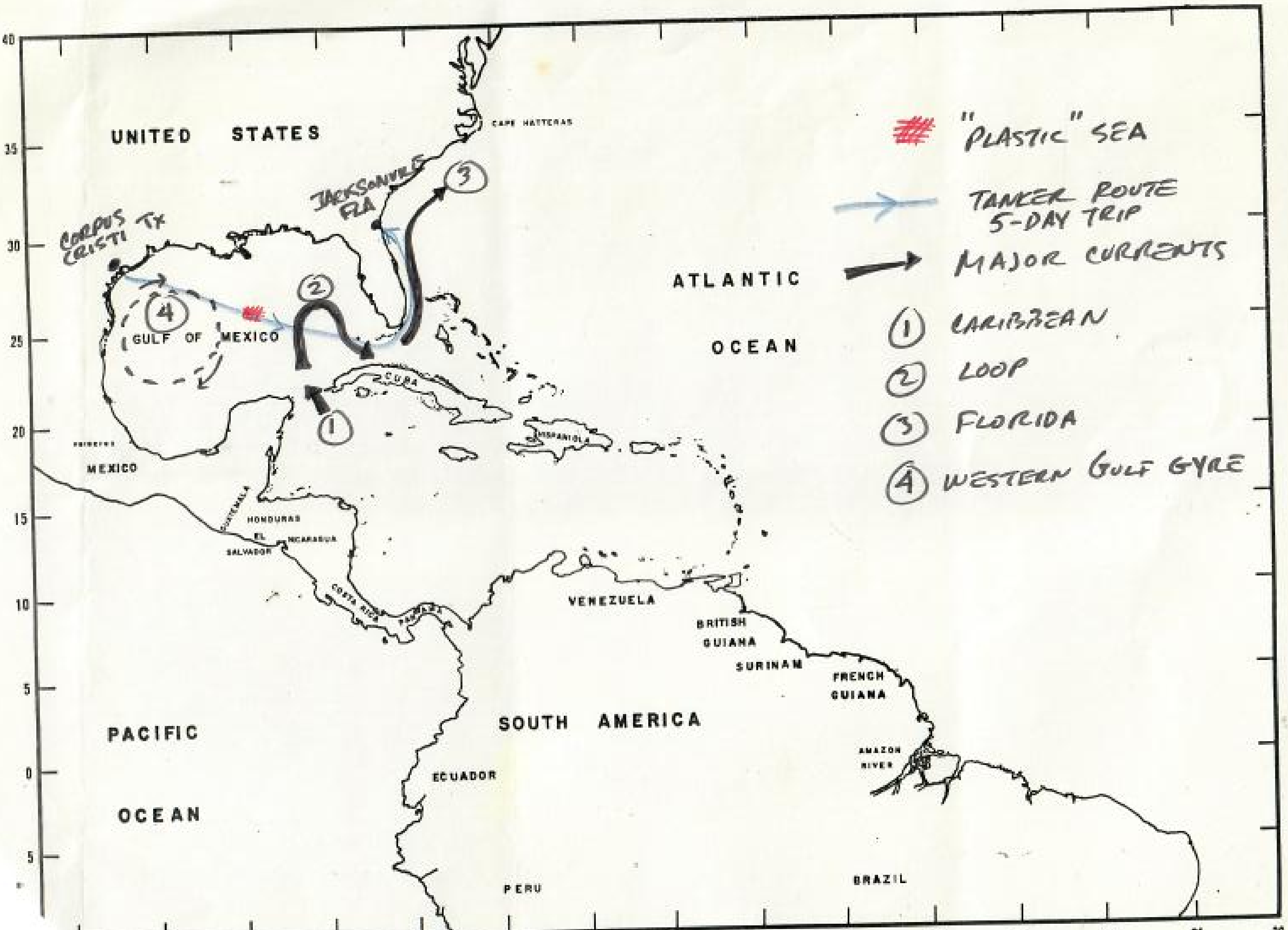
Please let us know if this request meets with your approval at your earliest convenience. According to Captain Wotherspoon, it is difficult to observe these concentrations of debris and marine life during high sea states. That is the reason we haven't contacted you earlier. Hopefully, the sea will subside later in the season and conditions will become more favorable for making observations and photography.

Sincerely yours,

Larry H. Ogren
Fishery Biologist (Research)

cc:
David Wotherspoon
Archie Carr

George:
David Wotherspoon has reported a "sea of plastic," ca. 30 nautical miles in linear extent, in the middle of the Gulf of Mexico — hope to take a first hand look. He's also observed other extensive concentrations of marine organisms in same area.



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Dr G R Hughes

30 August 1984

Mr George Balazs
National Marine Fisheries Service
Honolulu Laboratory
P O Box 3830
HONOLULU
HAWAII 96812

Dear George,

Thanks for your letter and paper received a few days ago. I thoroughly enjoyed the paper and was delighted to find that much of what pertains as attitudes towards and treatment of sea turtles parallels the attitudes of the Malagasy people in Madagascar especially the Vezo and Sakalava. Bear in mind that they are descendants of Malay-Polynesians that emigrated across the Indian Ocean in the c. 11th and 13th Centuries. Even the general name of sea turtle in Madagascar is Fano which is very close indeed to Fonu in your islands!

Did you consider that the "eight backbones" might be a leatherback - Joop Schulz has two names for his leatherbacks in Suriname with Aitkanti being one with eight ridges!

10-28 Wrote and asked him about this

referred ?

As far as debris is concerned I have come across lots of plastic beads etc. in hatchling guts and once I found a leatherback with a huge piece of heavy duty clear plastic in the gut. It measured 6m x 4m and was so tightly packed in the gut that we had to work extremely hard to twist it open. 3 x 4m (19.5' x 13') (NO)

A more recent incident (photo included) also involved a leatherback that had managed to get a piece of nylon rope around a foreflipper. The animal came ashore near Cape Town on 1 August 1984. A colleague of mine Reinhold Rau from South African Museum, Cape Town, sent me the picture. The wound itself appeared to have healed but there was a huge weight of Mytilus mussels and goose-neck barnacles on the rope which would suggest that the animal has done little diving since it picked up the rope. These organisms are never found on adult leatherbacks under normal conditions.

The new/.....

The new newsletter is good news and I'm glad to see that Karen is putting things together. Look after yourself.

Yours sincerely,

George

ASSISTANT DIRECTOR CONSERVATION
for DIRECTOR

P.S. It isn't easy to get turtles on stamps out here!

February 24, 1986 F/SWC2:GHB

Dr. Archie Carr
Department of Zoology
203 Bartram Hall
University of Florida
Gainesville, FL 32611

Dear Archie,

Many thanks for your telephone call last Friday. I was delighted to learn that you have accepted an invitation to speak at the ocean disposal symposium in California this April. The problems that drift plastics present to pelagic-dwelling sea turtles certainly need to be stressed at this international scientific gathering. You can count on me to provide you with whatever background information I have as a result of my November 1984 paper presented at the debris workshop here in Honolulu. Also, as you requested, I'll duplicate an assortment of slides that were used in presenting my paper. I can bring them with me to the Georgia workshop later next month.

Larry Ogren may have already told you that our Honolulu debris workshop unfortunately did not result in any of the special appropriations being committed for sea turtle debris interaction research. Cross-species competion for available funds invariably results in projects for marine mammals wining out. Sea turtles in the Pacific often suffer from this fate, unlike the situation in your area of the world. I am hoping that your speaking out independently on behalf of sea turtles at the forthcoming symposium will help to provide a better balance to the situation.

I look forward to seeing you again next month. Best personal regards to you and your family.

Sincerely,

George H. Balazs
Zoologist

cc: Balazs
HL

UNIVERSITY OF FLORIDA
GAINESVILLE, 32611

DEPARTMENT OF ZOOLOGY
223 BARTRAM HALL
904-392-1107

October 19, 1984

Mr. George Balazs
NMFS
P.O. Box 3830
Honolulu, HI 96812

Dear George:

Thanks for the copy of the report of your hatchling-tagging results. You got some surprizingly good durability.

What I was trying to do in my endless, fruitless trials of tagging technique was mainly to test the notion--which most of us have--that female turtles you see on shore were hatched somewhere nearby. Today that aim seems even more unattainable than ever, now that estimates of the time to sexual maturity have trebled or even quintupled.

With the good results you have you could expect to learn a lot about hatchling ecology and movements from short-term recoveries--made during the time before the tags are popped off or overgrown--but what about the "lost-year"? As you know, it's difficult to go out and find post-hatchlings yourself, and it's slow going even if you depend on the reports of a network of volunteer collaborators as I have come to do. Two years ago we marked 2000 Tortuguero green turtles, released them at the nesting beach, and then searched for them in the driftline off Colon and Bocas in Panama. Neither we nor any of the people whose help we enlisted have ever seen a single one of that lot. We marked these with coded lateral notches. Your tags would be a lot better because returns by strangers could be expected. What is now needed is a way to increase the reasonable recovery.

Circumstantial evidence on occupancy of convergences has grown, and large numbers of post-hatchlings of all ages up to a year or more have been reported in driftlines. You are right that hurricanes must play hell with the lost-year group--but so must it be unrestful for all of the driftline biota.

I did some snooping after hurricanes Diana and Isidore along the Georgia and Florida coast, made a lot of phone calls from North Carolina to Cape Florida, and received more from people there. The two storms added up to a real disaster for the U.S. loggerhead. Nests remaining unhatched were washed out or flooded, and hatchlings in the longshore driftline were driven ashore in rolls of weed. Everybody I talked with agrees it was a serious setback.

As for your question about the turtles eating banana wrappers in Costa Rica, I can't give you a specific reference. But when we lived there in the late 1950's it was common knowledge that mature green (black) turtles were dying near the banana docks at Golfito over on the Pacific coast, and that the cause was ingestion of the plioform sacks they put bananas in. If I were there, I could get references to newspaper articles. Sorry I can't do better.

Sincerely yours,

Archie Carr mes

Archie Carr
Graduate Research Professor

UNIVERSITY OF FLORIDA
GAINESVILLE, 32611

DEPARTMENT OF ZOOLOGY
223 BARTRAM HALL
904-392-1107

October 19, 1984

Mr. George Balazs
NMFS
P.O. Box 3830
Honolulu, HI 96812

Dear Mr. Balazs:

Dr. Carr asked me to send this on to you without his signature with a note that he did not have a chance to look over the final copy. He will not return to the office until Monday and wanted this mailed out as soon as possible.

Sincerely yours,

Marge Scerbo

Marge Scerbo
Secretary to Dr. Carr

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration

10/16/84

To : George

From: Larry

Just received Center approval for trip to Marine Debris meeting (see copy of memo). I'll write a letter to Shomura of my intentions to attend his meeting and my role as SEFC representative. Also, when Nakamura returns I'll ask him to call Shomura — they are old friends — if you think a phone call is necessary

OK?

P.S. Enclosed are my brief notes on turtles encountering discarded monofilament fishing line — please include them in your paper if you think they are significant (I won't be presenting a paper — no time to prepare at this late date).

- Adult female loggerhead (Caretta caretta) CL 84, CW 65 cm. Found drowned and entangled in monofilament fishing line by SCUBA diver. Turtle cut free, brought to surface and carried to lab. Fishing line apparently fouled in limestone reef outcrop, local name "Warsaw Hole", ca 4 miles offshore of Panama City, Florida, 5/29/78. Depth 75-80 feet. Autopsy, gross, revealed turtle to be in good flesh with ample reserves of fat. No internal (or external) lesions, wounds or other obvious signs of disease or debilitation observed. Stomach contents and intestines full of recently ingested forage items: sea cucumbers, portunid and hermit crabs primarily. Contents filled 3 one-gallon jars. Death presumed to be due to drowning.

- The skeletal remains of a loggerhead, Caretta caretta were found on the beach, Panama City, Bay County, Florida. Humerus was encircled with monofilament fishing line (ca. 60 lb test). Death may have been caused by the subsequent disabling effect of the fishing line acting as a permanent tourniquet and hindering locomotion (not to mention possible necrosis of limb through loss of circulation). Estimated date of mortality 1979.

- Subadult loggerhead (Caretta caretta) ca. 180 lbs captured in trawl at Cape Canaveral, Florida, Nov.-Dec. 1978. Specimen alive and apparently not adversely impacted by partial ingestion of large amount of discarded monofilament fishing line (ca. 60 lb test). Monofilament, coiled and twisted, protruded from turtle's mouth. The jaws were forced open and mass of line was pulled out from esophogeal opening--approximately two or three feet. Numerous encrusting organisms, primarily mussels, were attached to the line and showed signs of being partially digested. Believed part of line swallowed had entered small intestine because of presence of bile. Apparently turtle ingested line because encrusting organisms present were typical forage items of this species.

from Larry Ogren
10/22/184

UNIVERSITY OF FLORIDA
GAINESVILLE, 32611

DEPARTMENT OF ZOOLOGY
223 BARTRAM HALL
904-392-1107

8 February 1986

Nancy Wallace
6404 Camrose Terrace
Bethesda, MD 20817

Dear Ms. Wallace:

George Balazs, a member of the Marine Turtle Specialist Group, sent me a copy of the August 1984 issue of The Entanglement Network Newsletter. If this Newsletter is still being produced, I would very much appreciate being added to the mailing list.

Our Group is very concerned about the effects of marine debris on sea turtles. Our growing realization that the oceans' drift and shear lines are a critical habitat for the earliest life stages of sea turtles has greatly increased our concern because debris are also concentrated in these lines. George Balazs has volunteered to maintain an international data bank for all records of sea turtles either entangled in or ingesting marine debris. If you know of any such records, or know of anyone who could help us in accumulating such data, could you please either write to me or to George Balazs (National Marine Fisheries Service, P.O. Box 3830, Honolulu, Hawaii 96812)?

Thank you for your help. I look forward to hearing from you.

Sincerely,

Karen Bjorndal

Karen Bjorndal
Chairman, IUCN/SSC Marine Turtle
Specialist Group

cc: George Balazs

Marine Policy
and Ocean Management
Program

WOODS HOLE OCEANOGRAPHIC INSTITUTION
1930

Woods Hole
Oceanographic Institution
Woods Hole, MA 02543

Dr. George Balazs
National Marine Fisheries Service
Southwest Fisheries Center
P.O. Box 3830
Honolulu, Hawaii 96812

5 September 1984

Dear George:

I promised that I'd tell you when I took over the editorship of the MTN. Consider yourself told. The next issue (No. 31) will be mine. (Late fall sometime?)

I surely would like to be able to attend the Entanglement Workshop Nov. 26-29, but a snowball in hell would stand a better chance. I hope that you'll be there, though, and will jot down any thoughts on sea turtle entanglement that you have or may gather from others. I'd really appreciate a short note for the MTN on anything that is covered concerning sea turtle entanglement. Would you consider writing one up for me?

One of your NMFS folks at Naragansett, RI (Chuck Stillwell) has become interested in the sea turtles he finds inside the sharks he's looking at. I think he's planning to write up his shark/turtle predation observations for a short note. I wrote to him and mentioned that there was information in your Synopsis of Green Turtles concerning tiger sharks. I also sent him a xerox of Stancyk's predator paper from Bjorndal's proceedings.

Hope all is going well for you. I have gotten a second year at WHOI on my post-doc. In 12 months, though, I'll be thrown out into the cold, cruel job market. Yuk.

Remember to let me know about the Entanglement Workshop if you think MTN readers would be interested.

R.R. 7-A, Box 522-A
Narragansett, RI 02882

Sincerely,

NF

Nat B. Frazer, Ph.D.
Research Fellow
Marine Policy

9/13/84
letter

office
ext.
2610

Telephone: 617-548-~~1400~~

Telex: 951679

Rubbish on the High Seas

MY TURN/CHARLES OSTERBERG

Americans love the ocean and want its waters kept pristine. Why something we spend little time with is so revered is a mystery. I suppose we've seen our air, land and fresh waters polluted by man's hand and wish to keep at least one part of God's earth, the ocean, as he created it, for our children's sake. Another reason might be the environmental pressures that push a willing Congress into passing tougher laws to guard the ocean.

At any rate, "Save our seas" is a popular cause, but it is an affair of the heart, not the brain, and we are sacrificing more to Father Neptune, god of the sea, than even the "saltiest" among us should want. For the special laws discriminating in favor of the ocean require the most toxic wastes of civilization to go on the land or into the air.

That is getting too close to home. We breathe the air and live on the land, which produces 98 percent of our food, all of our lumber, fuel and the fibers that clothe us. More scary yet, the land covers and protects the ground water and the rivers, streams and lakes; it contains the tiny proportion—less than 1 percent—of the liquid water in this world that is fresh, without which human life could not exist.

Toxic Impurities: Already our fresh waters contain toxic impurities picked up by their intimate contact with the land on which the wastes are legally put. Half of us drink from the ground water, often without pretreatment, yet only now have we begun to realize the danger from waste disposal. In a 1984 article in Outdoor America, Ed Hopkins, research director with the Clean Water Action Project, stated that the Environmental Protection Agency "has identified 15,000 'uncontrolled sites'—sites that are clearly contributing to contamination of water and air. Of these, at least 347 pose direct threats to drinking water supplies and could cause birth defects, cancer and other diseases." In 1983 the National Academy of Sciences reported that "the use of landfills should be minimized since constituents will very likely migrate over long periods [greater than 100 years] into ground water."

Yet over half of the planet is covered with sea water that is more than two miles deep, and 300 million cubic miles of sea water is unlimited when compared with the relatively few drops of priceless drinking water. Why should salty, barren sea water, deep in the mid-ocean and containing far less man-made contaminants than our drinking water, receive greater protection from the United States Congress? Why have they gone overboard on the ocean? What this country needs is a Jacques Cousteau to protect the land and fresh water.

> We go overboard on the ocean; what we need is a Jacques Cousteau to protect the land and our drinking water.

Unfortunately, our laws regard the ocean as a single entity; they fail to recognize that shallow coastal waters are more valuable and more vulnerable than the deep, empty ocean and they protect the two alike. How foolish. The Chesapeake Bay, with only 18 cubic miles of brackish water, produces more food for man than millions of cubic miles of ocean water deeper than two miles. Like the land and fresh water, the Chesapeake Bay must be protected, but the deep ocean, so isolated and devoid of food for mankind, needs no such care. Our seafood comes from only 2 to 3 percent of the ocean's waters, from the top mile of sea water, mostly along the edges of continents.

Although it is an inefficient producer of human food, the ocean performs well as nature's trash basket. It is self-cleansing and can cope with pollution. Gravity carries clouds of particles downward, sweeping many contaminants out of the waters onto the bottom, where return to man is minimal. The ocean has a carrying capacity—an ability to absorb and dilute contaminants with little harm to flora or fauna, or man. Mother Nature knew what she was doing, and we should take advantage of her expertise.

Disposal Site: Do I exaggerate when I say the laws favor the ocean? When the Navy proposed a study to see whether old, retired nuclear subs (minus their reactors and fuel) should be sunk in the deep ocean or put on land, Congress passed a two-year moratorium that effectively removed the ocean option. Despite strong scientific evidence to the contrary, the Navy bowed to Congress and, at great additional expense, chose the land. And why not? To put the submarines in the ocean, the Environmental Protection Agency would have to select a disposal site and issue an environmental-impact statement before it could grant the Navy a permit—and both houses of Congress would have to approve within 90 days.

In other words, forget sea disposal. U.S. law makes it easier to put the subs on farmland in Indiana, in Central Park as a monument or even far inland in the desert, which is where some environmental groups want them stored.

No, everything shouldn't be thrown into the sea. But our laws should permit those materials that are found to be more innocuous in sea water than on the land to go there. At the very least, the law should encourage intelligent choices instead of outright bans on disposal in the least-used two-thirds of the earth's surface—the ocean.

Osterberg, an oceanographer, works for the Department of Energy and speaks only for himself, not the DOE.

NATAL PARKS, GAME AND FISH PRESERVATION BOARD
P.O. BOX 662, PIETERMARITZBURG 3200

T.A. "FAUNA
(0331)
51221
(8 Lines)
56527
54812
RESERVATIONS ONLY
SLEGS BESPREKINGS 51514
6-43481

RAAD VIR DIE BEWARING VAN NATALSE PARKE, WILD EN VIS
POSBUS 662, PIETERMARITZBURG 3200

OUR REFERENCE
ONS VERWYSING E. 6/1

INQUIRIES
NAVRAE Dr G R Hughes

Please address all communications to the Director
Gelewe alle briefwisseling aan die Direkteur te rig

13 November 1984

Dr George Balazs
N.M.F.S.
P O Box 3839
HONOLULU
HAWAII 96812

Dear George,

Thank you for your letter of 26 October and the enclosure on Jack. I knew that he had been in India because he came to the Réunion Workshop directly from there. It was in fact an interesting week as Nick, Jack and myself with three French biologists went through their entire ranching endeavour from collection of hatchlings to eating the products of the farm. The French called the meeting for the purposes of evaluating the endeavour following a series of questions being posed by CITES. I would say that despite some reservations most of us felt the ranch was a positive action. As I was the originator of the idea some 13 years ago I really had to be as objective as I could in order to avoid being accused of being partisan. However I have no doubt that that accusation has been made before I ever went to the commission.

Pardon my face glowing gently but I have not extended my hatchling gut contents of late and must ask you to quote only what has appeared in print. I have re-read my papers and would say that I have fallen victim to believing the incidence of something happening is greater than proven. In justification, there is no doubt that plastic beads are eaten but "come across lots" is not justified. Thanks for your criticism I shall watch it in future.

Our turtle season is only two weeks old and in full cry with many turtles coming out. I hope its going to be a good season. May I wish you all the very best for Christmas and the New Year.

Yours sincerely,

George.

ASSISTANT DIRECTOR CONSERVATION

for DIRECTOR

GRH/lcb

Established 1947. Constituted in terms of Ordinance 15 of 1974
In 1947 opgerig. Volgens Ordonnansie 15 van 1974 saamgestel.

BY AIRMAIL
PER LUGPOS
PAR AVION

Aerogramme
Aërogram

INVEST SAVE-TI...
WITH THE POST OF...
BELE SPAARGELD...
BY DIE POSKANTO...

RSA

TO
AAN

Dr George Balazs
N.M.F.S.
P O Box 3839
HONOLULU
HAWAII
96812

PT

SECOND FOLD—TWEEDE VOU

SENDER'S NAME AND ADDRESS
NAAM EN ADRES VAN AFSENDER

Natal Parks, Game and Fish Preservation Board
Raad vir die Bewaring van Natalse Parke, Wild en Vis
P.O. Box/Posbus 662
Pietermaritzburg
South Africa
3200

ENCLOSURES ARE NOT PERMITTED
INSLUITINGS WORD NIE TOEGELAAT NIE

FIRST FOLD—EERSTE VOU

THE UNIVERSITY OF TEXAS
MARINE SCIENCE INSTITUTE
Port Aransas Marine Laboratory

Port Aransas, Texas 78373
Phone 512 749-6711

6 Nov 84

Dr George Balazs
NMFS
P.O. Box 3830
2570 Dole St.
Honolulu, Hawaii 96812

Dear George,
Enclosed are copies of the stranding reports for five turtles that I have recently handled where plastic entanglement of one sort or another occurred.

In summary:

	date	species	contact with plastic
1	29 Aug 83	EI	onion bag entanglement
	02 Nov 83	EI	hooked by fisherman w. monofilament
2	20 Dec 83	EI	monofilament entanglement (photos enclosed)
	28 March 84	EI	Hooked by fisherman (mono)
3	14 Sept 84	CM	tar & plastic in mouth.

The slides are originals: please return when finished with them. Hope these data will be of use to you.

Regards
Tony Amos

SEA TURTLE STRANDING AND SALVAGE OBSERVATION REPORT

MAKE ALL MEASUREMENTS OVER THE CURVE AND DOWN THE MIDLINE OF THE TURTLE. MEASURE THE LONGEST LENGTH. THAT IS, FROM THE CERVICAL SCUTE NEAR THE NECK, TO THE TIP OF THE MARGINAL SCUTE (SEE DIAGRAM). BE SURE TO CIRCLE THE UNITS OF MEASUREMENTS (IN = INCHES AND CM = CENTIMETERS). MEASURE THE CARPACE WIDTH OVER THE CURVE AT THE WIDEST PORTION OF THE SHELL. AGAIN, CIRCLE THE PROPER UNITS. THE DIAGRAM PROVIDED, MAY BE USED TO DRAW OR OTHERWISE MARK WOUNDS OR MUTILATIONS FOUND ON THE STRANDED SPECIMEN AND TO MARK TAG LOCATIONS.

PRINT CLEARLY:

OBSERVER'S FULL NAME Anthony F. Amos DATE 83 08 29 (y y m m d d)

TURTLE NUMBER BY DAY ___ STATE ___ ___ COORDINATOR'S INITIALS ___ ___ ___

SPECIES CODE EI RELIABILITY OF I.D. 3 SEX U VERIFIED BY COORDINATOR? Y/N

LATITUDE 27° 49.6' N LONGITUDE 97 03.0' W DESCRIPTION OF LOCATION

Off Horace Caldwell Pier, Port Aransas, Texas Gulf Beach

CURVED CARAPACE LENGTH _ _ 29.8 CM/IN CURVED CARAPACE WIDTH _ _ 19.0 CM/IN

CONDITION OF ANIMAL ___ WAS ANIMAL SPRAY PAINTED? Y/N

TAG. NO. A6996 (left) DISPOSITION OF TAG & INFO see below

A6997 (right)

IF MORE THAN ONE TAG IS PRESENT, PLACE THE TAG NUMBER(S) IN THE REMARKS SECTION.

FINAL DISPOSITION OF CARCASS 0 IF 3, WHERE SENT ___

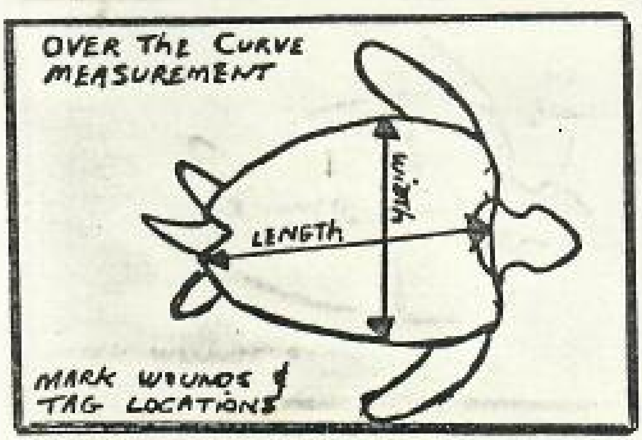
REMARKS: Animal was entangled around neck with piece of plastic "onion bag". Had abraded a groove in neck but no infection was present when plastic was removed.

CODES

SPECIES: CC = Loggerhead
CM = green
LK = Kemp's ridley
DC = leatherback
EI = hawksbill
UK = unknown

SEX: F = female
M = male
U = unknown

RELIABILITY OF I.D.: 1 = unsure
2 = probable
3 = sure
(if species is unknown, then reliability must be 3)



CONDITION OF ANIMAL: 0 = alive
1 = fresh
2 = brewing
3 = el stinko (soupy, foul)
4 = mummy (falling apart)
5 = skeleton

FINAL DISPOSITION OF CARCASS:
0= Released
1 = painted, left on beach
2 = buried on beach
3 = salvaged specimen
4 = pulled up on dune
5 = partially salvaged, left on beach or buried
6= Offshore sighting (Free Swimming)

Turtle was kept in tank at UTMSI where it revived & took food (dead shrimp, fish) readily. It was tagged with V.F. Gainesville tags #A6996 (left) & A6997 (right). photographed and released by R/V LONGHORN on 30 Sept 1983 at 27° 43.5'N ; 97° 0.6'W. ~~This was~~ The animal was released next to an oil rig by a diver who reported that it "took off like a shot" when he let go of it. Water depth at rig site = 13 m.

SEA TURTLE STRANDING AND SALVAGE OBSERVATION REPORT

MAKE ALL MEASUREMENTS OVER THE CURVE AND DOWN THE MIDLINE OF THE TURTLE. MEASURE THE LONGEST LENGTH. THAT IS, FROM THE CERVICAL SCUTE NEAR THE NECK, TO THE TIP OF THE MARGINAL SCUTE (SEE DIAGRAM). BE SURE TO CIRCLE THE UNITS OF MEASUREMENTS (IN = INCHES AND CM = CENTIMETERS). MEASURE THE CARPACE WIDTH OVER THE CURVE AT THE WIDEST PORTION OF THE SHELL. AGAIN, CIRCLE THE PROPER UNITS. THE DIAGRAM PROVIDED, MAY BE USED TO DRAW OR OTHERWISE MARK WOUNDS OR MUTILATIONS FOUND ON THE STRANDED SPECIMEN AND TO MARK TAG LOCATIONS.

PRINT CLEARLY!

OBSERVER'S FULL NAME ANTHONY F. Amos DATE 8 3 / 1 1 / 0 2 (y y m m d d)

TURTLE NUMBER BY DAY ___ STATE ___ COORDINATOR'S INITIALS ___ ___ ___

SPECIES CODE EI RELIABILITY OF I.D. 3 SEX U VERIFIED BY COORDINATOR? Y/N

LATITUDE 27° 50' N LONGITUDE 97° 03' W DESCRIPTION OF LOCATION

Aransas Pass South Jetty

CURVED CARAPACE LENGTH 30.0 CM/IN CURVED CARAPACE WIDTH 26.0 CM/IN (head 6.8 cm long 4.3 cm wide

CONDITION OF ANIMAL 0 WAS ANIMAL SPRAY PAINTED? Y/N weight 2180 g)

* TAG. NO. A6998 (left) DISPOSITION OF TAG & INFO ___
A6999 (right)

IF MORE THAN ONE TAG IS PRESENT, PLACE THE TAG NUMBER(S) IN THE REMARKS SECTION.

FINAL DISPOSITION OF CARCASS 0 IF 3, WHERE SENT ___

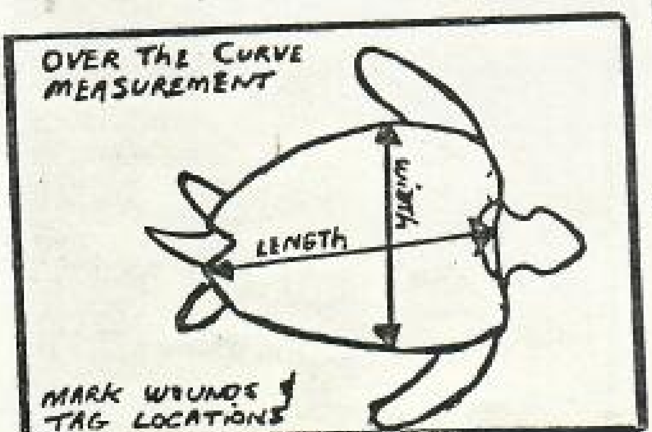
REMARKS: Brought in by fisherman who had hooked it while fishing.

CODES

SPECIES: CC = Loggerhead
CM = green
LK = Kemp's ridley
DC = leatherback
EI = hawksbill
UK = unknown

SEX: F = female
M = male
U = unknown

RELIABILITY OF I.D.: 1 = unsure
2 = probable
3 = sure
(if species is unknown, then reliability must be 3)



CONDITION OF ANIMAL: 0 = alive
1 = fresh
2 = brewing
3 = el stinko (soupy, foul)
4 = mummy (falling apart)
5 = skeleton

FINAL DISPOSITION OF CARCASS:
0= Released
1 = painted, left on beach
2 = buried on beach
3 = salvaged specimen
4 = pulled up on dune
5 = partially salvaged, left on beach or buried
6= Offshore sighting (Free Swimming)

* see remarks over

The fisherman claimed that the animal had taken a fish hook but I could see no sign of it when I opened it's mouth. It would not feed at first but later fed regularly & would dive for food on the bottom. No injuries. Animal has numerous acorn barnacles on carapace, plastron, limbs & head. On 24 Jan '84 it was tagged, photographed, weighed & measured. For several days it has not been feeding & looked emaciated when I examined it while measuring. Some scutes are ~~[illegible]~~ separated & it looks as if it has suffered an injury (crushed?). This is mysterious because ~~it is~~ the facility is always locked & unauthorized people cannot get in. It is the largest turtle in the tank & I doubt if the other animals could have done this (tank is 20ft x 10ft x 2½' deep) & they all get along well together.

At the time of it's being brought here the fisherman told me there were several hawksbills(?) around the jetty & people were offering him money to catch one for them !!?..

pno
Jm

SEA TURTLE STRANDING AND SALVAGE OBSERVATION REPORT

MAKE ALL MEASUREMENTS OVER THE CURVE AND DOWN THE MIDLINE OF THE TURTLE. MEASURE THE LONGEST LENGTH. THAT IS, FROM THE CERVICAL SCUTE NEAR THE NECK, TO THE TIP OF THE MARGINAL SCUTE (SEE DIAGRAM). BE SURE TO CIRCLE THE UNITS OF MEASUREMENTS (IN = INCHES AND CM = CENTIMETERS). MEASURE THE CARPACE WIDTH OVER THE CURVE AT THE WIDEST PORTION OF THE SHELL. AGAIN, CIRCLE THE PROPER UNITS. THE DIAGRAM PROVIDED, MAY BE USED TO DRAW OR OTHERWISE MARK WOUNDS OR MUTILATIONS FOUND ON THE STRANDED SPECIMEN AND TO MARK TAG LOCATIONS.

PRINT CLEARLY!

OBSERVER'S FULL NAME Anthony F. Amos DATE 8 3 1 2 2 0 (y y m m d d)

TURTLE NUMBER BY DAY ___ STATE ___ ___ COORDINATOR'S INITIALS ___ ___ ___

SPECIES CODE EI RELIABILITY OF I.D. 3 SEX U VERIFIED BY COORDINATOR? Y/N

LATITUDE 27° 50.3′ N LONGITUDE 97 03.1′ W DESCRIPTION OF LOCATION

University of Texas Boat Basin

CURVED CARAPACE LENGTH 25.0 CM/IN CURVED CARAPACE WIDTH 21.5 CM/IN

(head 5.8 cm long × 4.7 wide)

CONDITION OF ANIMAL 0 WAS ANIMAL SPRAY PAINTED? Y/N

(weight 1730 g)

TAG. NO. ___ DISPOSITION OF TAG & INFO ___

IF MORE THAN ONE TAG IS PRESENT, PLACE THE TAG NUMBER(S) IN THE REMARKS SECTION.

FINAL DISPOSITION OF CARCASS 3 IF 3, WHERE SENT U. Florida, Gainsville (A. Meylan)

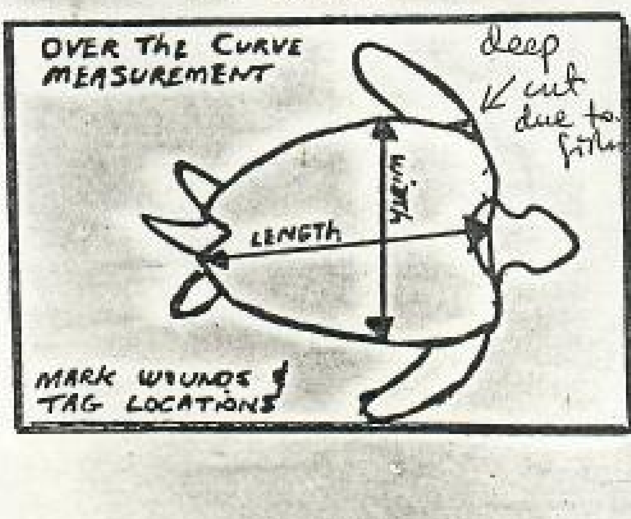
REMARKS: this animal was found entangled in monofilament fishing line & appeared to be dead. water temperature

CODES

SPECIES: CC = Loggerhead
CM = green
LK = Kemp's ridley
DC = leatherback
EI = hawksbill
UK = unknown

SEX: F = female
M = male
U = unknown

RELIABILITY OF I.D.: 1 = unsure
2 = probable
3 = sure
(if species is unknown, then reliability must be 3)



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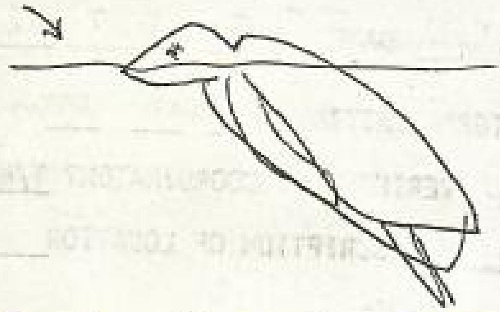
6= Offshore sighting (Free Swimming)

cont'd over

was 6.5°C at the time. After unwrapping fishing line - the animal moved & so was allowed to warm to near room temperature & then transferred to heated tank. Animal was very sluggish, could not be induced to feed & maintained an odd attitude in the tank



eyes may be damaged. Severe restriction on left front limb →

where line was wrapped

On 23 Jan 84 the animal died ~~[illegible]~~ it did not feed at all during captivity. Had many barnacles (Acorp) on plastron, carapace limbs & head, two large oyster spats one on plastron, one on carapace.

24 Jan 84 was weighed, measured & photographed.

SEA TURTLE STRANDING AND SALVAGE OBSERVATION REPORT

MAKE ALL MEASUREMENTS OVER THE CURVE AND DOWN THE MIDLINE OF THE TURTLE. MEASURE THE LONGEST LENGTH. THAT IS, FROM THE CERVICAL SCUTE NEAR THE NECK, TO THE TIP OF THE MARGINAL SCUTE (SEE DIAGRAM). BE SURE TO CIRCLE THE UNITS OF MEASUREMENTS (IN = INCHES AND CM = CENTIMETERS). MEASURE THE CARPACE WIDTH OVER THE CURVE AT THE WIDEST PORTION OF THE SHELL. AGAIN, CIRCLE THE PROPER UNITS. THE DIAGRAM PROVIDED, MAY BE USED TO DRAW OR OTHERWISE MARK WOUNDS OR MUTILATIONS FOUND ON THE STRANDED SPECIMEN AND TO MARK TAG LOCATIONS.

PRINT CLEARLY!

OBSERVER'S FULL NAME Anthony F. Amos DATE 8 4 0 3 2 8 (y y m m d d)

TURTLE NUMBER BY DAY ___ STATE T X COORDINATOR'S INITIALS ___ ___ ___

SPECIES CODE EI RELIABILITY OF I.D. 3 SEX ? VERIFIED BY COORDINATOR? Y/N

LATITUDE 27° 49.7' N LONGITUDE 097° 02.1' W DESCRIPTION OF LOCATION

South Jetty Aransas Pass N. end of Mustang I. Texas

estimated

CURVED CARAPACE LENGTH _ _ _ _ . _ CM/IN CURVED CARAPACE WIDTH _ _ _ _ . _ CM/IN

CONDITION OF ANIMAL 0 WAS ANIMAL SPRAY PAINTED? Y/N

TAG. NO. — DISPOSITION OF TAG & INFO —

IF MORE THAN ONE TAG IS PRESENT, PLACE THE TAG NUMBER(S) IN THE REMARKS SECTION.

FINAL DISPOSITION OF CARCASS 0 IF 3, WHERE SENT ___

REMARKS: Caught by fisherman who described it's hooked bill & confirmed the ID when he saw live Green, Ridley & Hawksbills

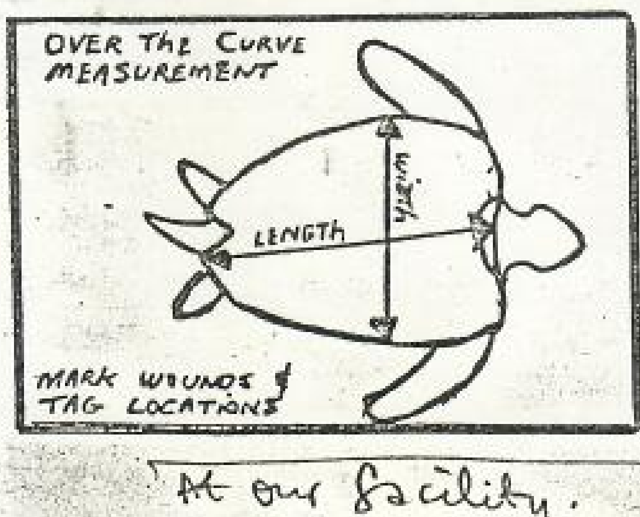
CODES

SPECIES:
- CC = Loggerhead
- CM = green
- LK = Kemp's ridley
- DC = leatherback
- EI = hawksbill
- UK = unknown

SEX:
- F = female
- M = male
- U = unknown

RELIABILITY OF I.D.:
- 1 = unsure
- 2 = probable
- 3 = sure

(if species is unknown, then reliability must be 3)



CONDITION OF ANIMAL:
- 0 = alive
- 1 = fresh
- 2 = brewing
- 3 = el stinko (soupy, foul)
- 4 = mummy (falling apart)
- 5 = skeleton

FINAL DISPOSITION OF CARCASS:
- 0= Released
- 1 = painted, left on beach
- 2 = buried on beach
- 3 = salvaged specimen
- 4 = pulled up on dune
- 5 = partially salvaged, left on beach or buried
- 6= Offshore sighting (Free Swimming)

At our facility.

SEA TURTLE STRANDING AND SALVAGE OBSERVATION REPORT

MAKE ALL MEASUREMENTS OVER THE CURVE AND DOWN THE MIDLINE OF THE TURTLE. MEASURE THE LONGEST LENGTH. THAT IS, FROM THE CERVICAL SCUTE NEAR THE NECK, TO THE TIP OF THE MARGINAL SCUTE (SEE DIAGRAM). BE SURE TO CIRCLE THE UNITS OF MEASUREMENTS (IN = INCHES AND CM = CENTIMETERS). MEASURE THE CARPACE WIDTH OVER THE CURVE AT THE WIDEST PORTION OF THE SHELL. AGAIN, CIRCLE THE PROPER UNITS. THE DIAGRAM PROVIDED, MAY BE USED TO DRAW OR OTHERWISE MARK WOUNDS OR MUTILATIONS FOUND ON THE STRANDED SPECIMEN AND TO MARK TAG LOCATIONS.

PRINT CLEARLY!

OBSERVER'S FULL NAME Anthony F. Amos DATE 8 4 0 9 1 4 (y y m m d d)

TURTLE NUMBER BY DAY 1 STATE TX COORDINATOR'S INITIALS ___ ___ ___

SPECIES CODE CM RELIABILITY OF I.D. 3 SEX U VERIFIED BY COORDINATOR? Y/N

LATITUDE 27° 49.8' N LONGITUDE 097° 03.0' W DESCRIPTION OF LOCATION

South of South Jetty Mustang Island Gulf Beach Texas

straight → 5-60 cm straight → 4-84 cm

CURVED CARAPACE LENGTH _ _ _ 5.9 CM/IN CURVED CARAPACE WIDTH _ _ _ 5.1 CM/IN

CONDITION OF ANIMAL 1 WAS ANIMAL SPRAY PAINTED? Y/N weight 20.32 gm

TAG. NO. _ _ _ _ _ _ _ DISPOSITION OF TAG & INFO ________

IF MORE THAN ONE TAG IS PRESENT, PLACE THE TAG NUMBER(S) IN THE REMARKS SECTION.

FINAL DISPOSITION OF CARCASS 3 IF 3, WHERE SENT UTMSI freezer

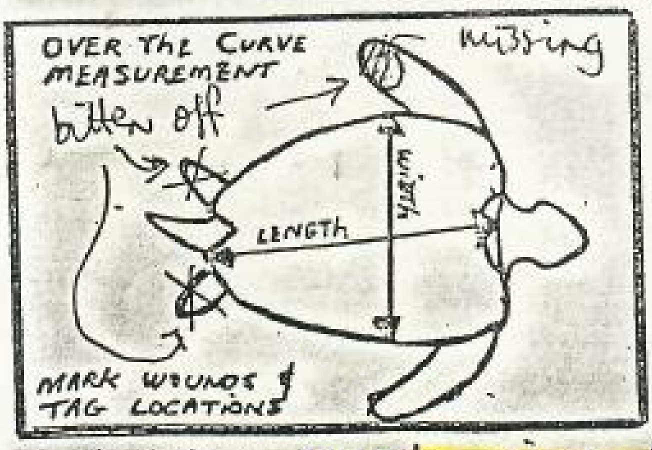
REMARKS: Had tar* in roof of mouth. sent tar specimen to Sandra Varga for analysis

CODES

SPECIES: CC = Loggerhead
CM = green
LK = Kemp's ridley
DC = leatherback
EI = hawksbill
UK = unknown

SEX: F = female
M = male
U = unknown

RELIABILITY OF I.D.: 1 = unsure
2 = probable
3 = sure
(if species is unknown, then reliability must be 3)



CONDITION OF ANIMAL: 0 = alive
1 = fresh
2 = brewing
3 = el stinko (soupy, foul)
4 = mummy (falling apart)
5 = skeleton

FINAL DISPOSITION OF CARCASS:
0= Released
1 = painted, left on beach
2 = buried on beach
3 = salvaged specimen
4 = pulled up on dune
5 = partially salvaged, left on beach or buried
6= Offshore sighting (Free Swimming)

* plus minute pieces plastic - colored foil and spherule of plastic used when polyethylene is cast

(404) 542-2968

Ga. Marine Turtle Cooperative
Research and Education
Inst. of Ecology
Univ. of Georgia
Athens, GA 30602

George Balazs
National Maine Fisheries Service
Southwest Fisheries Center
Honolulu Laboratory
P.O. Box 3830
Honolulu, HI 96812

Received 12/85

Dear George,
I recorded an unusual marine turtle fatality recently that I thought might be of interest to you. After returning from Puerto Rico, I mentioned this freak accident to Jim Richardson and he suggested that you would want to know about unusual mortalities like this.

On 11/24/85, four locals were lobster diving at a 50' coral reef located 100 yards west of Punta Tamarindo on Culebra Island, Puerto Rico (18 degrees 20' N. 65 degrees 20' W). They encountered a juvenile green turtle apparantly drowned by a long trailing "rope" encircling its left front flipper. The free end of the rope was entangled on a coral head which did not allow the animal to surface and breathe. All of the individuals are familiar with the restrictions on endangered species and turned the carcass over to a USFWS maintainance worker. I was given the carcass late that afternoon and refrigerated it until it was necropsied 11/26/85.

The animal was a juvenile Chelonia mydas, curved carapace length notch-to-tip 76.2 cm, weighing 90 kg, and was identified as a female upon gross dissection. The specimen was fresh, likely less than a day old. Nothing was found unusual internally upon necropsy. It was a healthy specimen that had fed recently upon Thalassisa. Pink froth at the base of the trachea, esophagus, and lungs were present, all characteristic of a death by drowning or asphixiation due to a glottal lock.

Externally however, the composition of the "rope" was unusual. It appeared to be fiberous, white, synthetic, but not tightly woven as if its primary use was not as cordage. An observer remarked that it resembled kapok, the element commonly used for flotation in many life vests. We concurred that it was likely a synthetic kapok filling from a discarded life preserver. The long strand of fiber evidently encircled the animals limb as it swam into it. There were no subdermal rope burns or bruises as might be expected if the turtle was purposefully roped. Also, the unusual nature of the fiber is not suggestive that the turtle was purposefully roped. When the trailing end of the strand caught on a coral head, the animal died when it was prevented from surfacing and breathing. Definitely an unusual occurrance but then it is also relatively recently that other discarded trash at sea has been documented as causing the deaths of other marine turtles. Plastic bags kill leatherbacks, right? If you wish to have a copy of the necropsy form, I will be happy to send one.

Although it is about an unrelated subject, I wanted to take the opportunity to ask a question about Pacific green turtles. Do you see any evidence that turtles of the same size class forage together? Or that different sized turtles prefer different foraging habitats? Is there habitat partitioning by different size classes, for instance, with smaller turtles prefering a specific depth or area of sea grass pasture than larger size class greens? Although I have insufficient evidence yet for Puerto Rican greens, my casual observations have been that different areas or depths host a group of foraging animals predominately composed of similar sized turtles. In general, shallow water (<15-20') pastures hosting smaller turtles seems to be a rule of thumb. Have you made any general observations that corraborate or contradict this? It may be that varying compositions of sea grass species are preferred by different size classes as well. Just wondering if there might be a similar pattern out in the Pacific.

Seen feeding? or Resting?

I look forward to your reply.

Sincerely,

Tony Tucker

Tony Tucker

Bill - I overlooked this report when I compiled my "Debris" paper for the workshop last year. I want to enter it into our continuing data base on worldwide entanglements and debris ingestion. Do you recall what year this was?
Mahalo - George

SEA TURTLE SIGHTING REPORT

Please return to: George H. Balazs
~~Hawaii Institute of Marine Biology~~
~~P. O. Box 1346; Kaneohe, HI 96744~~
~~Tel. 247-6631~~, 946-2181

Observation made by: MIKE SONE

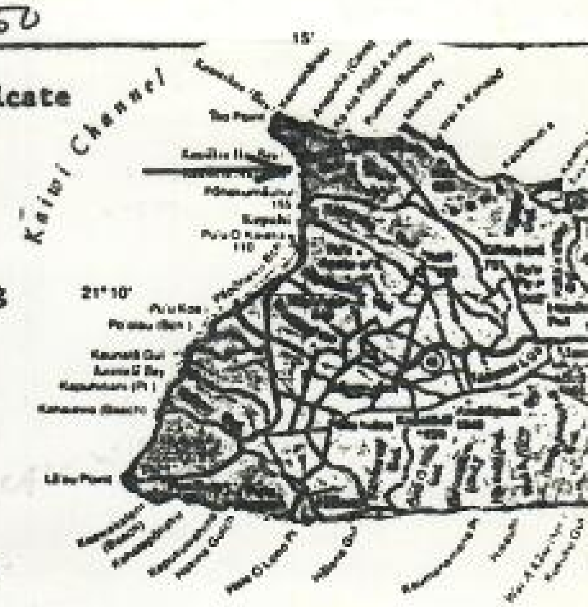
Address & Tel. No. (optional): 558-8850

Date: July 1983 Time: AM Location (indicate on chart): KAWAKIU BAY

Observation made from: ● shore; ___ boat; or while X skin ___ SCUBA diving

Estimated size (shell length): 24"

Turtle seen on: ● surface; or at depth of approx. 20 ft. Distinguishing characteristics (species I.D. if known, long tail, shell color, tags, injuries, tumors, etc)



Other comments: Turtle was seen laying on bottom with approx. 40 lb. Test fishing line tangled around neck + flipper. Line ~~was~~ had cut into flesh. We cut the line free + the turtle swam quickly away.

THANK YOU FOR YOUR COOPERATION

ADDITIONAL COMMENTS FROM RESCUERS:
"ANIMAL probably would not have SURVIVED if the lines had not been cut + removed. His MOVEMENTS WERE severely restricted + that's why they were able to capture him in the first place."

OKEANOS
OCEAN
RESEARCH
FOUNDATION
216 E. Montauk Hwy.
P. O. Box 776
Hampton Bays, N. Y. 11946
(516) 728-4522

George Balazs

National Marine Fisheries Service

P.O. Box 3830 2570 Dole St.

Honolulu, Hawaii

96812

Dear George;

It was nice to see the letter from Sarah went to you. Enough is enough. It seems that she may have had a change of heart regarding toxicants. In either case I have enclosed some representative data on toxicants that we have had. One animal is very interesting since the leval of PCB's was so high that other readings were being blocked. ? 1.92 PPM When I get a chance I will get some of this data together for you in a more complete form but in the interim you are welcome to use the enclosed.

I hope all is well there. We are planning more turtle work this year. Any interesting stomach contents we get I will forward to you.

Sincerely

Samuel S. Sadove

Research Director

Raltech Scientific Services
P.O. Box 7545 • Madison, Wisconsin 53707 • 608/241-4471
A Division of Ralston Purina Company

NY-015-81 A

Other Raltech Scientific Services Laboratories:
St. Louis MO
Gray Summit MO

Speciman #186 file

REPORT

LI 2/26/81

MRS. PEG HAJEK (SUBM. BY E. MCCAFFREY)
NEW YORK STATE DEPT. OF ENVIR. CONSS.
50 WOLF ROAD
ALBANY, NY 12233

RT LAB NO. 849775

ENTERED 03/26/81

REPORTED 04/10/81

LEATHERBACK SEA TURTLE LIVER: ESU 186

PURCHASE ORDER NUMBER C163679

ASSAY	ANALYSIS	UNITS
CADMIUM	0.630	PPM
LEAD	0.0700	PPM
MERCURY	0.0660	PPM

ORG PHOS, CHL INS, PCB

	(PPM)
DDE	LESS THAN 0.05
DDD	LESS THAN 0.05
DDT	LESS THAN 0.05
PCB	LESS THAN 0.10
DIELDRIN	LESS THAN 0.05
BHC	LESS THAN 0.05
LINDANE	LESS THAN 0.05
HCB	LESS THAN 0.05
ENDRIN	LESS THAN 0.05
H.E.	LESS THAN 0.05
MIREX	LESS THAN 0.05
PERCENT LIPID	1.31

METHOD REFERENCES

CADMIUM
PERKIN-ELMER, ANALYTICAL METHODS FOR ATOMIC ABSORPTION SPECTROPHOTOMETRY, NORWALK, CT, SEPTEMBER 1976.
METHODS FOR CHEMICAL ANALYSIS OF WATERS AND WASTES (1979), METALS 1-19 AND METHODS 213.1, U.S. EPA, CINCINNATI, OHIO.
PERKIN-ELMER, ANALYTICAL METHODS USING THE GRAPHITE FURNACE, NORWALK, CT, MARCH 1977.

LEAD
OFFICIAL METHODS OF ANALYSIS (1980) 13TH EDITION, METHODS 25.068-25.073, AOAC, WASHINGTON, D.C. (SAMPLES WITH LESS THAN 4.00 PPM LEAD).

Raltech
SCIENTIFIC SERVICES

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Other Raltech Scientific Services Laboratories:
St. Louis MO
Gray Summit MO

REPORT

MRS PEG SAUER (SUBM. BY E. MCCAFFREY)
NEW YORK STATE DEPT OF ENVIR. CONSS.
50 WOLF ROAD
ALBANY, NY 12233

RT LAB NO. 823840

ENTERED 12/09/80

REPORTED 12/26/80

LEATHERBACK TURTLE MUSCLE: 173

PURCHASE ORDER NUMBER C163679

ASSAY	ANALYSIS	UNITS
CADMIUM	0.215	PPM
LEAD	0.141	PPM
MERCURY	LESS THAN 0.05 PPM	

METHOD REFERENCES

CADMIUM
PERKIN-ELMER, ANALYTICAL METHODS FOR ATOMIC ABSORPTION SPECTROPHOTOMETRY, NORWALK, CN, SEPTEMBER 1976.
METHODS FOR CHEMICAL ANALYSIS OF WATERS AND WASTES (1979), METALS 1-19 AND METHODS 213.1, U.S. EPA, CINCINNATI, OHIO.
PERKIN-ELMER, ANALYTICAL METHODS USING THE GRAPHITE FURNACE, NORWALK, CT, MARCH 1977.

LEAD
OFFICIAL METHODS OF ANALYSIS (1980) 13TH EDITION, METHODS 25.068-25.073, AOAC, WASHINGTON, D.C. (SAMPLES WITH LESS THAN 4.00 PPM LEAD).
OFFICIAL METHODS OF ANALYSIS (1980) 13TH EDITION, METHODS 25.083-25.088, AOAC, WASHINGTON, D.C. (SAMPLES WITH GREATER THAN 4.00 PPM LEAD).

MERCURY
DIGESTION: ANALYST, VOL. 86, P. 608 (1961) WITH MODIFICATIONS.
DETERMINATION: ANALYTICAL CHEMISTRY, VOL. 40, P. 2085 (1968).

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Other Raltech Scientific Services Laboratories:
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Gray Summit MO

REPORT

MRS. PEG SAUER (SUBM. BY E. MCCAFFREY)
NEW YORK STATE DEPT. OF ENVIR. CONSS.
50 WOLF ROAD
ALBANY, NY 12233

RT LAB NO. 823838

ENTERED 12/09/80

REPORTED 01/21/81

LEATHERBACK TURTLE FAT: 173

PURCHASE ORDER NUMBER C163679

ORG PHOS, CHL INS, PCB

	(PPM)
DDE	0.21
DDD	LESS THAN 0.05
DDT	LESS THAN 0.05
PCB	1.84
DIELDRIN	LESS THAN 0.05
BHC	LESS THAN 0.01
LINDANE	LESS THAN 0.01
HCB	LESS THAN 0.01
ENDRIN	LESS THAN 0.05
H. E.	0.03

NO OTHER CHLORINATED INSECTICIDES DETECTED

METHOD REFERENCES

ORG PHOS, CHL INS, PCB
METHOD SUPPLIED WITH EACH SET OF SAMPLES

Raltech SCIENTIFIC SERVICES

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Gray Summit MO

REPORT

MRS. PEG SAUER (SUBM. BY E. MCCAFFREY)
NEW YORK STATE DEPT. OF ENVIR. CONSS.
50 WOLF ROAD
ALBANY, NY 12233

RT LAB NO. 823837

ENTERED 12/09/80

REPORTED 01/21/81

LEATHERBACK TURTLE BRAIN: 173

PURCHASE ORDER NUMBER C163679

CADMIUM
CANCEL, INSUFFICIENT SAMPLE FOR ANALYSIS

LEAD
CANCEL, INSUFFICIENT SAMPLE FOR ANALYSIS

MERCURY
CANCEL, INSUFFICIENT SAMPLE FOR ANALYSIS

ORG PHOS, CHL INS, PCB

	(PPM)
DDE	0.18
DDD	*
DDT	*
PCB	1.92
DIELDRIN	LESS THAN 0.05
BHC	*
LINDANE	*
HCB	*
ENDRIN	LESS THAN 0.05
H. E.	*

* UNABLE TO QUANTITATE DUE TO PCB INTERFERENCE

NO OTHER CHLORINATED INSECTICIDES DETECTED

METHOD REFERENCES

CADMIUM
PERKIN-ELMER, ANALYTICAL METHODS FOR ATOMIC ABSORPTION SPECTROPHOTOMETRY, NORWALK, CN, SEPTEMBER 1976.
METHODS FOR CHEMICAL ANALYSIS OF WATERS AND WASTES (1979), METALS 1-19 AND METHODS 213.1, U.S. EPA, CINCINNATI, OHIO.
PERKIN-ELMER, ANALYTICAL METHODS USING THE GRAPHITE FURNACE, NORWALK, CT, MARCH 1977.

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Other Raltech Scientific Services Laboratories:
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Gray Summit MO

Specimen #173
file

REPORT

dead at Nappeague LI 9/22/80

MRS. PEG SAUER (SUBM. BY E. MCCAFFREY)
NEW YORK STATE DEPT. OF ENVIR. CONSS.
50 WOLF ROAD
ALBANY, NY 12233

RT LAB NO. 823839

ENTERED 12/09/80

REPORTED 01/27/81

LEATHERBACK TURTLE LIVER: 173

PURCHASE ORDER NUMBER C163679

ASSAY	ANALYSIS	UNITS
CADMIUM	12.8	PPM
LEAD	1.95	PPM
MERCURY	0.934	PPM

ORG PHOS, CHL INS, PCB

	(PPM)
DDE	0.18
DDD	LESS THAN 0.05
DDT	LESS THAN 0.05
PCB 1254	0.58
DIELDRIN	LESS THAN 0.05
BHC	LESS THAN 0.01
LINDANE	LESS THAN 0.01
HCB	LESS THAN 0.01
ENDRIN	LESS THAN 0.05
H. E.	0.02

NO OTHER CHLORINATED INSECTICIDES DETECTED

METHOD REFERENCES

CADMIUM
PERKIN-ELMER, ANALYTICAL METHODS FOR ATOMIC ABSORPTION SPECTROPHOTOMETRY, NORWALK, CN, SEPTEMBER 1976.
METHODS FOR CHEMICAL ANALYSIS OF WATERS AND WASTES (1979), METALS 1-19 AND METHODS 213.1, U.S. EPA, CINCINNATI, OHIO.
PERKIN-ELMER, ANALYTICAL METHODS USING THE GRAPHITE FURNACE, NORWALK, CT, MARCH 1977.

LEAD
OFFICIAL METHODS OF ANALYSIS (1980) 13TH EDITION, METHODS 25.068-25.073, AOAC, WASHINGTON, D.C. (SAMPLES WITH LESS THAN 4.00 PPM LEAD).

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Other Raltech Scientific Services Laboratories:
St. Louis MO
Gray Summit MO

RT LAB NUMBER 823839

LEATHERBACK TURTLE LIVER: 173

METHOD REFERENCES

LEAD (CONTINUED)
OFFICIAL METHODS OF ANALYSIS (1980) 13TH EDITION, METHODS 25.083-25.088, AOAC, WASHINGTON, D.C. (SAMPLES WITH GREATER THAN 4.00 PPM LEAD).

MERCURY
DIGESTION: ANALYST, VOL. 86, P. 608 (1961) WITH MODIFICATIONS.
DETERMINATION: ANALYTICAL CHEMISTRY, VOL. 40, P. 2085 (1968).

ORG PHOS, CHL INS, PCB
METHOD SUPPLIED WITH EACH SET OF SAMPLES

00RF-04-80

STRANDING/SALVAGE FIELD FORMS

OBSERVER'S INIT. S.S.S. DATE 09 / 27 / 80 TURTLE NO. BY DAY 03 STATE N.Y.

COORDINATOR'S INIT. S.S.S. SPECIES CODE D.C. RELIABILITY OF ID 3 SEX U

VERIFIED BY STATE COORDIN. X LAT. 40°59'20" N/S LONG. 72°03'50" S/W

DESCRIPTION OF LOCATION Located 1 mile eas west of the west boundry of Nappeague.

CARAPACE LENGTH 59 . CM/IN HEAD LENGTH 17 . CM/IN COND. OF ANIMAL

WIDTH 33 . CM/IN WIDTH . CM/IN PHOTO TAKEN Yes

PLASTRON LENGTH . CM/IN TAIL LENGTH . CM/IN SPRAY PAINTED

(16) WEIGHT . KG/LB WOUNDS/MUTILATIONS Left front Flipper sliced and additional slices on back

TAG NO. TYPE LOCATION DISPOSITION OF TAG & TAG INFO.

TAG NO. TYPE LOCATION DISPOSITION OF TAG & TAG INFO.

FINAL DISPOSITION OF CARCASS 2 IF 3, THEN WHERE SENT

REMARKS: The head, left front flipper, and liver were collected and sent to the D.E.C. This anim[al] had severe slashed across the top and front part of the carapace. Five of them were there, alo[ng] with three on the Left front flipper. All slices were evenly spaced. One of the cuts had opened thoracic cavity to the outer water and sand. The chest cavity was full of sand and water. Insid[e] the trachea there were massive blood clots. The vascular system was almost empty also.

CODES:

Species

C C Caretta caretta, loggerhead

C M Chelonia mydas, green

L K Lepidochelys kempi, Kemp's ridley

D C Dermochelys coriacea, leatherback

E I Eretmochelys imbricata, hawksbill

U K Unknown

Sex

F= female M= male U= unknown

Tag type

M= metal P= plastic O= other

Tag Location

1= inside edge of front flipper
2= inside edge of hind flipper
3= outside edge of front flipper
4= outside edge of hind flipper
5= on margin of shell
6= on shell

Condition of animal

0= alive 2= brewing 4= mummy
1= fresh 3= El stinko 5= skeleton

Final disposition of carcass

1= left on beach (painted)
2= buried on beach
3= collected specimen

Reliability of ID

1= unsure 2= probable 3= sure
if U K, then also include a 3 here.

STRANDING/SALVAGE FIELD FORMS NY-003-80

OBSERVER'S INIT. SSJ DATE 11/26/80 TURTLE NO. BY DAY 14 STATE NY

COORDINATOR'S INIT. SSS SPECIES CODE LK RELIABILITY OF ID 3 SEX __

VERIFIED BY STATE COORDIN. ✓ LAT. 40°54'14" N/S LONG. 73°24'18" S/W

DESCRIPTION OF LOCATION ASHAY IN HUNTINGTON, NEAR A POWER PLANT EFFLUENT, CREATING WARMER WATERS.

CARAPACE LENGTH 33.0 CM/IN HEAD LENGTH __.__ CM/IN COND. OF ANIMAL __

WIDTH 31.3 CM/IN WIDTH 7.5 CM/IN PHOTO TAKEN __

PLASTRON LENGTH __.__ CM/IN TAIL LENGTH __.__ CM/IN SPRAY PAINTED __

(16) WEIGHT 11.4 KG/LB WOUNDS/MUTILATIONS __________

TAG NO. __________ TYPE __ LOCATION __ DISPOSITION OF TAG & TAG INFO. __________

TAG NO. __________ TYPE __ LOCATION __ DISPOSITION OF TAG & TAG INFO. __________

FINAL DISPOSITION OF CARCASS 3 IF 3, THEN WHERE SENT YALE, THEN AMNH.

REMARKS: NECROPSY TO BE PERFORMED AT YALE, THEN FINAL SPECIMEN WILL GO TO THE AMERICAN MUSEUM OF NATURAL HISTORY

CODES:

Species

CC Caretta caretta, loggerhead

CM Chelonia mydas, green

LK Lepidochelys kempi, Kemp's ridley

DC Dermochelys coriacea, leatherback

EI Eretmochelys imbricata, hawksbill

UK Unknown

Sex

F= female M= male U= unknown

Tag type

M= metal P= plastic O= other

Tag Location

1= inside edge of front flipper
2= inside edge of hind flipper
3= outside edge of front flipper
4= outside edge of hind flipper
5= on margin of shell
6= on shell

Condition of animal

0= alive 1= fresh 2= brewing 3= El stinko 4= mummy 5= skeleton

Final disposition of carcass

1= left on beach (painted)
2= buried on beach
3= collected specimen

Reliability of ID

1= unsure 2= probable 3= sure
if U K, then also include a 3 here.

NY-003-80

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Other Raltech Scientific Services Laboratories:
St. Louis MO
Gray Summit MO

Raltech file
Huntington Bay, Suffolk Co
11/26/80

REPORT

RT LAB NO. 837323

ENTERED 02/06/81

REPORTED 03/13/81

MRS. PEG SAUER (SUBM. BY E. MCCAFFREY)
NEW YORK STATE DEPT. OF ENVIR. CONSS.
50 WOLF ROAD
ALBANY, NY 12233

RIDLEY SEA TURTLE BRAIN: 183D

PURCHASE ORDER NUMBER C 163679

ORG PHOS,CHL INS,PCB

	(PPM)
DDE	0.11
DDD	LESS THAN 0.10
DDT	LESS THAN 0.10
PCB 1254	LESS THAN 1.00
DIELDRIN	LESS THAN 0.05
BHC	LESS THAN 0.05
LINDANE	LESS THAN 0.05
HCB	LESS THAN 0.05
ENDRIN	LESS THAN 0.10
H.E.	LESS THAN 0.05

METHOD REFERENCES

ORG PHOS,CHL INS,PCB
METHOD SUPPLIED WITH EACH SET OF SAMPLES

RECEIVED

MAR 26 1981

ENDANGERED SPECIES UNIT
WILDLIFE RESOURCES CENTER

Raltech
SCIENTIFIC SERVICES

P.O. Box 7545 • Madison, Wisconsin 53707 • 608/241-4471
A Division of Ralston Purina Company

NY-003-80

Other Raltech Scientific Services Laboratories:
St. Louis MO
Gray Summit MO

Raltech file

Huntington Bay, Suffolk Co.
11/26/80

REPORT

RT LAB NO. 837322

MRS. PEG SAUER (SUBN. BY E. MCCAFFREY)
NEW YORK STATE DEPT. OF ENVIR. CONSS.
50 WOLF ROAD
ALBANY, NY 12233

ENTERED 02/06/81

REPORTED 03/13/81

RIDLEY SEA TURTLE LIVER: 183C

PURCHASE ORDER NUMBER C 163679

ASSAY	ANALYSIS	UNITS
CADMIUM	0.400	PPM
LEAD	LESS THAN 0.05	PPM
MERCURY	0.170	PPM
ORG PHOS,CHL INS,PCB	(PPM)	
DDE	0.13	
DDD	LESS THAN 0.05	
DDT	LESS THAN 0.05	
PCB 1254	0.91	
DIELDRIN	LESS THAN 0.05	
BHC	LESS THAN 0.01	
LINDANE	LESS THAN 0.01	
HCB	LESS THAN 0.01	
ENDRIN	LESS THAN 0.05	
H.E.	LESS THAN 0.01	

METHOD REFERENCES

CADMIUM
PERKIN-ELMER, ANALYTICAL METHODS FOR ATOMIC ABSORPTION SPECTROPHOTOMETRY, NORWALK, CT, SEPTEMBER 1976.
METHODS FOR CHEMICAL ANALYSIS OF WATERS AND WASTES (1979), METALS 1-19 AND METHODS 213.1, U.S. EPA, CINCINNATI, OHIO.
PERKIN-ELMER, ANALYTICAL METHODS USING THE GRAPHITE FURNACE, NORWALK, CT, MARCH 1977.

LEAD
OFFICIAL METHODS OF ANALYSIS (1980) 13TH EDITION, METHODS 25.068-25.073, AOAC, WASHINGTON, D.C. (SAMPLES WITH LESS THAN 4.00 PPM LEAD).
OFFICIAL METHODS OF ANALYSIS (1980) 13TH EDITION, METHODS 25.083-25.088, AOAC,

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RIDLEY SEA TURTLE LIVER: 183C

METHOD REFERENCES

LEAD (CONTINUED)
WASHINGTON, D.C. (SAMPLES WITH GREATER THAN 4.00 PPM LEAD).

MERCURY
DIGESTION: ANALYST, VOL.86, P.608 (1961) WITH MODIFICATIONS.
DETERMINATION: ANALYTICAL CHEMISTRY, VOL.40, P.2085 (1966).

ORG PHOS,CHL INS,PCB
METHOD SUPPLIED WITH EACH SET OF SAMPLES

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MAR 26 1981

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REPORT

Huntington Bay, Suffolk Co.
11/26/80

RT LAB NO. 837321

MRS. PEG SAUER (SUBM. BY F. MCCAFFREY)
NEW YORK STATE DEPT. OF ENVIR. CONSS.
50 WOLF ROAD
ALBANY, NY 12233

ENTERED 02/06/81

REPORTED 03/13/81

RIDLEY SEA TURTLE FAT: 183B

PURCHASE ORDER NUMBER C 163679

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	(PPM)
DDE	0.70
DDD	LESS THAN 0.05
DDT	LESS THAN 0.05
PCB 1254	1.48
DIELDRIN	LESS THAN 0.05
BHC	LESS THAN 0.01
LINDANE	LESS THAN 0.01
HCB	LESS THAN 0.01
ENDRIN	LESS THAN 0.05
H.E.	LESS THAN 0.01

METHOD REFERENCES

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MAR 26 1981

ENDANGERED SPECIES UNIT
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Balloon barrage today to give lift to National Science Week

By Jim Borg
Advertiser Science Writer

Students from Hawaii schools will join those in 200 other U.S. cities in a massive launch of helium-filled balloons today to kick off National Science Week.

Some 900 balloons will be released in Hawaii, 200 of them from Farrington High School. Other schools participating are Maryknoll High School, Kamehameha Secondary School and Kona Adventist School on the Big Island.

The balloons aren't pure spectacle, however.

Each of the 150,000 balloons released nationwide will carry a yellow postcard, stamped and addressed, so that anyone finding it can mail it to the American Geological Institute in Washington, D.C. Many balloons will be lost at sea, but some may find dry land or passing ships in the Pacific, said Saul Price, staff meteorologist with the National Weather Service.

They will eventually be returned to the students for discussions on atmospheric conditions.

The week's activities here, billed as Science Awareness Hawaii '86, also include visits by scientists to schools, opportunities for school children to spend a day with a scientist, and the announcement of the winner of the Teacher in Inner Space competition. Schools also will have individual activities and there will be displays of science exhibits and posters at Kahala Mall.

The winner of the Teacher in Inner Space program will get a ride in the two-man submersible Makalii, operated by the Hawaii Undersea Research Laboratory at Makapuu.

The winner will be named Saturday at Sea Life Park at a 10 a.m. breakfast program sponsored by the Hawaii Science Teachers Association. Ten teachers are finalists.

Also at the breakfast, laboratory director Alexander Malahoff will give a talk on "Inner Space Frontiers." At 11 a.m., there will be a open house at the laboratory on nearby Makai Pier.

Jo Kanehiro, a Farrington chemistry teacher and president of the Hawaii Science Teachers Association, said the activities are designed to boost public understanding of science and technology and to encourage young students to study science and mathematics.

Other supporting organizations are the Hawaii Academy of Science, the Hawaii chapter of the American Chemical Society, the Hawaii Association for Women in Science and the National Weather Service. The nationwide balloon launch is sponsored by the Triangle Coalition for Science and Technology Education.

Translation No. 76

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
Southwest Fisheries Center
Honolulu Laboratory
P. O. Box 3830
Honolulu, Hawaii 96812

From Suisan Sekai Vol. 30, No. 12, p. 78-84, December 1981.

FISHERY BASED ON THE PAYAO METHOD IN THE PHILIPPINES
(Tōnan-Ajia no tsukegyohō (ukigyoshō) -- Philippine-hen)

By

Yoshifumi Kihara
Overseas Agro-Fisheries Consultants, K.K.
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PREFACE

The countries in Southeast Asia that are known to be using fish aggregating methods in their fisheries include the Philippines, Indonesia, Thailand, and Malaysia. Of the methods used in these four countries, I would like to present some information here on the methods used in the Philippines. The "payao" (a Filipino term for the fish aggregating device) method of the Philippines is described. A description of the Indonesian method will be presented in the next issue of Suisan Sekai.

INTRODUCTION

The author first went to the Philippines on January 3, 1968 in response to a request for a feasibility study on developing a tuna fishery for a local fishing company. That visit was the beginning of a deep, continuing relationship with the Philippines, a relationship that has been nurtured even beyond the wildest dream at the time of the initial visit.

The frozen tuna industry in the Philippines turned into a significant export industry beginning in 1969. The Philippines tuna fishery began with one 380-ton secondhand tuna vessel that caught about 500 tons of yellowfin tuna for export to the United States. With this humble beginning, the tuna fishery has grown year by year, and with the addition of large purse seine vessels to fish around fish aggregating devices (payaos), the landings have grown markedly. In 1979 and 1980, the annual exports of skipjack and yellowfin tunas reached 32,800 and 41,000 tons, respectively. Concurrently tuna canneries were built and this sector of the industry showed remarkable growth. About half of the tuna landings reportedly have been going to the

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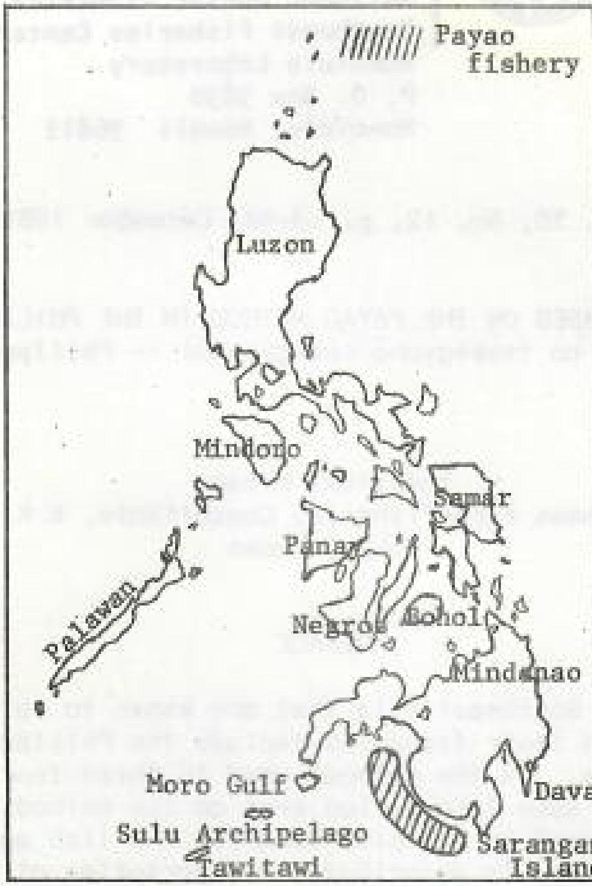
Translated from the Japanese by Tamio Otsu for the Southwest Fisheries Center, Honolulu Laboratory, National Marine Fisheries Service, NOAA, Honolulu, Hawaii 96812, December 1982.



The Philippine Islands

tuna canneries, and by fiscal year 1981, it was estimated that the combined volume of exported and canned tuna would amount to 100,000 tons.[1]

During the early stages of the fishery, from 1969 to 1971, the yellowfin tuna was the principal species sought. The fishery began in waters west of Mindanao. The fishing grounds gradually expanded to waters south of Negros Island, off central Palawan Island, and to waters off Tawitawi Island on the southernmost end of the Sulu Archipelago. At this stage of the fishery, it was observed that local fishermen were already utilizing the payao method in various locations in the Mindanao Sea, in waters surrounding Negros Island, Bohol Island, and Mindanao Island to aggregate such fishes as the suma (kawakawa, Euthynnus sp.) and aomuro (mackerel scad, Decapterus sp.). These payaos, however, served as the prototypes of payaos developed subsequently to attract skipjack tuna and other tunas.

At this writing it is not clear as to when the local fishermen began to use the payao to aggregate kawakawa, mackerel scad, etc. All we could learn

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[1]Translator's note: The text shows this figure to be 10,000 tons, which probably is an error.

from the fishermen was that they had been using this method for "many, many years." The search for the origin of the payao method is a subject for another study.

The basic construction of these "original" payaos was as follows:

1. The main floating body consisting of a bamboo raft.
2. A mooring line made of braided rattan.
3. Anchor of payao consisting of two or three metal drums filled with concrete.

These payaos for kawakawa and mackerel scad were installed in waters between 500 and 1,000 m deep. So that the raft would be visible from a distance, a marker pole made of bamboo and coconut fronds was prominently placed on each raft.

In the Mindanao Sea, anyone is allowed to fish around a payao by handlining, surface trolling, or even small-scale purse seining. The unwritten law, however, says that the owner of the payao is to be paid 25% of the value of the catch made from the payao. Because of this practice it is common to see people installing payaos even if they do not own any purse seine vessels themselves. In spite of this situation, there seems to be no move by any fishery cooperatives to install and manage payaos.

The fishermen are from the vicinity of Cebu Island and they speak Bisayan. One group of these fishermen that had migrated to the southern part of Mindanao was seen to be operating a rather large-scale fishery within the Gulf of Davao. A part of this migrant group had established a base at General Santos in southern Cotabato around 1970 and began carrying out experimental fishing using the payao method. They used 20-ton wooden, purse seine vessels in carrying out their experimental operation. At around that time, all of the catches were being consumed locally around Davao, and such fish as the kawakawa and mackerel scad were selling at higher prices than skipjack and yellowfin tunas. The fishermen were more interested in catching the higher priced fishes, however, as it turned out, the payaos were more effective in aggregating the tunas, and the catches of skipjack and yellowfin tunas increased greatly.

The fishing ground is located 6-7 miles off Sarangani Bay. To the south, off Mindanao, the water was found to be too deep and the currents too strong for payao installation. Not only did it cost more to install payaos in these deeper waters, but the incidence of payao losses was very high. In spite of these problems, the catches from payaos installed in these deeper waters amounted to around 5 to 20 tons per set (purse seine), and the revenues exceeded the higher costs of installation.

The purse seines used by these fishermen are relatively small, measuring about 400 m long and about 80 m deep. The purse line consists of a nylon rope 24 mm in diameter. The net is slow sinking, and the depth of the net is shallow.

The vessels were poorly equipped and did not have net haulers or power blocks. The nets were hauled in manually from either the bow or stern of the vessel. The only deck machinery was a warping drum winch to purse the net.

An American company in Manila introduced the U.S. purse seining method to the Philippines right after the War. The Philippine purse seine fleet has gradually increased since then and at present has grown to be the largest in Southeast Asia, and has played a vital role in the fishing industry of that country. However, it is interesting, and perplexing also, to see the "ancient" Japanese style of purse seining still being practiced in the southern Visayan Sea.

Direct observations have proven beyond any doubt that payaos aggregate schools of fish. Many fishermen fish around payaos and catch yellowfin and skipjack tunas by handline or surface trolling. Even at night, fish are taken around payaos by seining. Thus, there was no question about the effectiveness of payaos in attracting fish, and we decided to undertake our own experimental work with payaos.

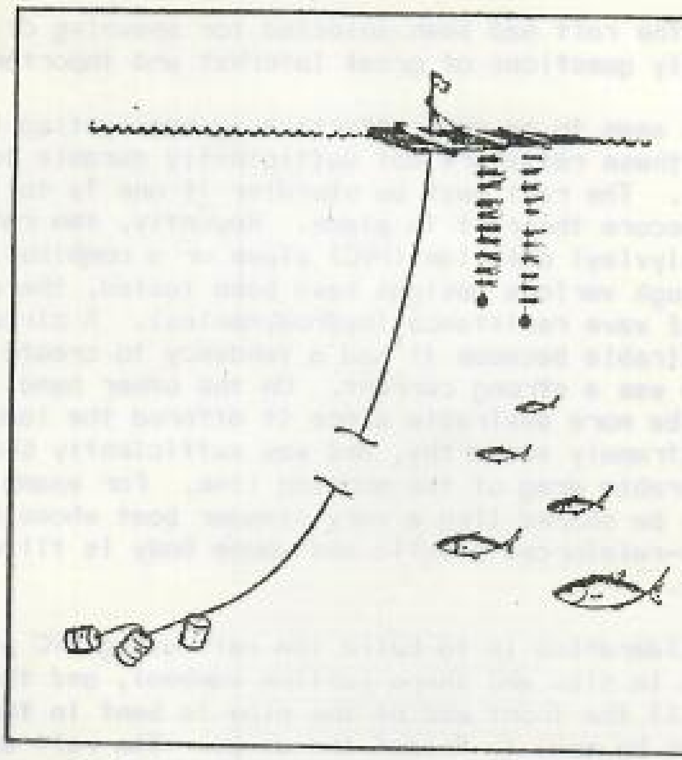
In 1973, we converted a 47-ton wooden tuna vessel (brought from Japan for some other purpose) to a purse seiner. A newly installed payao began attracting schools of fish from around the second week and the aggregation of fish began to increase gradually thereafter. In just a little while, any doubt or skepticism we may have had regarding the payaos, was dispelled by the results obtained. The payaos installed in offshore areas attracted not only such fishes as the dolphinfish, Coryphaena hippurus, but migrating schools of skipjack and yellowfin tunas that appeared to remain with the raft. Lights were used at night to entice the fish to rise closer to the surface where they could be taken by purse seining.

It was soon learned that this fishing method was successful in capturing only a relatively small portion of the school. It was surmised that by using a larger vessel and a much larger net, the payao catches could be dramatically increased, but at that time, no one in Japan would believe in such a possibility.

THE CONSTRUCTION OF A PAYAO

After tuna purse seining operations around payaos began, the installation of payaos increased greatly. In waters off Mindanao (Celebes Sea), it costs much more to install payaos because of the deeper water. At the present time, the cost of construction and installation of a payao is estimated at ¥1,000,000 [US$4,348 @ ¥230 = US$1]. About 50% of the payaos are lost each year from various causes. Thus, the local fishermen now consider the payao an expendable item in their operation. The reason is that once the payaos are adrift there is little chance of recovering them. Since the causes for these losses are not clear, there are no effective countermeasures at present.

With regard to construction of payaos, it must be realized that there is a limit in the availability of necessary supplies, as well as in product



Sketch of a payao in place. Note that drum anchors are placed in a series.

quality. Thus, there is a problem in constructing very substantial payaos that would be able to withstand the very severe conditions of the open ocean. At the present time in the Philippines, the fishermen are attempting by trial and error to build better payaos.

The Raft

The floating body of the payao consists chiefly of a bamboo raft. The raft serves to provide the "shadow" under which schools of fish may find shelter. In addition to the raft, additional attractions are offered by coconut fronds that are suspended under the raft. The coconut fronds provide protection to the small fish that first gather under the rafts. However, the details of the aggregating process are not yet well understood.

It appears that bamboo rafts are more effective in attracting fish than are metal rafts. However, there are other factors that need to be considered such as the difference in shape of the raft, differences in construction material, etc. From our observations, however, it seemed that the single most important ingredient of a payao was the coconut frond. Without it, the payao did not seem to attract fish very well.

In instances when fish gathered under a newly installed payao, it was noted that there was still no growth of barnacles or other organisms on the raft or on the coconut frond. Thus, the reason for the aggregation is not clear. It may have been the accidental (chance) meeting of fish and raft, or perhaps the raft had been selected for spawning or protection. These are certainly questions of great interest and importance.

Bamboo rafts seem to be very effective in aggregating fish. Unfortunately, however, these rafts are not sufficiently durable to withstand the rigors of the sea. The raft must be sturdier if one is to invest so much in anchor lines to secure the raft in place. Recently, the rafts have been constructed of polyvinyl chloride (PVC) pipes or a combination of bamboo and PVC pipes. Although various designs have been tested, there is still the serious problem of wave resistance (hydrodynamics). A circular raft was found to be undesirable because it had a tendency to create eddies (whirlpools) when there was a strong current. On the other hand, a streamlined raft appeared to be more desirable since it offered the least resistance to the waves, was extremely seaworthy, and was sufficiently buoyant to withstand the considerable drag of the mooring line. For example, a suitable raft may possibly be shaped like a very slender boat whose hull is constructed of fiber-reinforced plastic and whose body is filled with urethane foam for buoyancy.

Another consideration is to build the raft using PVC pipes. These pipes are uniform in size and shape (unlike bamboo), and the ends can easily be heat-sealed. If the front end of the pipe is bent in the shape of a sled, the raft can be made to "ride" the waves. The raft should also be very buoyant. The fishermen at Kaohsiung (Takao) in Taiwan are using such rafts as fishing vessels by mounting outboard motors on them. There are many such "boats" in use.

In this way, by a careful selection of construction materials, and by choosing the right design, the future payaos should not only be effective but very durable as well.

Use of Coconut Fronds

Lines to hang the coconut fronds under the raft must be strong and durable. The fronds are securely tied in place 40 m below the surface, and weighted down with rocks (or other materials) weighing about 4 or 5 kg. Expensive lines may in fact be a disadvantage in that they would be targets of thieves. Thus, it is recommended that inexpensive lines be used for this purpose. Wire may be suitable.

The purpose of the coconut frond is to provide food and shelter to small fish that appear under the rafts. Formerly hemp palm leaves were also used for this purpose, but the use of coconut fronds became more common. One problem with coconut fronds is its durability. After turning brown they tend to fall off the wires. Also, in the course of purse seining the fronds are hauled up several times, and they tend to fall off rather easily. Thus, it is necessary that the fronds be replaced frequently. When fronds are lost or become bare, the payao loses it ability to attract fish. Thus, the fronds are an extremely important component of the payao.

Mooring Line

Ever since payaos began to be installed in deep waters, the polyethylene rope came to be used for the mooring lines. The polyethylene rope available and being used locally is the three-strand twisted rope, 12 to 20 mm diameter. In the waters south of Mindanao, the payaos farther offshore tend to attract more fish. Thus, most of the payaos are located beyond 30 miles of the coast. Although the depths are greater than 3,000 m, the fishing vessels are not equipped with any fish finders or depth recorders with adequate range to sound these depths. Thus, when installing the payaos, the fishermen rely on charts for sounding data, and the length of the mooring line payed out accordingly. The known breaking strength of an 18-mm polyethylene rope is about 3 tons. If the depth is 3,000 m, about 18 or 19 coils of rope is used. A defect anywhere along this length of rope could be the cause of an eventual break in the line. The resistance of an 18-mm rope in the water can be estimated. For example, if the maximum current velocity is 5 knots, and if there is uniform effect of the current down to a depth of 250 m, the force on the rope is estimated at around 1.7 tons.

In reality, however, 12-mm polyethylene lines have lasted more than a year whereas 20-mm lines have parted within a month of installation. Thus, the cause of line breakage is not at all clear. However, the 18-mm polyethylene line is generally considered a suitable line for mooring payaos.

Wire is used for the first 50 m of the mooring line. This is to prevent theft and make it more difficult for vandals to cut the mooring line. Many local fishermen in small boats fish around the payaos, mostly handlining for yellowfin tuna. When the fish takes the hook, it requires considerable time before the fish is brought to the surface. While struggling on the hook, the fish may move in circles, and by doing so, may entangle the mooring line of the payao. When this happens, the fishermen will try to save his hard-won catch by cutting the mooring line. This would happen, of course, only when the payao owner is not there to witness this act of vandalism. The wire on the upper 50 m of the mooring line may help to prevent this type of vandalism.

Payao Anchor

Materials that are relatively easy to procure locally--cement, sand, and gravel for concrete to fill metal drums--are used in making the payao anchor. The connecting ring is similar to that used on the raft end of the mooring line, and is made of a large tire whose side is cut out and fitted with a wooden crossbar. As for the anchor ring all but the upper one-fourth of the tire ring is packed in concrete. The submerged weight of each anchor is approximately 260 kg. A total of three to five anchors are used to moor each payao. The anchors are set out in the form of "octopus legs" or strung out in series on a single anchor line. It seems that the latter has considerably greater holding power. As an example, at a depth of 2,000 m, three anchors set out as "octopus legs" (each anchor with its own line starting from the mooring line) were dragged a distance of 2-3 miles by a strong current. However, this slight displacement may actually be advantageous in preventing line breakage.

The reason for using metal drums is their ready availability. Also, from the standpoint of installing a payao, it is necessary that all of the components be readily handled from a small fishing vessel that has only very limited deck equipment. Anything heavier than these drums would be beyond the capability of these small boats.

To increase the holding power of these anchors, they should be set out in a series. In addition, the drums should be fitted with L-shaped steel bars that protrude as spines in various directions. These protruding spines would grab the bottom to further increase the effectiveness of the drum anchors.

GENERAL OBSERVATIONS ON FISH AGGREGATION

The fishing ground that first developed off General Santos (Cotabato) gradually expanded westward. At present, most of the vessels are operating in the Moro Gulf. The fishing ground is not limited to the northern part of the Celebes Sea but has spread throughout the western Philippines to as far north as the area off Lingayen (Luzon Island), to the area off Mindoro, and also to the Sulu Sea. The payaos installed in these areas reportedly have attracted fish in as few as 4 or 5 days. The skipjack and yellowfin tunas, however, generally begin forming aggregations within 2 weeks around payaos set in the northern part of the Celebes Sea. Even at the slowest, the payaos attract enough fish for purse seining in a month's time. Many small schools of fish have been observed in adjacent areas. Thus, it is possible that there is gradual accumulation of fish under the payaos as small schools move in to encounter the payaos. Therefore, it would be desirable to install the payaos in the migratory paths of tunas. Unfortunately, however, there has not been any systematic ecological studies conducted to define the migratory pathways followed by the tunas. The payaos, at present, are therefore installed at locations dictated by the past experience of fishermen.

The payaos should be installed in areas where there are as few current flows as possible. Also, the payaos should be as far removed as possible from others. The depths should not exceed 3,000 m if at all possible. These seem to be the more important practical considerations in selecting the location of payao installation at present. It would be a fortunate happenstance if the selected site should also fall within the migratory path of the tunas.

It is also known that in this general area, the yellowfin and skipjack tuna schools tend to migrate in waters relatively close to the coast. In May and June especially, large numbers of very young skipjack and yellowfin tunas are seen throughout these waters, and extending also into the waters surrounding the Sulu Archipelago. It appears from this that the spawning grounds extend over a very broad area.

The composition of the catch around payaos during the early stages of the Philippines fishery was as follows:

Small yellowfin tuna (2-5 kg)	25%
Skipjack tuna (1.5-4.0 kg)	40%
Kawakawa (0.3-3.0 kg)	25%
Yellowfin tuna (10-20 kg)	5%
Mackerel scad	5%

WINDS AND CURRENTS

Winds and currents have a great effect on the payaos. In the Philippines there are two major seasonal winds (monsoons) as follows: the December-March northeast monsoon and the July-September southwest monsoon. In the waters off southern Mindanao, the influence is greatest when the southwest monsoon blows shoreward. The winds follow a pattern of blowing stronger after midday and continuing strong at night until sometime after midnight. The winds then begin to subside and there is a period of calm lasting from just before daybreak to around midmorning. The wind velocity varies from day to day but is generally high for a period of 3-5 days, and at times up to a week, followed generally by 3-4 days of relatively calm weather.

During the northeast monsoon, strong winds may continue for 5-6 days without any letup, with winds blowing strong throughout the day. Then, there is a 2-3 day period of calm before the strong winds again return. In any case, the strong winds of the monsoons are even stronger than can be imagined, and especially during the southwest monsoon, they blow in sudden gusts. When these winds are encountered, it is difficult to believe that one is sailing in tropical seas. The winds frequently blow at Beaufort force 5, and force 6 winds are not at all rare. Therefore, the winds cause a strong surface current which tends to disperse any fish aggregations that may have formed. Unfortunately, there was no opportunity to measure current velocity. However, it was observed that when the waves were high, the raft of the payao would appear on the verge of sinking from wave action. The raft would submerge and rise violently in a rapid action that could cause loss of raft from line breakage.

Judging by the movement of water around the anchored raft, it was estimated that the current velocity was no less than 5 knots. It is known that in certain localities such as the Zamboanga Channel or between the various islands of the Sulu Archipelago, the currents flow at speeds reaching 7 or 8 knots. Incidentally, the name "Sulu" is derived from a native word that means "current," according to elderly Filipinos.

THE FISHING OPERATIONS

The purse seine operations around payaos are carried out by "purse seine units" which consist of a purse seine vessel, a net skiff, and a light boat. Sometimes a unit may also include one or two fish transport vessels.

Depending on the size of the purse seine vessel, the net skiff is either carried on board or is towed to the fishing ground by the seiner. The light boat is carried or towed by the seiner. Normally, it is sufficient for the light boat to generate 5-10 kW of electricity.

The purse seine vessels vary from 20-gross-ton wooden vessels, to secondhand wooden seiners from Japan, to secondhand tuna vessels that have been modified into purse seiners. Last year, several 500- to 800-ton secondhand seiners were obtained from Mexico, France, the United States, etc. In addition, there are presently some vessels undergoing conversion as well as some that are still on the drawing boards. The total Philippines purse seine fleet is expected to increase to around 50 vessels by the end of this year.

Many of the purse seiners are now being equipped with fish finders and sonars that enable the fishermen to locate fish schools more effectively. It was only a few years ago that the vessels were not so equipped and the fishermen had to estimate the condition of the fish school through other means such as observing handlining and trolling results of small fishing boats around payaos, or by observing bird flock behavior in the vicinity of the payaos. At times, the fishermen also resorted to skin diving to make the observation.

When a purse seiner decides to make a set around a payao, the light boat is moored to the payao and the light is turned on at sunset. The light may either be placed above the water or underwater; there is no observable difference in effectiveness. Only during a full moon, however, is there a difference. The underwater light is more effective during the period of a full moon.

The purse seine set is usually begun in very dim light at dawn (0400-0430 local time) when winds and currents are relatively still. Direct observations have not yet been made of the behavior of the fish school under the raft between the time the light is turned on at sunset and the time the set is made the next morning. However, it is interesting that the behavior of skipjack and yellowfin tunas, either separately or in mixed schools, can be controlled to a certain extent by manipulating the lights and coconut fronds. About 45-60 minutes before the beginning of the set the coconut fronds are detached from the payao and attached to the light boat without lifting them out of the water. The mooring line of the light boat is then disconnected and the light boat is set adrift with the coconut fronds suspended beneath it. Since the raft is connected more or less permanently to the anchor line, it is not practical to detach the raft each time a set is made.

The reason for transferring the submerged coconut fronds from the raft to the light boat is not only to induce the school of fish to move away from the raft to the light boat, but also to have the fronds serve as a "sea anchor" to reduce the drift of the light boat in the winds and currents.

The light bulb is hooded so that light diffusion is prevented. The light is aimed like a spotlight in the immediate vicinity of the light boat. The generator output is gradually reduced to slowly decrease light intensity. When the generator output is reduced to the very minimum, the incandescent light takes on a reddish hue. A transformer may also be used to adjust the intensity of the light. After the light's intensity is reduced, 5-10 minutes are allowed to elapse during which it is assumed that the main body of the fish school is under the light boat. At that time, the net is set around the light boat.

Better results may be expected with the use of fish finders and sonars. When making a set, all the lights on the seiner are turned off. A light boat is usually manned by two persons. The crew on the light boat receives instructions from either the captain or the fishing master on the purse seiner by means of a single sideband radio, a loudspeaker, or signal lights.

Until the purse rings are brought aboard the seiner, the light boat remains within the circle of net, continuously correcting its position. Once the purse rings are aboard, the coconut fronds are hauled aboard and the light boat is moved outside the net. The coconut fronds are examined and replaced as necessary before they are once again suspended beneath the payao.

The purpose of varying the light intensity is to induce as much of the fish school to move from under the raft to the vicinity of the light boat. Also, the lights are intended to draw as many of the fish from the depths to the vicinity of the boat so that they will be within reach of the purse seine. However, the skipjack and yellowfin tunas, unlike, saury, Cololabis saira, bigeye scad, Trachurus japonicus, mackerel, Pneumatophorus japonicus, or sardine, Sardinops melanosticta, are not strongly phototropic. Thus, it is difficult to induce tuna schools to the surface where most of the fish could be taken by a net only 70 or 80 m deep. Up until now, it seems that only a very small fraction of each school was taken by the seiners. This fact was made clear by results of subsequent operations. Without fish finders, let alone a net sonde, it was virtually impossible to determine the exact position of the net in relation to the fish school. Some of the more affluent fishermen invested in larger nets and demonstrated that the catches could be increased by using larger, deeper nets. There was then a rush to larger nets. Today, there are nets that are over 1,000 m long and 300 m deep.

The result has been an increase in the proportion of large yellowfin tuna in catches made with the deeper nets. This confirmed that smaller fish tended to be near the surface and that larger fish tended to be distributed at progressively greater depths. Also, in terms of density, there seemed to be more fish concentrated at the greater depths than near the surface.

Once a set had been made around a payao, it required only a week or two before this same payao was re-populated with fish. Thus, if a purse seine unit had ownership of 20 payaos, the seiner would be able to make continuous sets by carefully selecting the payaos to be fished each day. In this way, it is not difficult for a seiner to average an annual catch of more than 2,000 tons. Since these vessels do not have to run continuously in search of fish schools, having only to run directly to a preselected payao, there is also the advantage of fuel economy, a most important consideration in these times of rising fuel costs.

CONCLUSION

The payao purse seine fishery of the Philippines, although successful in many respects, is still replete with problems. There is the need to improve the payaos so that they are better able to withstand the severe conditions at sea. Various construction materials need to be tested. Installation methods need to be improved. In other words, there are many problems remaining that are related to the physical aspects of constructing and installing the payao.

However, a more serious problem lies in the capture of young fish. Especially during May and June, the catches include fish that appear to be only a few months old. The spawning season in the Philippines is believed to be around January-February. In January-March, there are large numbers of uniformly large fish in the catches. Then there is a sudden appearance of 5-10 cm skipjack and yellowfin tunas in the latter part of April. The uniformly small fish that appear in the catches in large numbers in May are seen to join the ranks of the adult fish by July. The Philippines tuna fishermen have been making an effort, to avoid capturing the young, immature fish. By working through their local tuna associations, they have established voluntary regulations to conserve the resource. However, judging by the number of small tunas that are being processed by the local tuna canneries, it does not appear that the regulations are very effective in preventing the capture of immature fish.

To realize the optimum utilization of the tuna resources on a sustainable basis, it is hoped that this problem of the capture of young fish, as well as other problems mentioned above, will soon be solved.

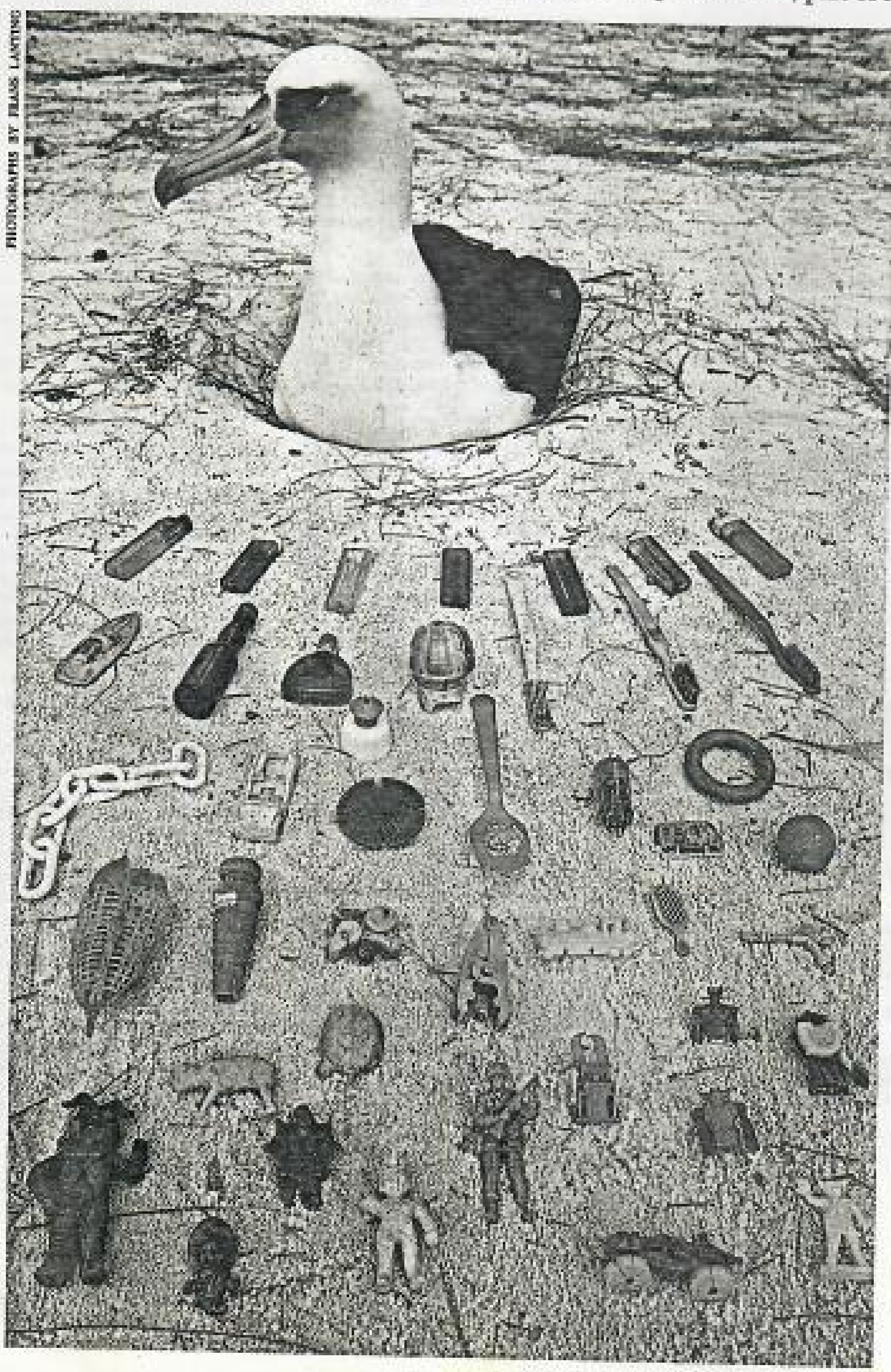
A TIDE OF PLASTIC

RUTH NORRIS

THE SEA TURTLE, a hawksbill, died two days after it was found stranded on a Hawaiian beach. It was a young turtle, its shell only a foot long, and when found it was emaciated and unable to dive.

"This is what I found in its gut," says George Balazs, a National Marine Fisheries Service sea turtle biologist, handing over a plastic Ziploc bag, about eight inches square. It contains a mass of garbage. There are a few pieces of pumice stone, but most of it is plastic—a golf tee, shreds of bags and sheeting, bits and pieces of monofilament line, a plastic flower, part of a bottle cap, a comb, chips of Styrofoam and hard plastic, dozens of small round pieces. "The intestine was completely blocked with this stuff, all matted with fecal matter. That's eight-tenths of a kilogram of plastic. The animal weighed less than five and a half kilograms, so it's no wonder it couldn't dive."

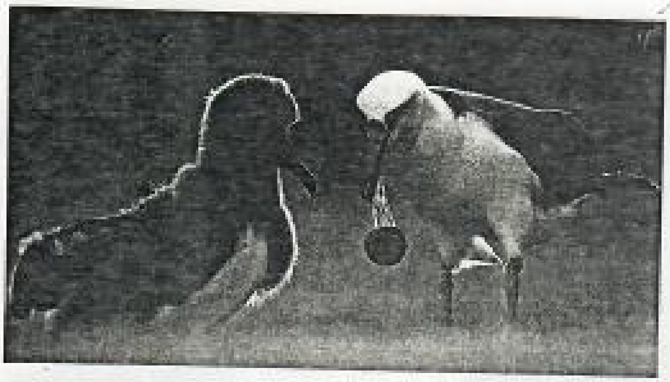
PHOTOGRAPHS BY FRANS LANTING



The western Hawaiian island where this turtle was found is one of the more remote places tracked by the biologists who study creatures of the sea—a tiny speck in a huge ocean, two thousand miles from the American mainland and from the nearest island group to the south. Visitors, however, don't escape constant reminders of those distant worlds. Their litter fills the sea and accumulates daily on the beaches. There are scraps of ropes and lines, strapping, containers, sometimes a whole fishing net weighing hundreds of pounds. Hawaiian monk seals as well as sea turtles have become entangled in plastic lines and nets, which sometimes snag on rocks or reefs and drown their captives. As the carcasses of dead albatrosses decompose on the beaches, the nondecomposing contents of their stomachs remain: plastic fragments, pellets, cigarette lighters, toy cars and soldiers. A recent U.S. Fish and Wildlife Service study of albatross chicks on Laysan Island found 90 percent with some quantity of plastics in their digestive systems.

Almost anyone who treasures remote beaches can tell of discovering some isolated spot littered with fishing gear, plastic sandals, detergent bottles, bags, and assorted debris. Participants in a "coastwalk" cleanup of Oregon beaches two years ago picked up twenty-six tons of garbage in just three hours. Plastic pellets—the raw material

A Laysan albatross surrounded by plastic items collected on the beach of its nesting island in the Hawaiian chain. Five million containers are chucked overboard every day.



A Laysan albatross regurgitates a plastic bottle cap as food for its nestling, and remains of an albatross show plastic debris that had accumulated in its intestine. A study of albatross chicks on Laysan found 90 percent had plastics in their digestive systems.

of which all those utensils, containers, and toys are made—have washed up on New Zealand beaches in such quantities that the beaches seem coated with plastic sand. Some Alaskan beaches are so littered with lost and discarded monofilament fishing nets that any animal hauling ashore risks entanglement and death.

More than 50,000 ships sail the seas, with crews numbering one and a half million. Since very few ports provide adequate facilities for collecting ship-generated garbage, it's not surprising to find the oceans serving as a giant dump. More than five million plastic containers are chucked overboard every day. Plastic cargo nets, sheeting used to protect cargo, strapping bands, and utensils all get the same treatment. Garbage ships haul city refuse out into the ocean to be dumped. Commercial fishermen alone, the National Academy of Sciences estimates, dump more than fifty million pounds of plastic packaging into the sea each year and lose some 300 million pounds of plastic nets, lines, and buoys. Raw plastic particles—nibs, pellets, and beads—find their way into the oceans from the outfalls of manufacturing plants, by spilling as they are loaded for shipping, or by being dumped or hosed off the decks of ships.

Unlike old-time fishing nets of hemp or flax, unlike tin cans and cardboard containers, which sink and eventually disintegrate, plastic garbage is buoyant and nearly indestructible. It collects in huge masses wherever wind and currents take it. It snags and kills wildlife. Plastic banana bags thrown from docks in Costa Rica wind up in the digestive tracts of sea turtles, perhaps because the turtles mistake them for a favorite food, jellyfish. Lost fishing nets continue to capture fish, even though their owners will never return to claim them. They also capture seabirds that dive to catch the fish, unable to see the transparent netting until it is too late. In the North Pacific, netting has been recovered with one hundred dead seabirds and two hundred dead salmon entangled in a single piece.

This tide of plastic garbage began to surge just after World War II, when disposable, durable, inexpensive polymer materials came into wide use. The 1960s brought a tremendous increase in commercial fishing, with an attendant loss and abandonment of more and more gear. Each year brings new and stronger plastics and yet more uses: oxygen-barrier bottles that can keep the fizz in soft drinks; plastic containers tough enough to be reheated after packing perishable foods. Unfortunately, products made more durable for supermarket shelves are also more durable after disposal. But "upscale convenience products" continue to replace bottles and cans. Plastic packages can go from microwave to table, and plastic containers are lighter and take less energy than metals to manufacture. "Almost everything that's in other packaging now is apt to find itself in plastic eventually," declares a spokesman for the Society of the Plastics Industry.

Something similar could be said for the creatures of the sea. They find themselves in plastics, and plastics in themselves, accidentally. Seabirds may mistake plastic pellets for the tiny crustaceans they normally feed on. One part of the problem, notes George Balazs, is that "tides and currents tend to concentrate plastics in the same way they normally concentrate food items. If it's where food is supposed to be, it gets eaten."

Seals and sea lions are in particular danger because they tend to cozy up to nets, strapping bands, and lines. At the National Marine Fisheries Service lab in Honolulu there are pictures of Hawaiian monk seals—among the most endangered marine mammals occurring in U.S. waters—entangled in nets, encircled by packing bands, muzzled by container rings. One seal is easily recognizable by a scar around its neck left by a strapping band. For years the seal carried the band, which became tighter and tighter as the seal grew around it.

Anecdotal evidence from other areas is even more gruesome. "I observed a sea lion with a net fragment so deep in its tissues that the net had cut through skin, blubber, and muscle and had actually cut open the trachea," Rich Tinney of the Center for Environmental Education told a congressional committee two years ago. "The animal was incapable of diving for food because water would enter its throat through the opening cut by the net."

THE BEST EVIDENCE of the plastics pollution problem, and perhaps the most devastating effect on a single species, can be found in the North Pacific. There, each night, Japanese, Taiwanese, and Korean fishermen set out their eight-mile-long, twenty-six-foot-deep nets, with weights at the bottom and floats at the top. In all, the night's work stretches 20,000 miles of invisible curtains of net. Because their gills catch on the nets, fish too large to make it all the way through the mesh become caught when they attempt to back out. Each morning, when the nets are retrieved, an average of ten miles of netting escapes detection. And thousands of miles of deteriorated nets are abandoned or dumped overboard each year. These "ghost nets" continue to fish until they wash ashore or sink from the weight of their catch.

This fishery has been controversial since its inception. Native Alaskans have objected to the Asians' interception of anadromous salmon that otherwise would return to Alaskan waters. Although an agreement with Japan has recently been signed, it will have little effect beyond moving the fishery to inshore waters, and it postpones a planned phaseout for five years.

A few of these nets, and a great many more from the bottomfish trawlers that ply the Bering Sea, are a major threat to northern fur seals. Fur seals have themselves been a subject of considerable controversy: Their population has declined dramatically, and reauthorization of the treaty that protects them was held up because of protests by animal-rights groups against the hunting of seals by Pribilof Islanders. But, according to National Marine Fisheries Service researchers, ten times as many seals are killed each year when they become caught in plastic fishing nets as are killed in the hunt. On at least four separate occasions, floating balls of netting and debris containing eight to twelve dead fur seal pups have been sighted. Since the area inhabited by fur seals is vast, these few sightings undoubtedly represent only a tiny fraction of actual occurrences.

WHAT IS TO BE DONE about a problem whose dimensions can only be guessed at, whose consequences appear only as its victims happen to be washed up by winds and currents, whose sources encompass the whole of factories on land and ships at sea? Although there are laws and treaties prohibiting the disposal of persistent plastics at sea, they are not binding on all ships, and detection and enforcement have not been high on any country's priority list. The unintentional loss of fishing gear is not criminal. In the United States, the National Oceanic and Atmospheric Administration is responsible for preparing five-year plans for the control of oceanic pollution. But the agency has barely begun to address the plastics problem. Until 1985, notes Michael Bean of the Environmental Defense Fund, it was possible to read the national marine pollution plan from start to finish without even finding mention of entanglement.

Those who study the problem have several items on their action agenda. Existing legal authorities could be used to pursue research. Current laws could be enforced and aid programs administered in such a way as to minimize dumping. Development of more biodegradable plastics could be encouraged, and additional international treaties could be brought into force.

It was by congressional directive—a million-dollar appropriation specifically designated for work on marine debris—that a NOAA agency, the National Marine Fisheries Service, came up with a plan. The overwhelming majority of the funds have been put into research and education, however. Less than fifteen percent are for measures actually aimed at reducing the amount of garbage in the sea, and even here, the emphasis is on encouraging the shipping fleet not to litter and on studying potential alternatives. Only five thousand of the million dollars are earmarked for developing strategies to enforce existing prohibitions on disposal of plastics at sea.

Two treaties currently regulate the dumping of plastics at sea: the London Dumping Convention (implemented in the United States by the Ocean Dumping Act) and MARPOL, diplomatic shorthand for the 1973 Marine Pollution Convention. The former regulates trash-hauling ships, the latter other vessels. MARPOL's prohibition against dumping persistent plastics, though, is contained in an "optional" section known as Annex V. It has been signed by twenty-four countries but will not be put into effect until it has been signed by countries representing half the gross tonnage of the world shipping fleet. If the United States and Britain, each with about five percent of the world tonnage, were to sign, Annex V would acquire force of law.

"There are a number of laws enacted for other purposes that might be brought to bear, assuming a creative and aggressive desire on the part of agencies to address the entanglement problem," adds Michael Bean. For example, the Endangered Species Act, Migratory Bird Treaty Act, and Marine Mammal Protection Act prohibit the killing of marine birds, turtles, and mammals. Negotiations with fishermen might produce agreements on precautionary measures to be taken in return for immunity from prosecution for accidental kills. Then there are programs that compensate fishermen for lost gear. Fishermen who wished to participate in those programs could be required to mark their gear, dispose of it safely, report inventories and disposition of all gear, and notify authorities when they spotted concentrations of debris. (Presently, foreign fishermen operating in U.S. waters are required to mark gear with their radio call signals, and they have U.S. observers on board who at least theoretically could enforce the Fishery Conservation and Management Act's prohibition on discarding gear into the ocean. But there are no such requirements on U.S. ships.)

Some states have made attempts to attack the problem at its source, enacting laws and creating incentives for the use of biodegradable plastics. Although it is too soon to rely on these products as a solution, their hazards at least are shorter-lived than those of what's out there now.

Eight states now require the plastic yokes that bind six-packs to be made of biodegradable materials, and similar legislation has been proposed in two dozen other states. These plastics remain strong while kept inside stores and homes but become brittle and decompose into tiny flakes when exposed to sunlight. Since the ultraviolet rays that do the job don't penetrate seawater, a different tack would have to be taken for plastics used by ships—perhaps disintegration when exposed to saltwater.

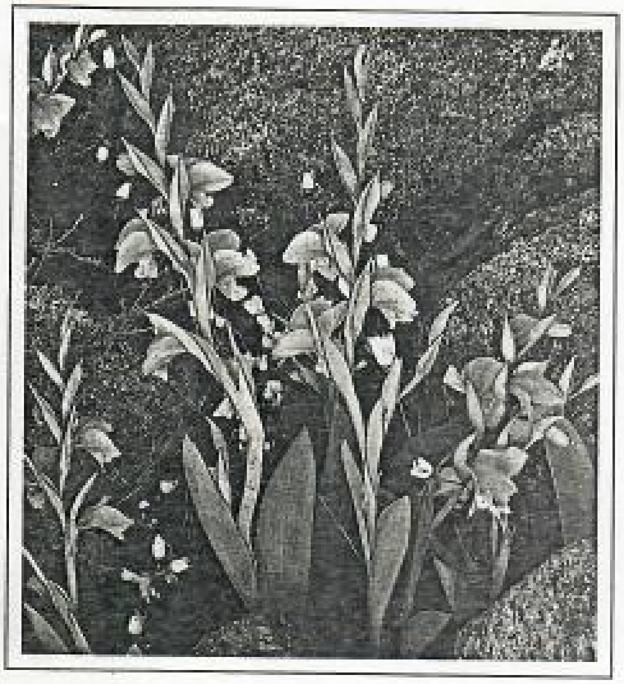
Firms that have specialized in biodegradable plastics (Good 'n Tuff garbage bags, for example) have found their products to be price-competitive with standard-issue plastics, but the real question is whether consumer demand will lead to an expanded array of degradable products. One of plastics' prime selling points has been their durability, and many firms fear that degradables will hurt plastics' overall reputation for reliability.

And so the masses accumulate. The same currents and tides that shift and deposit sands on shorelines also bring their daily loads of oceanic litter. In the northwestern Hawaiian Islands, observers have begun gathering the trash, hauling it off or burning it, and they have seen a decrease in the number of monk seals entangled. But the fur seals, whales, sea otters, manatees, turtles, and all the birds—murres, puffins, shearwaters, auklets, albatrosses—are not so closely concentrated or so carefully tended. Each species has its band of dedicated researchers. All of these monitors have ideas about the extent to which their charges are being harmed by plastic debris, and about the strategies that might bring the problem into focus and under control. What is missing is that creative and aggressive desire, fuel to turn agencies that *could* be doing something into partners in pollution control.

SEPTEMBER 1986
VOLUME 88, NUMBER 5

AUDUBON

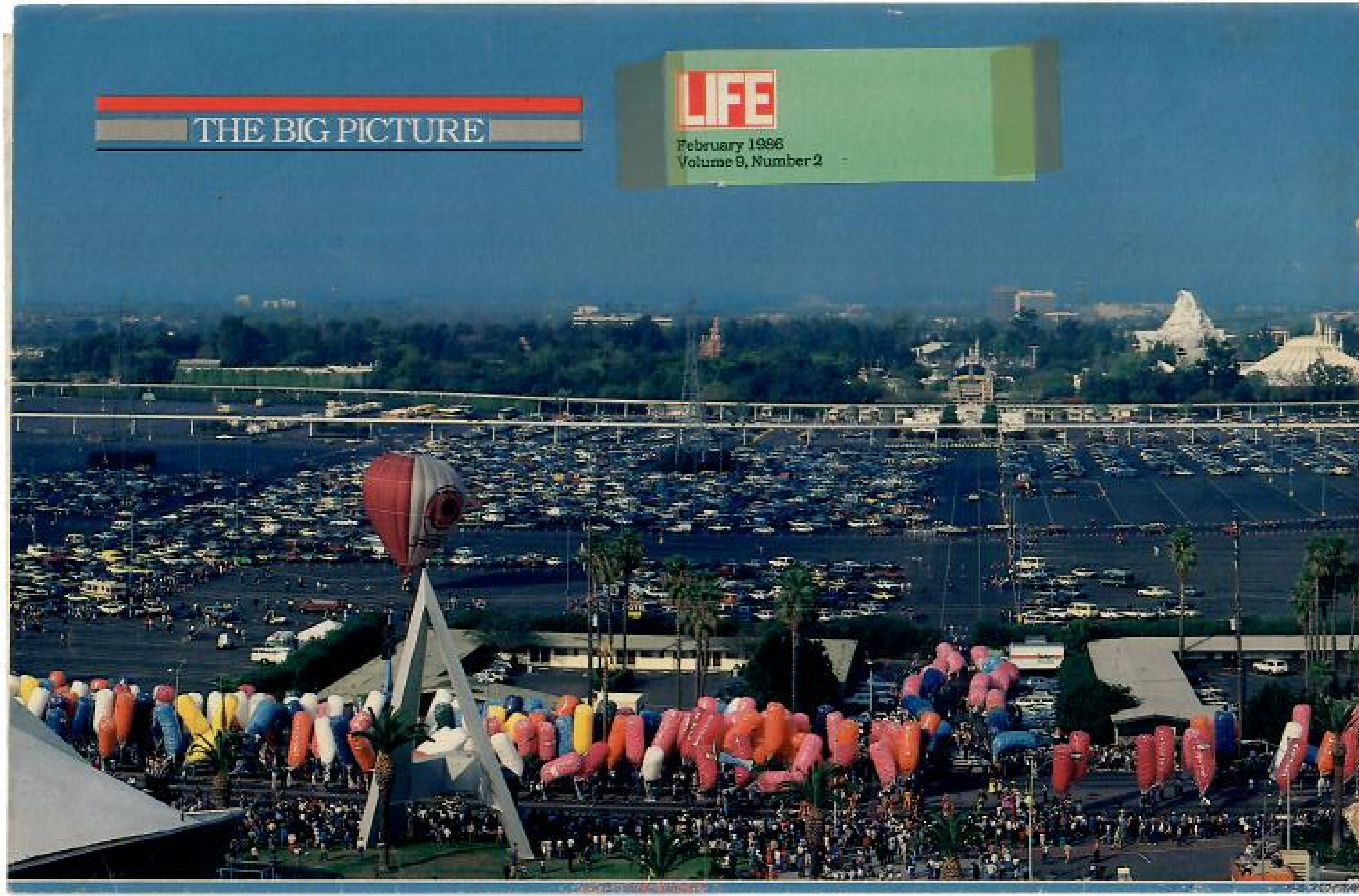
The Magazine of the National Audubon Society



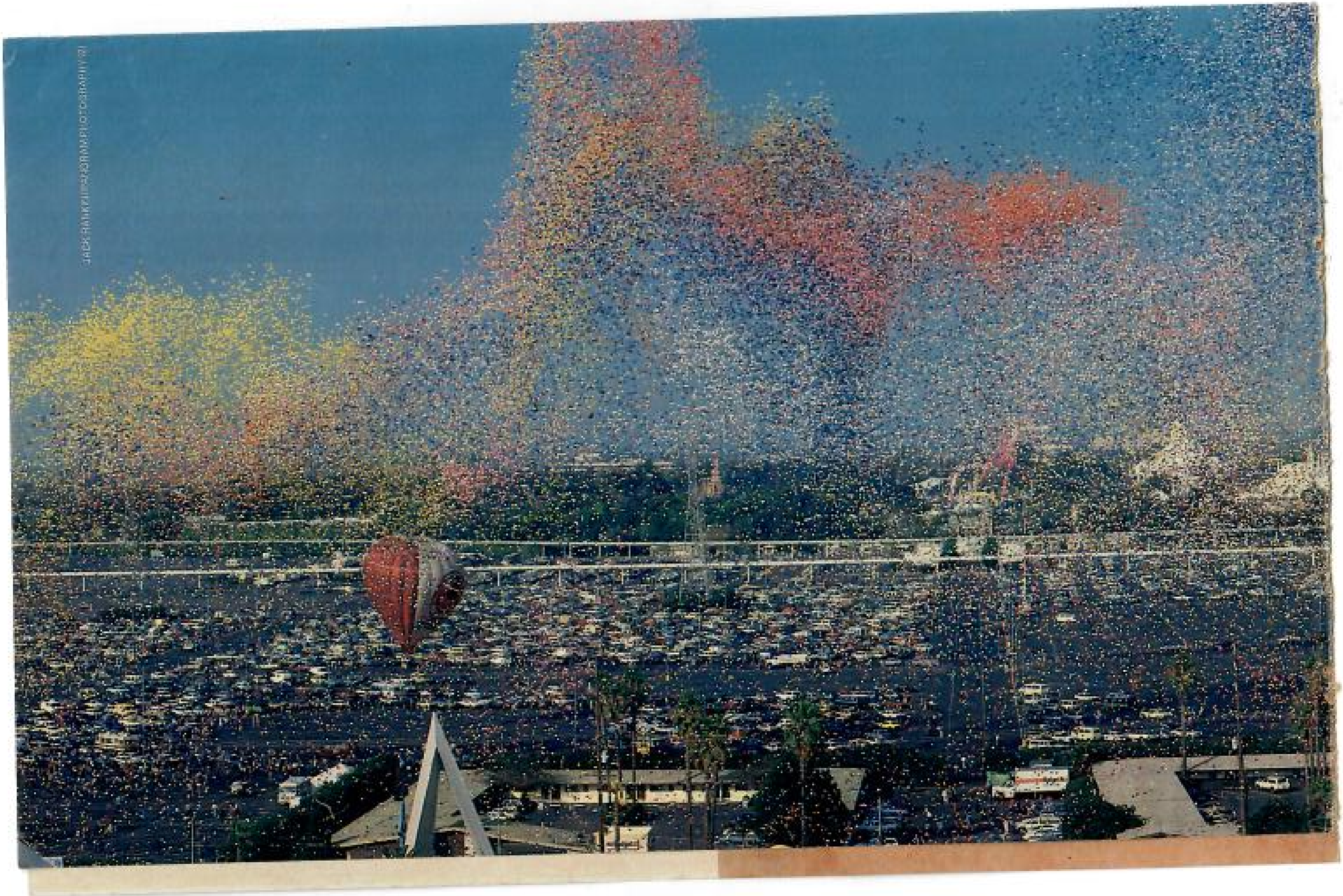
ARTICLES

DEPARTMENTS

The cover: *Alaskan caribou, photographed by Mark Newman.*

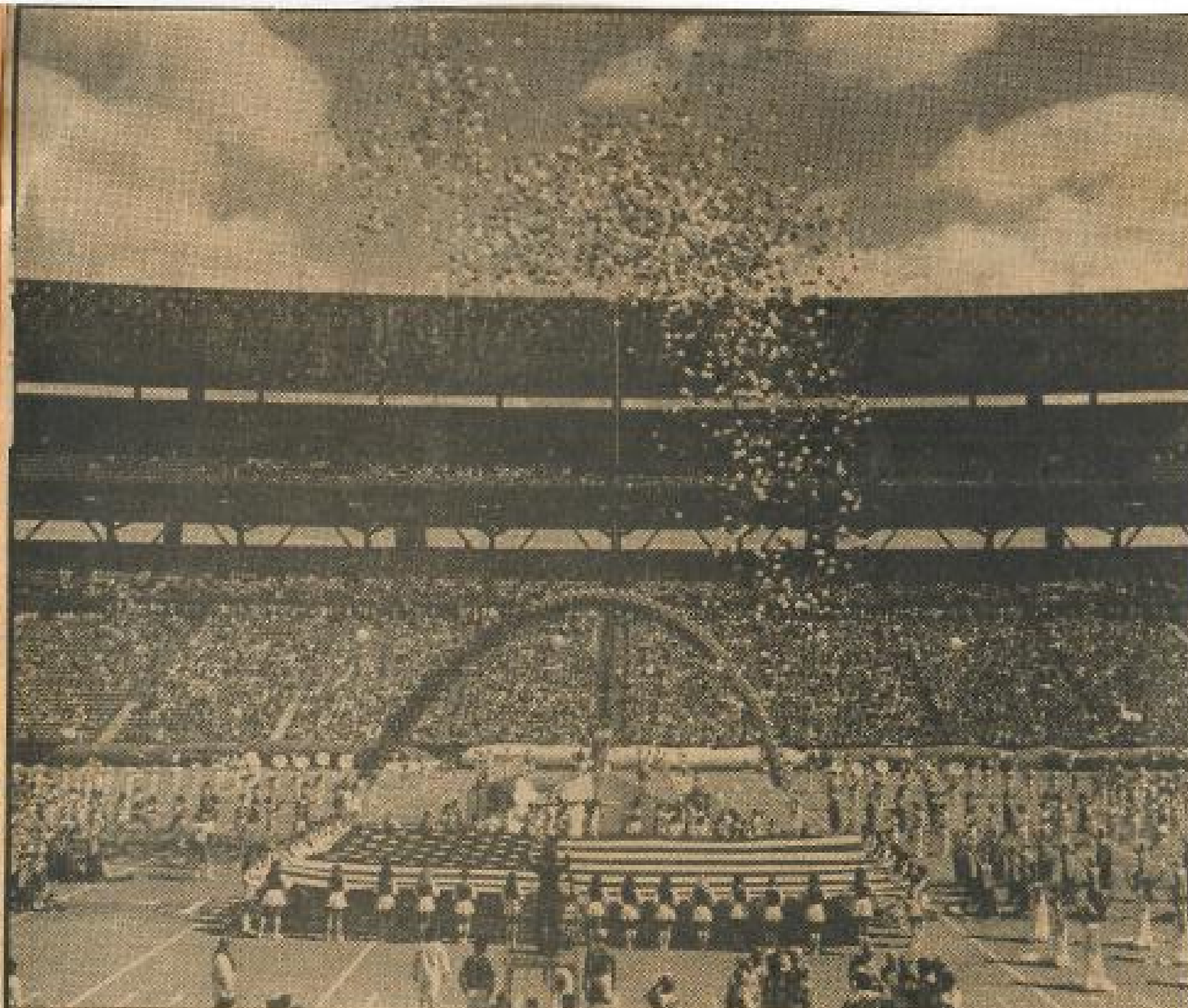


THE BIG PICTURE
LIFE
February 1986
Volume 9, Number 2



Aloha!

Today is Sunday,
Jan. 12, 1986
ADVERTISER



Advertiser photo by Carl Viti

20,000

Hula-balloo(n)

Sometimes the Hula Bowl halftime show provides as much excitement as the game. Thousands of balloons were released during a "A Salute to the Statue of Liberty" presentation yesterday. Oh, yes, the West defeated the East, 23-10. The Advertiser's Hula Bowl coverage is on Pages I-1, 2 and 3.

Oct. 10, 1986 SAMOA NEWS (Pago Pago, Am. Samoa)

Peace Message Inside Balloons

At sunrise on October 11th, approximately 300 girls from the Pago Pago Stake and Pago Pago West Stake will join with 300,000 other girls throughout the world to attach messages of peace to helium-filled balloons. The balloons will then be sent aloft in a massive international exercise, symbolizing a rising generation committed to peace, faith and hope for the future.

The event on October 11th will involve young women from 95 nations, aged 12 to 17, most of them members of the Church of Jesus Christ of Latter Day Staints. Local leaders, Salei'a Faamuli and Rosemary Chamberlain, extends this opportunity to other young women in American Samoa to join with the local unit in sending messages of peace. Interested young women may contact them for further information about their participation.

A brief program will be held on Saturday morning, prior to the releasing of the balloons. Special music has beeen rehearsed and several of the girls will share their messages with the audience. The balloons will be released at Pago Pago Park Stadium. Parents, friends and other interested persons are cordially invited to attend the celebration.

Balloon launch goes astray, closes airport

The Associated Press

CLEVELAND (AP) — About 1.5 million multicolored balloons were released Saturday as part of a charity fund-raiser, but shifting winds carried them onto an airport runway, closing it for a half-hour.

The balloons were held inside a net-covered structure built with scaffolding on Public Square in downtown Cleveland until their release as part of the United Way Services of Cleveland's fund-raising campaign.

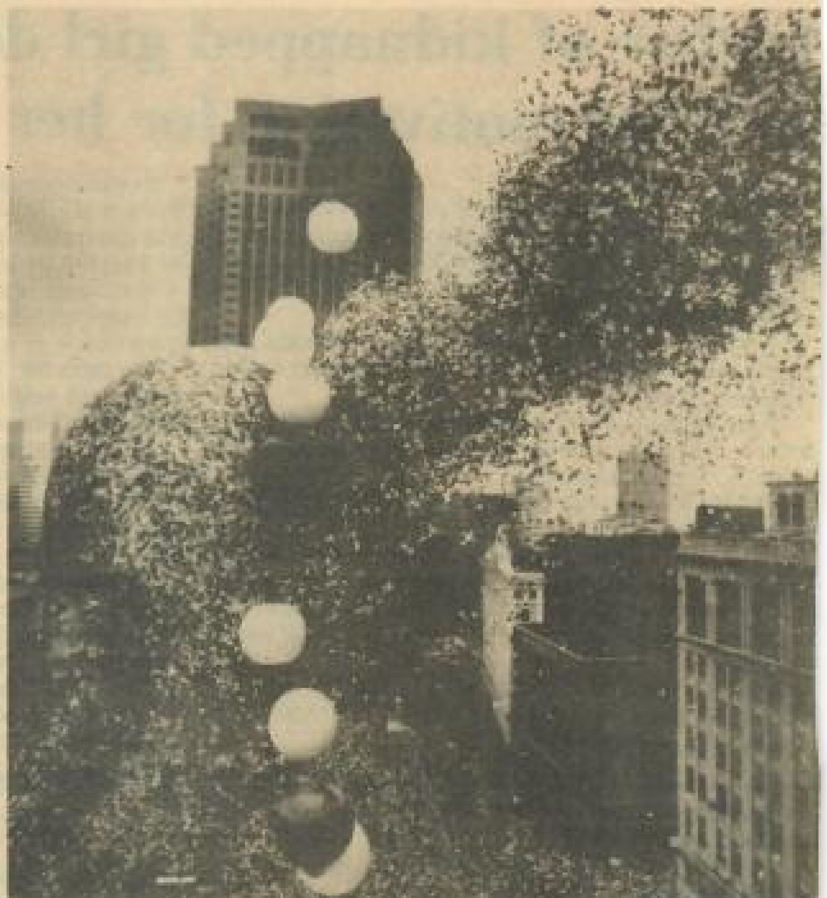
They were released about 15 minutes early as bad weather threatened to interfere. Thousands of people jammed nearby downtown streets that had been closed.

However, as winds shifted and carried thousands of ballons north to Lake Erie, where they dropped into the water, and onto the runway at Burke Lakefront Airport, less than a mile away.

The runway was closed for a half-hour because the ballons made it unsafe for aircraft, according to an airport tower worker who would not give her name.

Promoters claimed the event set a world's record for a balloon launch, breaking the world record of 1.1 million set in December 1985 at Disneyland in California.

Officials from the Guinness Book of World Records were said to have attended to verify the number of balloons.



The Associated Press

A balloon launch in Cleveland may have been a record, but in the process closed an airport runway along the banks of Lake Erie when shifting winds carried them toward Burke Lakefront Airport.

Hundreds of high schools students arrived as early as 4 a.m. to help fill the ballons with helium.

The balloons were released a net, creating a huge dome-shaped mass, then large balloons attached to the net lifted one side, allowing the smaller ones to break free.

HONOLULU ADVERTISER Advertiser photo by T. Umeda

10,000 balloons, 10,000 bucks

11-17-86

The Hawaii Chapter of the Arthritis Foundation launched about 10,000 of these balloons at Ala Moana Park yesterday during its "Up, Up and Away with Arthritis" Christmas craft fair. Each of the balloons represented a $1 contribution to the organization.

Sunday Star-Bulletin & Advertiser

Aloha!

Today is Sunday,
Jan. 11, 1987

Advertiser photo by Carl Viti

Aloha — and then the West won

The finale of the 41st Hula Bowl halftime extravaganza set thousands of balloons free over Aloha Stadium. The theme of the show was "A Tribute to the Great Men of Hawaii." Those honored were King Kamehameha I, Ellison Onizuka, Duke Kahanamoku, Alfred Apaka and John A. Burns — the final three are pictured here. The West won the game, 16-14. Report of the game starts on Page F-1.

Bill → George

Pact limits dumping in S. Pacific waters

London Observer Service

GENEVA, Switzerland — A treaty for the protection of the South Pacific's coastal seas outlaws the dumping of a long list of wastes, including radioactive materials and persistent plastics.

The accord, which overcomes sharp differences of policy over nuclear power, has been approved by 12 independent island-states plus the United States, France, Australia and New Zealand.

The treaty is one of three environmental protection agreements adopted for the South Pacific. Promoted by the United Nations, the agreements commit the signatories to prevent, reduce and control pollution and to cooperate in combating pollution emergencies.

The agreements resemble several earlier international arrangements for the protection of the major "regional seas," such as the Mediterranean and the wider Caribbean. But they go further.

With the conclusion of the South Pacific accord, the United Nations' marine protection program virtually rings the globe. The only remaining missing link is a regional treaty now under discussion for the Indian Ocean.

The global plan amounts to a coordinated attempt to bring the conflicting priorities of economic development in harmony with the needs of nature.

"Contrary to popular belief, the South Pacific islands are not tropical paradises removed from serious worries," says a specialist spokesman for the U.N. Environment Program. "The fragile ecology of the islands is under growing pressure.

"They are faced with substantial environment problems, including waste disposal, soil erosion, forest destruction, coral reef damage, unsound coastal development, water pollution and the poisoning of people and the environment by toxic chemicals."

The treaty area covers an immense combined marine zone taking up 200 miles around every island in the South Pacific — including New Zealand and Papua New Guinea in the west, to the Pitcairn Islands in the southeast.

The Northern Marianas, the Marshalls and Kiribati lie on the northern extremities. New Caledonia, Vanuatu, Fiji, Tonga and the Cook Islands lie on the southern periphery, along with Australia and New Zealand.

Each of the U.N.'s regional marine protection plans amount to a compromise reconciling many conflicting local interests. Discussions leading to such regional strategies have often brought together hostile neighbors in search of cooperative solutions to their common problems.

The South Pacific accord establishes a "black list" of materials which may not be put into the ocean under any circumstances. Among them are radioactive substances, mercury, persistent plastics, crude oil and refined petroleum products.

A "gray list" of materials that may be dumped with a special permit includes arsenic, lead, copper, cyanides, chromium, nickel, fluorides and pesticides.

All the regional sea treaties call for environmental protection against pollution. The South Pacific accord also records the region's commitment to safeguarding the traditions and cultures of its peoples.

The signatories assert that resource development must be placed in harmony with the maintenance of the unique environmental quality of the region.

2/22/87

187 Sunday Star-Bulletin & Advertiser

Someone's trash is absolutely nobody's treasure

By Jan TenBruggencate
Advertiser Kauai Bureau

KEANAHAKI BAY, Niihau — It may strike many as ironic, but the most littered beach in all Hawaii is on remote Niihau.

The white sand beach at Keanahaki is barely visible under the plastic.

I remember catching sight of it years ago during a flight over the island. From on high, the shore looked like a bucket of plastic beads, all red and blue and white and pink and orange.

But last week, I jogged down the Niihau coast and walked on it.

On the trash. The northern end of the beach has so much jetsam that you walk on it, not around it.

The stuff has been collecting for years. The unique configuration of this island keeps it coming. It also keeps it from leaving.

The result is the most amazing pile of floatable trash imaginable.

The dead fish, seaweed and driftwood are there, but they're outmatched by the man-made litter.

Plenty of the litter had come from ships: heavy black and green cargo nets and torn fishing nets, lengths of nylon and polypropylene line, buoys mainly in orange and black shades, most of them cracked or crushed.

Plenty of fishing floats, too, and all of them plastic. There are fewer and fewer glass balls to be found these days on Hawaii's beaches.

A bunch of plastic crates, sized to hold liter bottles. Perhaps milk bottles, but I suspect stronger stuff. Foreign lettering.

There were the things that might have been thrown from ships. A bottle of Suntory whiskey, empty, and various other glass jars and bottles, many with their caps on. None had a message.

I looked, because I thought of George Green, a man I interviewed who worked on cruise ships. Green threw bottles off ships, but he always first stuck in a note, perhaps the day's shipboard menu and maybe a little flag. Finding a George Green bottle was finding a treasure.

No treasures of that sort this day at Keanahaki.

I found five-gallon paint cans and five-gallon fuel cans, all plastic and all battered. There were pieces of pipe, a big plastic garbage can, bits of rubber, colored plastic bottle caps, light bulbs.

Toys of various kinds washed up. Little toy creatures, a toy pistol.

There were mysterious things it seemed better not to touch. Things with metal and pieces of wire attached. Explosives have been known to wash ashore on this island, with the Pacific Missile Range Facility's test range just upwind.

A glass television set's picture tube was half buried in the sand.

The stuff in some places was two feet deep. In other spots you could actually see stretches of sand. Room for more of the ocean's floating litter.

Advertiser photo by Jan TenBruggencate

Keanahaki Bay is the most-littered beach in all Hawaii.

Niihau is a long island that points its low northern end into the northwest trade winds. The trash from across the shipping lanes of the north Pacific blows down here and can bump along the base of the island's eastern cliffs.

At the south end of Niihau, there's a little hook, Kawaihoa, that sticks out and gathers it in. Keanahaki's beach is a crescent of sand and rock inside the hook.

Just perfect for trapping the trash of the sea. Or rather, the trash that humans relegate to the sea.

FLORIDA NEWSMAKERS

Ocean trash means trouble for turtles

Oceangoing litterbugs and industrial waste pose a major threat to the endangered sea turtle, University of Florida researcher **Archie Carr** of Gainesville says.

Sea turtles often eat floating plastic bags, bottles and other pollutants and these indigestible objects clog their digestive tracts and kill them, says Carr, a zoologist who is widely recognized as the world's foremost expert on sea turtles.

"Records of such mishaps have increased markedly in recent years," Carr said, "And this definitely poses a threat to sea turtle survival, if not now, then 10 or 15 years in the future."

Carr will publish an article on the problem in a special issue of the "Marine Pollution Bulletin."

A colleague of Carr, **George Balzas**, who is a marine scientist in Hawaii, has documented massive evidence on the threat plastic pollution poses to sea turtles.

FLORIDA TODAY—AP

ARCHIE CARR AND FRIEND: University of Florida zooligist ponders the future of sea turtles as a female crawls back into the water after burying her eggs on a Costa Rican beach. Plastic pollution is taking a heavy toll on the turtles, Carr says.

The Western Pacific Fishery Management Council, a federally sponsored organization representing Hawaii, American Samoa, Guam and the Commonwealth of the Northern Mariana Islands will be holding a series of meetings to discuss management of Bottom-fish, Lobster, and Pelagic Fisheries, and will be co-sponsoring with the National Marine Fisheries Service a presentation on the effects of Ocean Trash on wildlife and fish.

Photo by: George H. Balazs

What starts out as innocent garbage can cause inhumane effects.

- The Presentation will be held on Monday, March 9, 1987 at the Ala Moana Americana Hotel 7:30 pm-9:00 pm
- The Council Meeting will be held March 10, 1987 at the Ala Moana Americana Hotel 9:30 am-5:00 pm and March 11, 9:00 am-2:00 pm.
- The Council's Scientific and Statistical Committee Meetings will be held March 9, 1987 at the Ala Moana Americana Hotel 8:30 am-5:00 pm, and March 10, 8:00 am-2:00 pm.

FOR MORE INFORMATION CALL (808) 523-1368

3/7/87 Honolulu Star-Bulletin

The Western Pacific Fishery Management Council, a federally sponsored organization representing Hawaii, American Samoa, Guam and the Commonwealth of the Northern Mariana Islands will be holding a series of meetings to discuss management of Bottomfish, Lobster, and Pelagic Fisheries, and will be co-sponsoring with the National Marine Fisheries Service a presentation on the effects of Ocean Trash on wildlife and fish.

Photo by: J.R. Henderson

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FOR MORE INFORMATION CALL **(808) 523-1368**

3/6/87

WESTERN PACIFIC REGIONAL FISHERY MANAGEMENT COUNCIL

1164 BISHOP STREET - ROOM 1405
HONOLULU, HAWAII 96813
Telephone (808) 523-1368 FTS (808) 546-8923
Telex 7431871

February 12, 1987

Mr. George Balaz
Honolulu Laboratory, NMFS
2570 Dole Street
Honolulu, HI 96822-2396

Dear George:

I am returning your 2 original pictures showing the effects of junk on ~~marine~~ turtle life. Thank you very much for letting me duplicate the slides for our files and for making a print of the best slide to be used for an ad announcing the "Trash in Our Oceans" presentation.

Sorry that it took so long to get everything back to you. I credited the photographer instead of the organization that the photographer works for. I hope that's okay.

Sincerely,

Justin Rutka

Justin Rutka

Enclosures

cc: Kitty Simonds

P.S. The plastic "gut content" picture is shocking but ad viewers won't know what they're seeing. I decided to use the photo of the dead turtle laying on its back. Now that is a vivid picture. Again, thanx a lot for all of your help

UF zoologist Archie Carr with a sea turtle.

The Associated Press

Junk 'food' threatens turtles, researcher says

By FRANK ADAMS
UF information services

Plastic garbage, tar balls and other forms of persistent junk in the world's oceans are killing sea turtles, increasing the threat to these endangered creatures, said a University of Florida researcher.

Sea turtles often eat floating plastic bags, bottles and other pollutants and these indigestible objects clog their digestive tracts and kill them, said Archie Carr, a zoologist who is widely recognized as the world's foremost expert on sea turtles.

"Records of such mishaps have increased markedly in recent years," Carr said, "and this definitely poses a threat to sea turtle survival, if not now, then 10 or 15 years in the future."

Carr will publish an article on this subject in a forthcoming special issue of the "Marine Pollution Bulletin."

A colleague of Carr's, George Balzas, who is a marine scientist in Hawaii, has documented massive evidence on the threat plastic pollution poses to sea turtles.

"The gut of one turtle (he) found dead contained a sheet of heavy plastic measuring three by four meters," Carr said. When plastic lines a turtle's gut, it can't digest the plastic or any food, and starves to death.

The problem, Carr and other scientists speculate, is that some species of sea turtles that eat plastic bags and bottles mistake them for jellyfish, one of their favorite foods.

"One old leatherback turtle ate 180 meters of fishing line. This shows the poor devils don't have any discrimination at all. Nothing could pass where that rope was coiled up in his gut," Carr said.

Tar is another problem, Carr said. "When sea turtles eat tar balls, that either glues their jaws shut, or it chokes them."

In the fall, when heavy seas wash Florida's East Coast, dead and dying young loggerhead turtles often wash ashore in great numbers. "The stomachs of the dead ones often contain pellets of tar and the ubiquitous plastic that is delivered to the sea in industrial waste water," Carr said.

"Some of our factories are known to sluice into the ocean plastic scraps and plastic waste," said Carr, who awarded the UF Presidential Medallion, on Saturday, , for his contributions to zoology and the university.

Carr said he has seen lanes of industrial plastic pellets as wide as an interstate highway floating in sections of the Atlantic Ocean between Fort Lauderdale and Little Bahama Bank.

And the same ocean forces that gather the pellets into lines on the sea also sweep young sea turtles and masses of sargasso into the same place.

Young turtles spend from three to five years on the edges of ocean currents where sargasso and other sea weeds accumulate.

"This same force mobilizes and aligns buoyant pollutants; and the ecologic implications of this have not been given the attention they warrant," Carr said.

Nobody knows the entire solution to the problem, Carr said. "But we definitely need more international treaties."

University of Hawaii
Sea Grant College
Program

makai

"Toward the Sea"

Vol. 8, No. 11
November
1986

PLASTIC POLLUTION A PERSISTENT PROBLEM

by Daniel Bauer

A young, emaciated hawksbill turtle was found stranded on a remote western Hawaiian island beach. It was unable to dive. The cause became apparent 2 days later when the 11-pound turtle died and an autopsy was performed.

Completely blocking its intestinal tract was a mass of plastic and styrofoam chips, monofilament line, and shreds of plastic bags — well over one pound of it — compacted in fecal matter. The bouyancy of the material had the same effect as a life preserver. Unfortunately for the turtle, this meant it could not reach the sea floor to sleep.

For George Balazs, sea turtle biologist with the National Marine Fisheries Service who performed the autopsy, this is becoming a disturbingly frequent problem. Numerous sea turtles have been found with plastic bags hanging from their mouths, lining or totally blocking their intestinal tracts, and extending from their excretory orifices. Balazs is currently compiling data about the effect of marine debris on sea turtles.

A large source of the plastic debris problem is the incredibly large amount of packing material and fishing gear dumped or lost by commercial fisheries and sailing vessels. A recent report by the U.S. Academy of Sciences estimated that up to 50 million pounds are dumped and 300 million pounds are lost each year. Much of it is plastic or plastic-related material, which does not break down like hemp netting or cardboard packaging, materials commonly used before the boom in plastics use following World War II.

Instead, plastic remains remarkably durable, a fact that can have deadly consequences for sea life. Monofilament netting, for example, goes on "ghost-netting" fish for years after it is lost by fishermen. Sea birds, attracted to the netted fish, and sea turtles, which are possibly attracted to marine life encrusted on the netting, become further victims of the ghost nets as they remain awash or snagged on rocks or coral reefs. One case was even reported of a sea turtle found trapped inside a plastic bag floating in the water near French Frigate Shoals. Doomed to drown in such a predicament, it was fortunately rescued by a sympathetic scientist from a passing research vessel.

In the open seas, plastic debris, largely in the form of plastic bags and styrofoam pellets, is blown by prevailing winds into long rows called drift lines, which become virtual highways of concentrated

(Continued on page 2)

Balloon releases, such as this one at the January 1986 Hula Bowl in Honolulu, contribute to the littering of Hawaii's land and ocean environments.

—*Honolulu Advertiser* photo by Carl Viti

Plastic Pollution a Persistent Problem *(Continued from page 1)*

floating waste. These persistent, buoyant masses become a target for sea animals who are attracted to the naturally occurring organic material present there. According to Balazs, the plastic itself often has some marine growth on it, possibly making it appear to be food and increasing the likelihood of its being eaten by sea turtles. It is unknown what chemicals or polymers may be released by the plastic as an animal attempts to digest it, or what their effect may be on the animal's health.

Floating, undulating plastic bags may appear to sea turtles as jellyfish, one of their favorite foods. Balazs held up one of those popular round silvery balloons that was found awash in the sea. Its mirror-like aluminum coating had long since oxidized in the salt water, but the extremely durable mylar body itself showed little sign of deterioration. With its curly, 4-foot plastic string trailing beneath it, the opaque balloon looked eerily like a huge jellyfish.

What begins as a visual feast for human eyes — those massive releases of thousands of multi-colored balloons at sporting events and other celebrations — can end as a lethal feast for fish and sea mammals when the balloons return to earth, particularly when the releases take place near coastal areas, such as last January's Hula Bowl halftime release of 20,000 balloons at Aloha Stadium near Honolulu. Another 10,000 balloons were released at the city's waterfront Ala Moana Park on November 16 as part of a nationwide charity fundraiser.

These figures themselves pale in comparison to some recent record-breaking balloon releases undertaken in other coastal areas: 1,121,448 balloons at Disneyland in Anaheim, California (that's 8,000 pounds of latex); 384,000 in Japan to promote instant noodles; 1.5 million in downtown Cleveland (where thousands of them were blown into Lake Erie); 300,000 balloons carrying peace messages released by girls throughout the world;

What begins as a visual feast for human eyes . . . can end as a lethal feast for fish and sea mammals

and 150,000 released by students throughout the United States, including Hawaii, as part of a meteorological survey for National Science Week. Indeed, among the plastic debris George Balazs found compacted in the intestines of that young, doomed hawksbill turtle unable to dive was the neck of a latex balloon.

Controlling the dumping of oceanic plastic debris remains a huge task. New uses are continually being found for ever-more-durable plastics, and the plastics industry remains in a high growth stage. Some laws and international treaties exist which control oceanic dumping of waste, but interpretation of jurisdiction remains vague, and enforcement is hard to maintain. An amendment to the Marine Pollution Convention of 1973 called Annex V, would regulate oceanic dumping of persistent plastics. However, it is just short of the necessary votes for ratification, and the United States has not yet approved it.

Mounting concern over the environmental effect of plastic debris has prompted Senator John Chafee (R-R.I.) to introduce the Plastic Waste Reduction Act of 1986 (#S-2596), which would have a two-fold purpose. First, it would require that all beverage-connecting devices (such as six-pack holders, which commonly lead to entanglement and subsequent strangulation of a wide variety of birds) be biodegradable. Ten states have already passed similar legislation. Secondly, the Enviromental Protection Agency (EPA) would be required to conduct a study on plastic pollution of the environment, including its effects on fish and wildlife. EPA would then report back to the Senate Subcommittee on Environmental Pollution, which is chaired by Chafee. The bill has been referred to this subcommittee, where it is currently awaiting action. Interested persons are encouraged to contact the committee by writing to Senator Chafee at Dirksen Senate Office Building, Washington, D.C. 20510.

According to the plastics industry, some plastic milk and soft-drink bottles are being recycled into insulation and construction materials, and further recycling efforts are underway. The plastics industry can be contacted by writing The Bottle Information Bureau, The Society of Plastics Industry, Inc., 355 Lexington Ave., New York, NY 10017.

Beach cleanup efforts have been organized in several coastal states. A recent cleanup effort at Hanauma Bay, a popular snorkeling site near Honolulu, resulted in more than 50 large trash bags being filled in 3 hours of work, according to Rich Neumann, president of the University (of Hawaii) Aquanauts Dive Club that participated in the cleanup. Most of the garbage picked up was plastic or styrofoam material. Another cleanup effort at Hilo Bay on the island of Hawaii yielded 100 bags of garbage.

Any information, old or new, about sea turtles eating or becoming entangled in marine debris is being sought by George Balazs. He can be contacted at Southwest Fisheries Center, Honolulu Laboratory, National Marine Fisheries Service, NOAA, P.O. Box 3830, Honolulu, HI 96812. □

Volume 8, Number 11 ISSN 0745-2896

SEA GRANT HAWAII

MAKAI

published monthly by
UNIVERSITY OF HAWAII
SEA GRANT COLLEGE PROGRAM
1000 Pope Road, Room 213
Honolulu, HI 96822

Second-class postage paid at Honolulu, HI

POSTMASTER: Send address changes to *Makai*, 1000 Pope Road, Room 213, Honolulu, HI 96822

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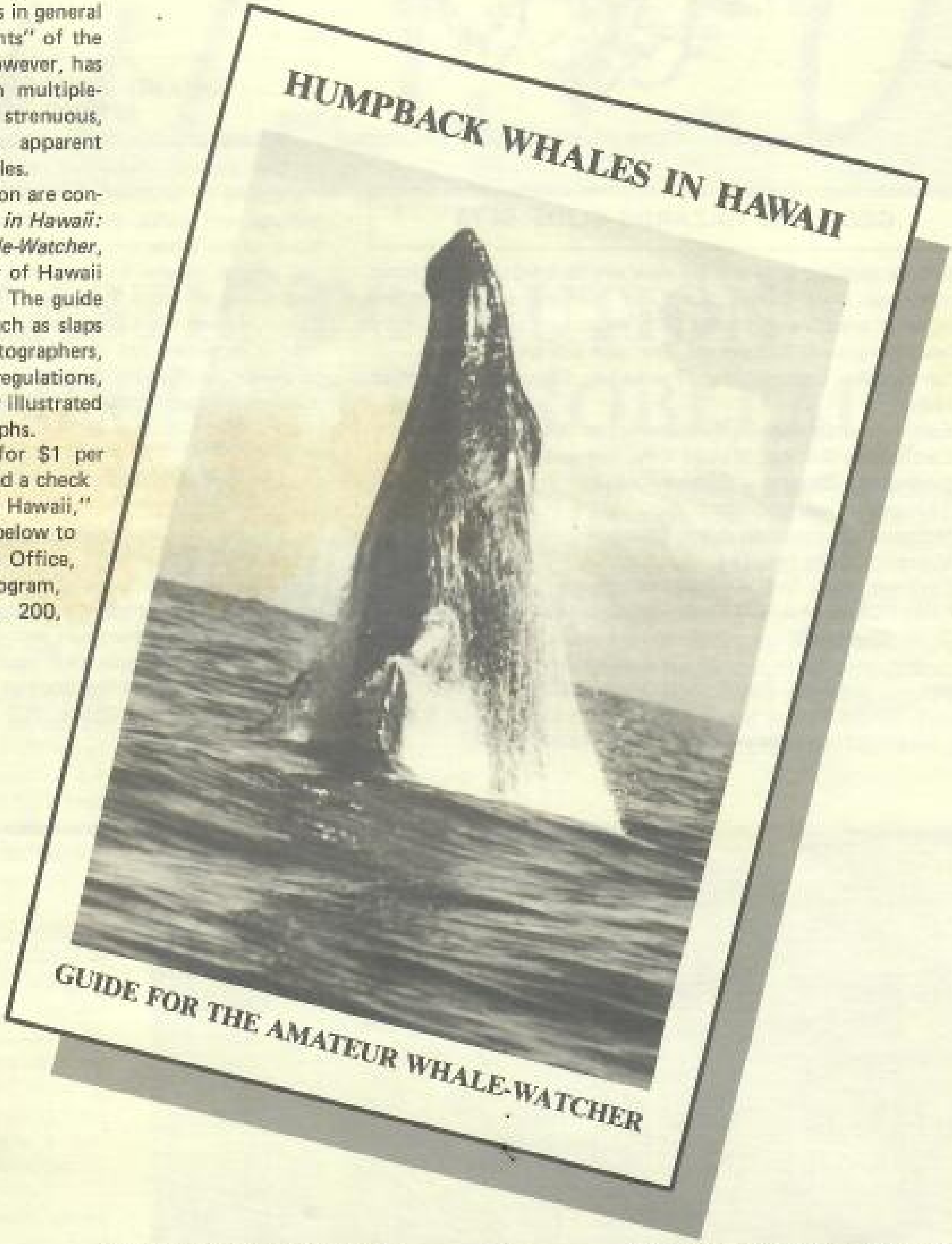
This newsletter, a product of the "Sea Grant Extension" project (AS/A-1), was published by the University of Hawaii Sea Grant College Program under Institutional Grant No. NA85AA-D-SG082 from NOAA Office of Sea Grant, Department of Commerce.

Whale-Watching Guide Available

The conception of whales in general has been as the "gentle giants" of the ocean. Recent evidence, however, has shown male humpbacks in multiple-escort pods to engage in strenuous, even violent, combat in apparent contests over access to females.

This and more information are contained in *Humpback Whales in Hawaii: Guide for the Amateur Whale-Watcher*, published by the University of Hawaii Sea Grant College Program. The guide explains whale behaviors such as slaps and leaps, offer tips for photographers, describes anti-harassment regulations, and more. The text is amply illustrated with drawings and photographs.

The guide is available for $1 per copy. To obtain a copy send a check payable to "University of Hawaii," along with the order form below to Whale Guide, Publications Office, UH Sea Grant College Program, 1000 Pope Road, Room 200, Honolulu, HI 96822.



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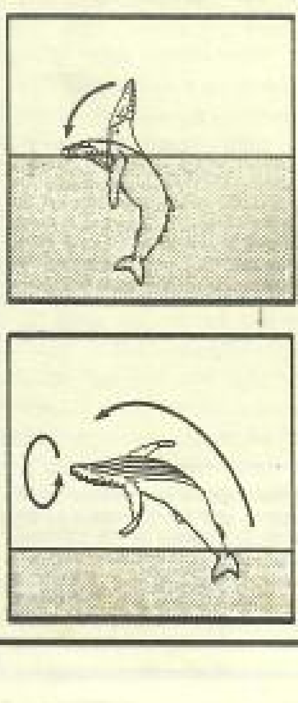

Enclosed is my check for $_______ for _______ copies of *Humpback Whales in Hawaii: Guide for the Amateur Whale Watcher*. Please send to:

Name ______________________________

Mailing Address ______________________________

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MARINE MISCELLANY

GEOLOGIC HAZARDS SLIDE SETS

Several geologic slide sets are now available from the National Geophysical Data Center. Each set contains twenty 35-mm slides with captions and costs $31. When two or more sets are ordered the price is $25 per set. The slide sets are:

- Earthquake Damage, San Francisco, CA, April 18, 1906 (b&w)
- Earthquake Damage to Transportation Systems (b&w, color)
- Earthquake Damage, Mexico City, September 1985 (color)
- Earthquake Damage – General (color)
- Tsunami – General (color)
- Volcanoes in Eruption (b&w, color)
- Volcanic Rocks (color)

Payment may be by check or money order payable to COMMERCE/NOAA/NGDC or by American Express, Master Card, or Visa credit cards; include card account number, expiration date, telephone number, and signature with order. Send orders to National Geophysical Data Center, NOAA, Code E/GC4, Department F10, 325 Broadway, Boulder, CO 80303. For telephone inquiries and orders, call (303)497-6541.

WAIKIKI AQUARIUM ANNOUNCES SPRING PROGRAMS

The Waikiki Aquarium has announced its programs for "A Spring of Discovery" and Pacific travel. Scheduled activities include reef walks, courses on marine mammals, and explorations of the aquarium after dark. The aquarium is also sponsoring several natural history tours in 1987, including snorkeling and diving on Maui, Palau, and Fiji and sea kayaking in British Columbia and the Galapagos Islands. For brochures and registration information call the Waikiki Aquarium at (808) 923-9741 or write to Waikiki Aquarium Education Department, 2777 Kalakaua Ave., Honolulu, HI 96815.

NEW GUIDE TO PERMITS AVAILABLE

The Hawaii Department of Planning and Economic Development has a free booklet, *An Applicant Guide to State Permits and Approvals for Land and Water Use and Development*, prepared by the department's Coastal Zone Management Program. The guide is for developers and others unfamiliar with required permits and approvals that apply to their proposed land and water use. Copies of the booklet are available from the department's Information Office, 250 South King Street, 7th Floor, Honolulu, HI 96813.

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Makai ISSN 0745-2896
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Sea Grant Extension
1000 Pope Road, Room 213
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Second-class postage paid at Honolulu, HI

The National Sea Grant College Program is a network of institutions working together to promote the wise use, development, and conservation of the nation's coastal, marine, and Great Lakes resources. Provisions of the National Sea Grant College and Program Act of 1966 called for the creation of Sea Grant Colleges, and in October 1972, the University of Hawaii was designated one of the first five Sea Grant Colleges in the nation. Locally, Sea Grant is a unique partnership of university, government, and industry focusing on marine research, education, and advisory/extension service.

S.R. NO. 189 S.D.1

SENATE RESOLUTION

REQUESTING THE SUPPORT OF HAWAII'S CONGRESSIONAL DELEGATION FOR THE SUPPORT OF LEGISLATION AND OTHER PROGRAMS TO HELP CONTROL THE PLASTIC AND NET POLLUTION OF OUR OCEANS.

WHEREAS, plastic pollution in its various forms, including lost fishing nets, causes damage to marine life in general and to species managed, protected, and conserved under the law; and

WHEREAS, floating plastic rubbish is a major source of beach pollution in Hawaii and throughout the Pacific; and

WHEREAS, floating, lost fishing nets are becoming an increasingly frequent hazard to navigation; and

WHEREAS, monofilament nets, nylon ropes, and other miscellaneous plastic containers and products have an extremely long life before being degraded in the ocean; and

WHEREAS, the worldwide production of plastics has been and will continue to increase, and land based sources of marine plastic pollution are probably of greater magnitude than ship based plastic pollution; and

WHEREAS, there is before the United States Congress a bill, H.R. 940, "Plastic Pollution Research and Control Act, Annex V, Regulations for the Prevention of Pollution by Garbage from Ships, relating to the International Convention for the Prevention of Pollution from Ships, 1973", (hereinafter referred to as "MARPOL Annex V") which addresses concerns of plastic and net pollution; now, therefore,

BE IT RESOLVED by the Senate of the Fourteenth Legislature of the State of Hawaii, Regular Session of 1987, that Hawaii's congressional delegation is urged to support the passage of MARPOL Annex V; and

BE IT FURTHER RESOLVED that Hawaii's congressional delegation encourage research, legislation, and education through appropriate government agencies including the National Oceanic and Atmospheric Administration and the U.S. Coast Guard for the purpose of managing the impacts of persistent refuse on the marine environment, including development of controlled lifetime plastics; and

BE IT FURTHER RESOLVED that the State department of education and the department of land and natural resources are urged to include ocean pollution issues as a part of their educational programs; and

BE IT FURTHER RESOLVED that industrial associations and organizations will be encouraged to develop internal education and training programs and policies consistent with environmental concerns; and

BE IT FURTHER RESOLVED that certified copies of this Resolution be transmitted to Hawaii's Congressional delegation, the National Oceanic and Atmospheric Administration, the National Marine Fisheries Service, the U.S. Coast Guard, the Chairperson of the Board of Education, and the Chairperson of the Board of Land and Natural Resources.

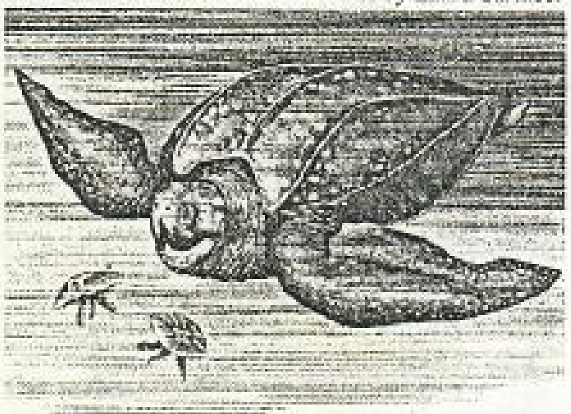
One That Got Away

Sea turtles are familiar to everyone who lives near the ocean. But Rom Duran and his wife Barbara called us recently with a once-in-a-lifetime story about their encounter with one of the most rarely observed of all sea creatures, the leatherback turtle.

Rom and Barbara had set out for a day of fishing for mahimahi, but while trolling far out at sea, they spotted what they thought was a large raft. When they got closer they saw it was a turtle of gigantic proportions; but it was trapped in the mesh of a fish net, a high seas drift net with at least 75 floats attached to it. The turtle was terrified by the boat and people and tried to dive, but the floats on the fish net quickly brought him back to the surface. After making three attempts, the turtle was too tired to continue diving; and Rom was able to maneuver his boat close enough to grab the turtle. Barbara recounts that cutting away the fish net was no simple task: "Try to picture a turtle whose shell is between 5 and 6 feet in length with a head bigger than a man's. And this turtle was in a state of complete terror, trying to protect himself against us. He was so strong he pulled Rom's 21-foot boat backward with no problem at all."

Rom finally cut the turtle free of the net and the turtle immediately dove out of sight. A few days later Rom called the Waikiki Aquarium for more information about the turtle they had rescued. Only one species of turtle matched the description given by Rom: the leatherback turtle. Unique in that by weight it is the largest of all reptiles, a leatherback can reach lengths of 5 to 8 feet and weigh up to 1,400 pounds. Its shell is very unusual, covered by smooth leathery skin with numerous ridges running down the back. Sean McKeown in his book, Hawaiian Reptiles and Amphibians, notes that the leatherback turtle is the "fastest and most powerful of any of the sea turtles and it may be encountered in the open ocean a considerable distance from land." Both young and adults feed on jellyfish, but squid, octopus, sea urchins, and other organisms are eaten too.

George Balazs, Hawaii's resident turtle expert at the National Marine Fisheries Service, confirmed the turtle's identity. George adds that the leatherback is rarely seen in Hawaii. The nearest nesting beaches for Hawaiian leatherbacks are Mexico to the east; peninsular Malaysia to the west; and Papua New Guinea to the southwest. The leatherback is obviously the most highly migratory of sea turtles. It is also listed as an endangered species. Barbara recounts an old Hawaiian legend that if one saves a sea creature from death, then it becomes your aumakua or protector, and it and all others of that species will keep you safe forever on the seas. Rom and Barbara now have a very special aumakua all their own. ● *Illus. by Laura Sartucci*



KILO IʻA
WAIKIKI AQUARIUM NEWSLETTER
JUNE/JULY 1987

San Bernardino, California

Plastics pose threat to sea life

WASHINGTON (AP) — Six-pack rings and other plastic throwaways tossed into the ocean kill an estimated 1 million seabirds and thousands of marine mammals each year, coastal congressmen said Wednesday in calling for tough restrictions on plastic dumping.

"There seems to be a prevailing attitude that we can't do any harm by throwing plastic refuse into the ocean," said Rep. William J. Hughes, D-N.J. "It's the same 'out of sight out of mind' mentality that has turned our oceans into the repository of last resort for sewage sludge, chemicals and other refuse."

More than 1 million pounds of plastics are dumped into the sea each year, according to a report by a House Merchant Marine and Fisheries subcommittee on fisheries and wildlife conservation.

Birds and marine mammals, mistaking plastic garbage for food, try to eat the objects. That blocks their respiratory or digestive tracts, suffocating or starving them to death. Others become entangled in the objects and choke to death.

Plastic trash is suspected of aiding in the decline of several species, including the northern fur seal, steller sea lion, Hawaiian monk seal and certain sea turtle and seabird species.

U.S. law prohibits the disposal of garbage from ships within three miles of the coast. But a measure by Rep. Gerry E. Studds, D-Mass., would ban disposal of plastic garbage by U.S. flag vessels in all ocean waters and prohibit plastic disposal by foreign vessels within 200 miles of the U.S. coast.

In addition, all types of garbage would be banned within 12 miles of the shoreline under the measure.

The Studds bill mirrors the provisions of an international agreement now being considered by countries in the International Convention for the Prevention of Pollution from Ships.

The agreement would halt all plastic garbage dumping worldwide and ban the disposal of all types of trash within 12 miles of land.

Nations would be bound by the agreement when countries representing 50 percent of the world's shipping tonnage have ratified it.

Environmental update

Fishing lines, other plastic objects pose danger to sea life

By Jan TenBruggencate
Advertiser Kauai Bureau

A floating plastic bag might look like an edible jellyfish.

A plastic lighter to a fast-moving seabird might resemble a squid.

A piece of a detergent bottle could flash in the sun like the gleam off fish scales.

The prevalence of plastics is one of the hallmarks of a developed society, and in some senses like nuclear power and pesticides, plastics are being viewed with an increasingly concerned eye.

Hawaiian seabirds, for example, are eating more pieces of plastic than they used to, according to comparisons of stomach contents 20 years ago and today.

It is still not clear what the effects are of the non-digestible diets, said U.S. Fish and Wildlife Service biologist Stewart I. Fefer.

Fefer, with Fish and Wildlife Service researchers Louis Sileo of the National Wildlife Health Center, Darcy Hu and Ken McDermond, spent May 16 to June 11 sampling about 20 species of Hawaiian seabirds on Nihoa, French Frigate Shoals, Laysan, Pearl and Hermes and Midway islands.

Those Northwestern Hawaiian Islands, the only spots of land in vast stretches of ocean, are the nesting sites for the seabirds that soar over those thousands of miles of water.

Most of those birds can eat and sleep out on the ocean, and only need to come to land to produce their young. The islands are a wildlife refuge in part because of their large populations of seabirds.

The seabirds go fishing, and feed their young by regurgitating their catch for fat chicks in burrows, open ground or in nests in the shrubbery.

Fefer said the researchers caused the chicks to regurgitate their stomach contents, figuring an adult's belly would contain only its last meal, while a chick's would be a repository of what the adults eat over a larger period of time.

Preliminary results of the study show most birds don't seem to have a large amount of plastics in their bodies, and most seem to naturally regurgitate their undigestible stomach contents, Fefer said.

Many of the birds naturally feed on squid, whose hard beaks aren't digested and even-

Advertiser photo by Jan TenBruggencate

Plastic garbage lines this beach on Niihau, and what's on the beach is only a fraction of what's in the ocean.

tually are regurgitated. That habit may protect the birds from problems with most plastics.

Some birds do seem to have difficulties, though. Fefer said about half the Bonin petrels at Midway have pieces of monofilament line in their bellies. Many of the pieces are knotted, suggesting they came from abandoned or lost gillnets, he said.

There is also a high incidence of plastic in Laysan and black-footed albatrosses at Midway, and researcher Paul Sievert is there studying them, Fefer said.

There are several reports of birds choked or with holes in their throats from eating plastic lighters or rubber balls, but most of the stuff is "multicolored, fragmented plastic particles...picture a Joy bottle broken into 150 pieces...toys, lighters, bottle caps, toothbrushes, manufactured articles broken into small pieces," Fefer said.

Further research may show more clearly the effect of eating this stuff on the birds, but "we really don't have an indication the (ingestion of) plastics is causing a problem," he said.

Plastic bags, mimicking jellyfish, apparently have caused concern over fatalities in sea turtles, he said.

But the big known problem is entanglement.

Fefer said his crew found a masked booby entangled in monofilament fishing line on Lisianski. There is a significant problem with green sea turtle deaths related to their eating plastic bags they apparently mistake for jellyfish, he said. And Hawaiian monk seals are sometimes found caught in pieces of fishing net.

The plastics come from many sources. Several nations have joined in treaties to attempt to control the dumping of plastics at sea. There is increasing concern about "ghost nets," fishing nets that have been lost or abandoned, on reefs or floating free, and which continue to kill fish for many years.

The plastic holders for six-packs of beer and soft drinks, the plastic straps used for packing, bags of various kinds. They can and do all entrap creatures of the sea.

It's not only in Hawaii. A 1985 report of the National Marine Fisheries Service estimated more than a 5 percent mortality rate among northern fur seals from entanglement in various kinds of marine debris.

Flocks of celebration balloons, released into the air, come down eventually, often into the ocean, where they persist and pose a hazard to wildlife.

Plastic cartons, plastic bottles, lengths of rope, they all join the multitude of throw-away items of modern society.

There will be increasing efforts to find ways to recycle them, so they don't get thrown away, to promote responsible disposal of plastics that are thrown out, and to fabricate plastics that break down quickly in the environment, Fefer said.

Nation/world

Sea experts fear flood of plastics

Knight-Ridder Newspapers

WASHINGTON — When a young Hawksbill turtle washed up with the surf on Oahu Island, Hawaii, and died a few days later, scientists wanted to know why—and performed an autopsy.

Inside the turtle, which was a little bigger than a dinner plate, they found more than 1,000 pieces of plastic, including part of a pocket comb, a toy truck wheel and unravelled strands of nylon rope. The plastic formed a plug in the turtle's gut, and the animal had starved to death.

"Essentially, if it floats, they'll eat it, because for millions of years the things at the surface have been animal things that are a nutrient to them," said George H. Balazs, a zoologist with the federal Marine Fisheries Service and leader of the Hawaiian Sea Turtle Recovery Team. But what was true for millions of years is not true now.

A rising tide of plastics is bobbing in the world's oceans. Every year, more than 77 tons of plastic trash is routinely—and legally—tossed over the sides of naval and merchant marine ships, according to the Center for Environmental Education, a non-profit association in Washington. Plastics dumped from garbage barges and washed to sea in rivers, streams and sewers add to the flotsam.

Environmentalists have realized only recently that plastic, long viewed as an eyesore at the beach, also is a menace to wildlife. "Plastics may be as great a source of mortality among marine mammals as oil spills, heavy metals or other toxic materials," ecologist David Laist of the Marine Mammal Commission told a conference on ocean trash disposal last year.

For example:

● Off Florida's west coast, brown pelicans frequently get tangled in discarded plastic fishing line, and often die after a furious struggle to get free.

● Up to 30,000 northern fur seals, a depleted species whose members habitually investigate floating objects, are entangled in lost or discarded plastic fishing nets each year, according to Charles Fowler, a scientist at the National Marine Mammal Laboratory in Seattle.

● Lobster and crab traps made entirely or partially of plastic and lost on the sea bottom continue to catch shellfish, according to the Center for Environmental Education. In 1984, 25 percent of the 96,000 stone crab traps set off Florida's west coast were lost, according to the center.

Light, strong and cheap, plastics are a staple of modern life, with more than 45 billion pounds sold in the United States in 1986. But its strength is a problem: it doesn't decay after it's thrown away.

"Nobody knows how long [plastic] would stay in the environment, but it does stay for a long time, hundreds of years," said Anthony L. Andrady, an expert in plastic deterioration at Research Triangle Institute in North Carolina. An ordinary plastic six-pack ring could last 450 years, he said.

Eleven states have passed laws requiring that six-pack rings be made of biodegradable plastic. To comply, manufacturers have added light-absorbing molecules that break down after a few months exposure to sunlight, Andrady said.

A bill to require biodegradable six-pack rings throughout the nation was introduced in March by Sen. Frank R. Lautenberg, (D., N.J.).

But there is no evidence that light-sensitive plastics will break down at sea, according to Andrady. Water keeps the plastic cool, and thin films of sea algae shield it from the sun's rays, he said.

Because plastic is so slow to break down, especially at sea, the amount floating in the oceans is continuously increasing, Andrady said. Volunteers who cleaned up 122 miles of Texas beaches last September picked up more than 171,000 items—95,000 of them made of plastic. State officials blame the merchant ships that ply the waters off their coast for most of that mess.

"The world's fleet [is] using our shores as a garbage dump," said Garry Mauro, the Texas land commissioner, in testimony June 17 before the House Merchant Marine and Fisheries environmental subcommittee.

Mauro called on the United States to ratify a new provision of the International Convention for the Prevention of Pollution from Ships that would prohibit merchant ships from dumping plastic into the sea. Twenty-six nations, which register 44.5 percent of the world's ship tonnage, have ratified the treaty, but it will not take effect until nations representing 50 percent of the world's ship tonnage have ratified it.

The Reagan administration sent the treaty to the Senate in February recommending that it be approved. However, legislation that would establish how it would be enforced off U.S. shores is mired in bureaucracy, according to environmental lobbyists.

Wrigley Doublemint Chewing Gum

Wrigley's Doublemint gum is the youngest of Wrigley's famous triad: Juicy Fruit, Spearmint, and Doublemint. Spearmint, introduced in 1893, was the first Wrigley product to use the spear logo and was designed by William Wrigley Jr. himself, who remained unhappy with a number of submitted designs. Pulling out a pencil and paper, Wrigley sketched out the basic design, which became one of the world's classic trademarks. At the suggestion of Maurice Fitzgerald, ad manager in 1962, the spear design was incorporated into the tear-tape package opener.

The story of the development of the Wrigley company is a classic tale of American entrepreneurship. Wrigley arrived in Chicago in 1891, at twenty-nine years of age, with thirty-two dollars in his pocket. He eventually settled on selling baking powder as a livelihood; with each can sold, he gave away two sticks of gum. Sensing that the chewing gum market was undeveloped, he gave up baking powder sales and marketed his first two flavors of gum, Lotta and Vassar, in 1892. He introduced the Juicy Fruit and Spearmint flavors the following year and added Doublemint in 1914. Throughout his selling career, Wrigley never gave up his penchant for premiums, giving away everything—from lamps to razors—to merchants who agreed to carry his gum.

Product: Wrigley Doublemint Gum

Manufacture: William Wrigley Jr. Co.

Design Credit: Product developed and package designed by William Wrigley, Jr.

Date: Introduced in 1914

Hi-Cone Carrier

The concept of selling a half-dozen of a thing is an ancient one. However, the ingenuity of the American packaging and canning industry effectively exploited and definitively refined this concept. The Hi-Cone Carrier, the plastic pressing that holds six cans together, is astoundingly minimal in its material requirements yet creates an effective package with a carrying handle. The task of holding six cans together is performed so anonymously that the plastic pressing itself goes unnoticed. Because of its inconspicuousness, the Hi-Cone Carrier does not need to be customized to each individual product; identical Hi-Cone Carriers can be used on all canned beverages at minimal additional expense to the consumer. The Hi-Cone Carrier is by far the least expensive packaging device ever developed for six-pack type containers. In America alone, 95 percent of all canned beverages purchased in multiple quantities leave the store in a Hi-Cone Carrier.

The Hi-Cone Carrier is only one of the myriad American innovations in canned beverage history. The Beer Can Collectors of America chronicle twenty-eight notable dates marking American design innovations for canned beverages. One of the earliest significant developments was the invention of the "church key" opener created by D. F. Sampson, a designer for American Can Company. A church key opener was included free with each case of flat-top beer sold in 1935, the first year beer was packaged in cans. Among other innovations are the aluminum can, introduced in 1958; the pull-top can, introduced in 1963; and the StaTab one-piece pull-top lid, introduced by Reynolds Aluminum in 1975.

Product: Hi-Cone Carrier

Manufacture: Originally manufactured by Illinois Tool Works; currently manufactured by Hi-Cone Division of Illinois Tool Works and by Owens-Illinois under license granted by Illinois Tool Works

Design Credit: Designed by Jules Poupitch, engineer

Date: Introduced in 1961

The Hi-Cone Carrier creates a subtle but highly effective packaging device.

"American Style
Classic Product Design
from Airstream to Zippo"
by Richard Sexton
Chronicle Books - San Fran.
©1987

Artificial Diversity

Those of us who worry about the loss of organic diversity that seems to be one of the dominant ecological processes which are prevalent in the present-day world, frequently see, or have pointed out to us, cases of apparent, or even real, *increase* in biodiversity. Students of island floras, or of island ecology, especially in the tropics, frequently see that an island or group of islands which is strongly subject to human influence, has now a larger flora, augmented by exotics, than it supported before becoming subject to human disturbance.

The question is asked, at least in principle: 'Why all the concern about human-caused disappearance of species? Extinction is merely a natural phenomenon, having gone on for untold millions of years, whereas on many islands, Man has caused an increase in diversity—at least of the plants, and possibly also of the insects. What could be wrong about this?'

Some Examples

Johnston Island, in the central Pacific, had, when first visited by a botanist, only three species of vascular plants. Some years later, in 1946, when it had become a military post, the flora had been increased to 27 species. At the latest count, in 1973, the number was 127. The Hawaiian Islands, with a very diverse set of habitats, had between 1,700 and 2,100 native flowering plant species. St. John's *List and Summary* (1973) gave 2,668 indigenous species and infraspecific taxa, and a total number of taxa present of 7,722, the difference being made up of exotics—whether naturalized, adventive, or cultivated. The Marshall Islands—coral islands with small floras to start with—now have 197 species (excluding those only in cultivation), of which 92 are considered native but the remaining 105 were supposedly brought in by Man. In addition another 187 are in cultivation only.

The same phenomenon has taken place on many other islands, indeed probably on most of the tropical ones.

High and Low Islands and the Pantropical Flora

When the lists of species are examined, however, another feature is noticed. From island group to island group, on high islands the native flora varies a great deal, whereas on low coral islands there is not so much variation. However, looking at the lists of non-native species one is struck by their similarity. They are not identical, because of the accidental or chance differences in what is brought to one island or another, but there is an overall sameness to the lists. The plants are either commensals with Man, cultivated useful or ornamental plants, or what have been called camp-followers, door-yard or garden weeds, or else aggressive pioneer-type plants that produce many long-lived seeds and thrive on disturbed ground, or even in bare mineral soil. These species tend to be widespread in the tropics, so many of them occurring on all or at least more than one tropical continent that we have come to refer to them as 'The Pantropical Flora.' Anyone with any botanical interests who has travelled in the tropics will recognize what is meant: the same weeds and cultivated plants are seen in human habitats and disturbed places wherever one goes.

There are perhaps a few hundreds of these pantropical denizens in all, and for some reason a majority of them are of tropical American origin. They dominate the vegetation in the lowlands in many places, especially on islands, while some of them are able to grow also at higher elevations. It has been said that a visitor to Oahu or Tahiti could be on either island for three months and not see a native plant—except, perhaps, for a half-dozen common beach species.

Local and Regional Diversity Differences

What does this mean, diversity-wise? On some islands—and even in some continental places—floristic diversity has been augmented by an influx of exotics. But on a regional scale, if the local indigenous floras are largely replaced by the same range of exotics, the plant diversity region-wide will have been seriously reduced. If we could see the insects and other small arthropods as well as we can see the plants, we might very well find the same pattern.

Birds have tended to decline in numbers and in the numbers of species in inverse relation to the prevalence of people, though some exotic birds have come in to replace native ones. Thus in Hawaii, the present total exceeds that in the original fauna, so perhaps something like the local floristic pattern (*see* above) prevails there. As for mammals on tropical islands, there are very few native species and sometimes none: exotic ones such as rats, mongooses, dogs, cats, pigs, goats, sheep, and cows, have been brought in and prospered at the expense of all other kinds of biodiversity.

Nevertheless there can still be no doubt that, regarded on a regional—perhaps even a global—scale, the introduction, by Man, of exotic organisms, has resulted in a serious and continuing loss of overall biodiversity.

REFERENCE

ST JOHN, Harold (1973). *List and Summary of the Flowering Plants in the Hawaiian Islands.* Pacific Tropical Botanical Garden, Lawai, Kauai, Hawaii, USA: 519 pp.

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Pollution on the Marine Turtle Nesting-beach in Tortuguero National Park, Costa Rica

Three species of marine turtles—Green (*Chelonia mydas*), Leatherback (*Dermochelys coriacea*), and Hawksbill (*Eretmochelys imbricata*)—nest on the beach in Tortuguero National Park (Parque Nacional Tortuguero) on the Caribbean coast of Costa Rica, where the nesting turtles are a major attraction for the large numbers of tourists visiting the Park. Each of these three turtles is listed as an endangered species by the International Union for Conservation of Nature and Natural Resources (Groombridge, 1982).

The nesting beach is and always has been somewhat littered with a variety of natural debris, much of which is transported to the strand by ocean currents or washed up on the high-energy beach by tides and storm-waves. During a short trip to the Park in 1983, however, I was dismayed to see much more Man-made debris on the beach than I recollected or recorded during three summers which I had spent there some 25 years previously (Hirth, 1963). In 1985 I spent 6 months in the Park, studying the nesting behaviour of the Green, Leatherback, and Hawskbill, turtles and so was able to collect data on the amount of litter on the beach.

The purpose of this study was to quantify the amount of natural debris, debris of human origin, and beach vegetation, now on the sea turtles' nesting-beach in Tortuguero National Park.

TABLE I

Comparison of Numbers of Natural and Artificial Objects on the Sea-turtle Nesting-beach in Tortuguero National Park, Costa Rica

Object	*Southern transect*	*Northern transect*
	Natural objects (N = 513)	Natural objects (N = 701)
Ipomoea spp.	44%	41%
Other plants[1]	17%	20%
Seeds	15%	20%
Wood	7%	8%
Coconut husks	5%	7%
Turtle eggshells	5%	0
Sea-shells	4%	1%
Others[2]	3%	3%
	Artificial objects (N = 663)	Artificial objects (N = 615)
Plastics	43%	37%
Tar-balls[3]	31%	25%
Wood	11%	6%
Glass	7%	11%
Others[4]	8%	19%

[1] *Croton punctatus, Euphorbia* sp., *Remirea maritima, Sesuvium portulacastrum, Sporobolus virginicus, Uniola pittieri*, and pieces of coconut palm frond and wrack.

[2] Pieces of bone, crab, 'sand dollars', sponge, and turtle scutes.

[3] Some may be the result of natural processes.

[4] Canvas, cellophane, cloth, cork, fibreglass, fishing-line and string, leather, metal and alloys, paper, rope, rubber, and rubber sponge.

Transects Run

Two transects, each 0.8 km in length and 5 cm wide, were run parallel to the tree-line through the middle of two typical segments of the nesting-beach. One transect was near the southern end of the Park, and data were collected from it on 15–16 April. The other transect was near the northern limit of the Park, and information was collected from it on 25–26 July 1985. The transects were 20 km apart. All living and abiotic objects touching the transect and having any dimension greater than 5 mm, were recorded—apart from wind-blown objects, such as leaves, which were not counted.

Two major conclusions can be drawn from the transect data (Table I). First, both natural and artificial objects occur on the beach at the very high frequency of about 1 object every 64 cm. Second, the results of the surveys indicate that debris items of human origin now outnumber the totality of items of natural debris and living plants on the nesting-beach. Fifty-six per cent of the 1,176 objects recorded on the southern transect were of human origin, while 47% of the 1,316 objects recorded on the northern transect were human-related.

Plastic articles were the most abundant artificial objects on the beach, and ranged in size from 5-gallon (18.92-l) containers to caps of toothpaste tubes. Tar-balls, from 5 to 100 mm in diameter, were the next most common synthetic objects. The wooden objects included pieces of furniture, toys, and tools. I believe most of the artificial debris was derived from the ocean. A few articles may have been discarded by nearby villagers but there is a good and growing environmental ethic among the local people. Besides living near the beach themselves, the local people reap economic rewards when tourists have an aesthetically pleasant Park experience, and thus littering is minimal.

Not included in the counts, although they were on both transects, were hundreds of small plastic particles. These particles were white, opaque (or in a few cases translucent) plastic cylinders or discs (or a few spherules) having diameters of between 3 and 4.9 mm, and they, or particles like them, are also found in other areas of the Caribbean Sea (Colton *et al.*, 1974).

Hazards to Feeding Sea-turtles

Floating oceanic debris constitutes a hazard to feeding sea-turtles during their pelagic life-stages. Plastic bags, plastic particles, tar, fishing-line, rope, glass, and other synthetic articles, have been found in the digestive tracts of sea-turtles from various areas, and plastic articles have been recorded in the stomachs of Green and Hawksbill turtles that had been caught off Tortuguero (*see* Balazs, 1985).

Beach plants accounted for about 61% of the natural objects encountered on the transects. Railroad vines (*Ipomoea* spp.) were the most common plants on both transects, and they were also the most common plants on the beach 25 years earlier (Hirth, 1963). The turtle eggshells were chiefly those of the Green Turtle, and most likely represented depredations of predators. The sea-shells were mostly of *Donax* sp.

I do not believe that any of the debris on the beach in 1985, except for large logs, directly interfered with the nesting behaviour of the three species of turtles. In a few instances an emerging nester was unable to crawl over or around a log, and so returned to the sea. Such individuals may, however, successfully nest later during the same night in a nearby area. On the other hand, both artificial and natural objects on the beach can have indirect and subtle effects on turtle reproduction. Sharp objects on the beach can cut flippers of nesting females, especially those of Leatherbacks. Large or heavy objects that have been washed-up on the beach over a clutch of eggs may interfere with emergence of the hatchlings from the nest.

If hatchlings are chemically 'imprinted' to the natal beach as some research workers contend, then the abundance and weathering of tar-balls and the potential resultant change in the chemistry of the sand, may affect the nest-site selection process. The nest-site selection of remigrants may also be affected by changes in sand chemistry. These possibilities need to be investigated. Litter of all kinds impedes the crawl of the hatchlings to the sea, and thus lengthens their exposure-time to predators, while the large amount of Man-made debris on the strand lowers the aesthetic quality of the beach—an undesirable situation at a time when large numbers of tourists are visiting the Park.

REFERENCES

BALAZS, G.H. (1985). Impact of ocean debris on marine turtles: entanglement and ingestion. Pp. 387–429 in *Proceedings of the Workshop on the Fate and Impact of Marine Debris, 26–29 November 1984*, Honolulu, Hawaii (Eds R.S. SHOMURA & H.O. YOSHIDA). US Dept of Commerce, NOAA Tech. Memo. NMFS, NOAA-TM-NMFS-SWFC-54, 580 pp., illustr.

COLTON, J.B., jun., KNAPP, F.D. & BURNS, B.R. (1974). Plastic particles in surface waters of the Northwestern Atlantic. *Science*, **185**(4150), pp. 491–7.

GROOMBRIDGE, B. (1982). *The IUCN Amphibia–Reptilia Red Data Book, Part 1: Testudines, Crocodylia, Rhynchocephalia*. IUCN, Gland, Switzerland: xliii + 426 pp.

HIRTH, H.F. (1963). The ecology of two lizards on a tropical beach. *Ecological Monographs*, **33**(2), pp. 83–112.

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Toxic Chemicals—United Nations Initiative

Four weeks being about the normal 'media' half-life of a major environmental disaster, it is not surprising that in March 1987, three months after the Sandoz chemical plant in Basel, Switzerland, spilled toxic herbicides into the River Rhine, even such a striking disaster seems to have been almost forgotten, at least as an issue of international concern.

Weeks one and two after the disaster were dominated by somewhat ghoulish accounts of a red Rhine and tons of dead eels being fished out. The following fortnight produced familiar outraged cries of scandal, folly, and duplicity, followed by contrite confessions by corporate executives.

It is a pattern of horror, catharsis, and ultimate forgetfulness, that has long accompanied major environmental disasters—perhaps by way of relieving anxieties about the dangers of modern technology. If it were a process that elicited a coherent response to the dangers of toxic chemicals, all could be well. But there has been a tendency to let the issues fade before any serious effort is made to prevent such disasters from recurring.

Pattern Seemingly Changing

Recently, however, there have been fledgling signs that the pattern may be changing. For example, in response to the lethal 1984 gas-leak at Union Carbide's plant in Bhopal, India, the United States Environmental Protection Agency introduced a programme to alert communities to the presence of toxic chemicals in their areas, and to involve them in various contingency plans. How effective such a system will be remains to be seen, but the fact that it exists should provide grounds for some optimism.

Likewise, the nuclear disaster at Chernobyl has led to two international treaties on notification and assistance in case of nuclear accidents. Now at least we have a legal framework spelling out nuclear states' international obligations. But in the case of the Rhine, the international community will have to move beyond the question of compensation and the immediate problem of cleaning up the mess, and plan for the long term.

The initial response from the affected governments, industry, and the public, has been encouraging. Certainly in the Rhine basin it looks as if the inquiry that is now under way will address many of the most obvious shortcomings at Sandoz and will leave the governments better prepared than formerly. But if the Third World, where the use of chemicals has grown considerably, is to benefit, the broad implications of the European inquiry must be taken into account.

Plan to Avoid Repetition

It is not enough simply to bemoan the fact that a 15-years-old law governing pollution on the Rhine proved useless. Now that the glare of publicity has dimmed, it is time for governments and international organizations to sit down with industry and make sure that mistakes are not repeated.

The participants at such meetings could reflect on the scene in Basel in the hours following the accident: government vehicles issuing warnings to the public to keep windows closed; messages broadcast in German to Italian- and Turkish-speaking families. They could reflect on incompatible alarm systems that delayed response to the emergency. They could remember the sudden realization that the Swiss authorities did not immediately know who were the responsible officials in neighbouring France and West Germany. Most of all, they should reflect upon the fact that regulations governing safety standards and industrial codes of conduct had proved ineffective.

Many of the lessons are simple enough. Contingency plans, procedures for notification, chemical identification, early assistance—these are not costly measures. Beyond them, there is a need for national regulations, particularly in setting safety standards.

Unfortunately, regulation is often used as a stick with which to beat industry. If Sandoz and, indeed, Union Carbide, had been encouraged to play a more constructive role in contingency planning, perhaps their respective disasters would have been less catastrophic. In addition, statutory regulations require a national commitment to monitoring compliance with their standards: there is no point in having fine environmental legislation if nobody accedes to it!

Progress is not simply a measure of mechanical competence: it includes an ability to formulate a coherent response to failure. It requires a package of international legislation that will organize procedures for notification and assistance in case of chemical emergency. And it should include a programme to alert local people to any toxic chemicals with which they live and to help limit the dangers that they consequently face.

The United Nations Environment Programme is proposing just such a package. The extent to which the international community, including giant industry, is willing to join in, may be the best measure of the world's ability to break out of its cycle of forgetfulness.

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Dr Marvin Stephenson, 1935–1987

The field of resource conservation lost an ardent supporter and activist with the sudden death of Marvin Stephenson in Brig, Switzerland, on 24 January, when he was serving as Deputy Director of the Environment and Human Settlements Division, Economic Commission for Europe.

Dr Stephenson's was a strong voice in ECE's efforts in the field of low- and non-waste technology—the integrated approach to eliminating waste at the 'front end' of industrial production rather than treating wastes after generation. He had also served as acting head of other environmental programmes of ECE's Environment and Human Settlements Division, including the air pollution programme.

A native of the State of Oregon (USA), Dr Stephenson had gained his PhD in Chemical Engineering from the University of California at Berkeley. He taught at the University of Southern California and at Michigan State University before entering into interdisciplinary work aimed at environmental conservation. After serving as an officer of the Rockefeller Foundation, he became a division director at the National Science Foundation's Research Applied to National Needs programme, until in 1981 he was named to the ECE post in Geneva. Dr Stephenson is survived by his wife, Ursula, and their daughter Lesley.

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The Plastic

Styrofoam cups, sandwich bags, soda bottles, a disposable lighter, balloons and a grocery store bag. Supplies for a Sunday picnic at the park? Well, maybe they were once. Now they are part of the plague of plastic pollution floating in a corner of the Ala Wai Boat Harbor, working their way to the sea.

And what happens to this garbage then?

Nothing good. It either drifts in the ocean's currents until it washes ashore causing polluted beaches or some unfortunate marine animal mistakes it for food and swallows it — or tries to — which then causes the animal suffering and death.

Plastic, which has been around since 1860, began its popularity during World War II when some natural resources, such as rubber, were scarce. Since then, plastic has gradually replaced many items traditionally made of metal, leather, wood and glass. Plastic is desirable because it is abundant and durable, two characteristics that are now causing grief to marine animals.

When an autopsy was performed on a small hawksbill turtle that washed ashore near Honolulu, biologists found three pounds of plastic in its intestines. Plastic rope, a balloon, part of a plastic comb, a toothpaste cap, a golf tee, a baggie, a plastic flower — these were just some of the items found inside this young turtle. Deflated balloons trailing a ribbon are particularly lethal to sea turtles who mistake them for one of their favorite foods — jellyfish.

Turtles and whales, seals and sea birds — all are being hurt by the plastic garbage of our throw-away society. The beaches of Hawaii's Leeward Islands, which are a refuge for many species of marine animals, are littered with every kind of plastic trash imaginable. Blue poker chips, yellow fishing bobbers and red toy soldiers give grotesque color to Leeward Island bird nests. Of 50 albatrosses found dead on the Midway Islands, 45 had eaten some form of this trash!

One pygmy sperm whale died with a 30-gallon plastic garbage can liner, a plastic bread wrapper and a Fritos bag in its stomach. In the last two years, 20 humpback whales have been reported ensnared in lost nets. Two died because they were unable to eat.

And the seals. These playful and curious mammals are getting caught in plastic nets and packing straps which kill by strangulation and starvation.

At least 30,000 northern fur seals (some estimates are as high as 50,000) die each year in the Bering Sea west of Alaska from entanglement in plastic nets.

"Turtles and whales, seals and sea birds — all are being hurt by the plastic garbage of our throw-away society . . ."

Fifty-eight dolphins were stranded on beaches in California in the last three years, flippers and snouts hopelessly entangled in plastic netting. More than 8,000 Dall's porpoises have been killed in stray nets in the North Pacific alone.

Seven per cent of California's sea otter population has been killed by plastic.

How does all this plastic garbage get into our oceans? The same way our highways get littered — people throw it there.

According to the national Center for Environmental Education (CEE), the Navy alone dumps more than 60 tons of plastic into the ocean PER DAY.

Since U.S. law requires that ships arriving from foreign shores sanitize their garbage before landing in our ports, which is a costly proposition, the captains simply dump the trash in the ocean. Merchant ships, according to the National Academy of Sciences, dump 6.6 million tons of trash overboard every year.

The plastic industry itself flushes resin pellets, tiny plastic beads, with liquid factory wastes into sewage treatment plants which eventually spews them into bodies of water. One square mile of ocean southeast of

"What can we do? Don't let balloons get away. Tie them securely to something, then make sure they get punctured and put into a garbage can. Voice some opposition to balloon-releasing extravaganzas." Carol Hogan photo.

Scientists launch giant balloon to study supernova radiation

United Press International

WASHINGTON — NASA scientists have launched a giant helium-filled balloon from Australia to kick off a high-altitude campaign to detect energetic radiation from a nearby supernova.

The agency said the unmanned balloon, filled with 28.4 million cubic feet of helium and carrying a 1,500-pound package of sensitive instruments, took off this week from Alice Springs, Australia, and rose to 130,000 feet.

Three other balloons are scheduled for launch from Alice Springs as part of an intensive NASA campaign to study supernova 1987a, an exploding star 170,000 light years away that has electrified the astronomical community since its discovery in February.

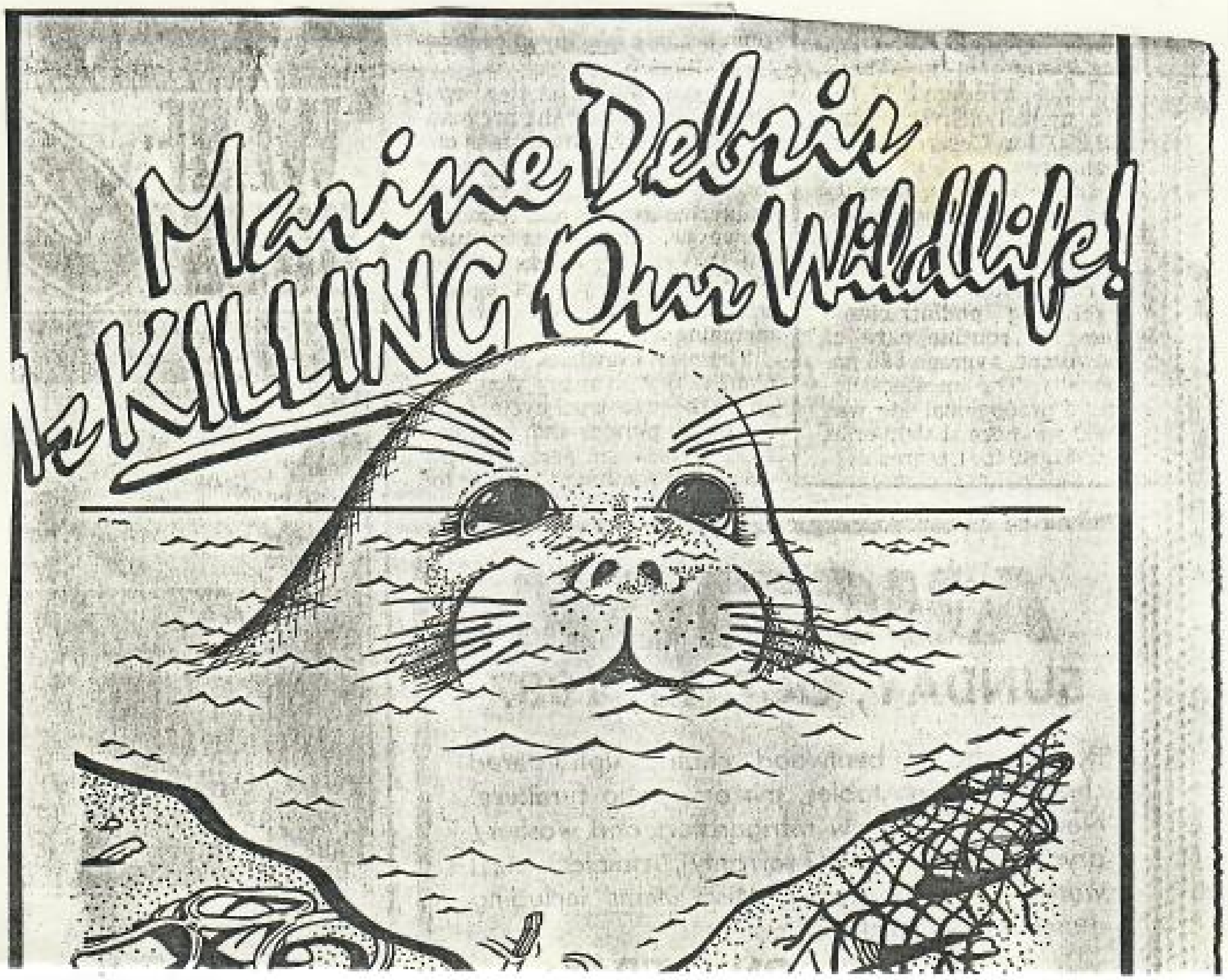
Along with the balloon campaign, NASA plans to launch X-ray and ultraviolet telescopes on sounding rockets from Woomera, Australia, about 600 miles north of Alice Springs, and to conduct other observations with the Kuiper Airborne Observatory, a large jet equipped with a sensitive infrared telescope.

The balloon launched Thursday carried nine advanced instruments, seven sensitive to gamma rays and two that can detect X-rays. The payload was developed by the Lockheed Palo Alto Research Center in California and NASA's Marshall Space Flight Center in Huntsville, Ala.

Supernova 1987a is the closest exploding star detected in nearly 400 years. Located in the Large Magellanic Cloud, a sister galaxy to Earth's Milky Way, light from the titanic explosion was first detected on Feb. 24.

By studying the radiation emitted by the supernova, astronomers hope to refine theories about the nature of the cosmic explosions and how they produce most, if not all, of the heavy elements in the universe.

X-rays have been detected by a Japanese satellite and by instruments aboard the Soviet Mir space station and astronomers theorize that energetic gamma rays will soon arrive at Earth.


Marine Debris
Is KILLING Our Wildlife!

Get The Drift & Bag It!

Everyday innocent marine life is being killed by man made pollution of our oceans. "GET THE DRIFT & BAG IT!" is aimed at ridding our beaches and oceans of marine debris and focusing public attention on the effects of discarded plastics, fishing nets and lines, and other debris.

PLEASE KOKUA. Join us in this statewide cleanup.

Saturday, October 17 — 8:30 to 12 noon

FOR MORE INFORMATION CALL:

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Community Work Day Program 548-6444

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Kauai - Mayor's Beautification Task Force 742-9142
Hawaii, Hilo - County of Hawaii Dept. of Parks & Recreation 961-8311
Kona BIORTA/TORCH 329-7585

"Get The Drift & Bag It!" is coordinated by the Pacific Whale Foundation and the State Litter Control Office.

illustré
No 42 Fr. 3.50 Lausanne, 14 octobre 1987

ANNE SINCLAIR

«Questions à domicile» à la plus intello des journalistes de TV, qui détrône C. Ockrent dans les sondages

ÉLECTIONS

- Le Parlement comme si c'était fait
Hommes à élire, hommes à biffer
Les femmes à la cuisine (électorale)

FUNAMBULE

- Philippe Petit efface à New York son ratage de Lausanne

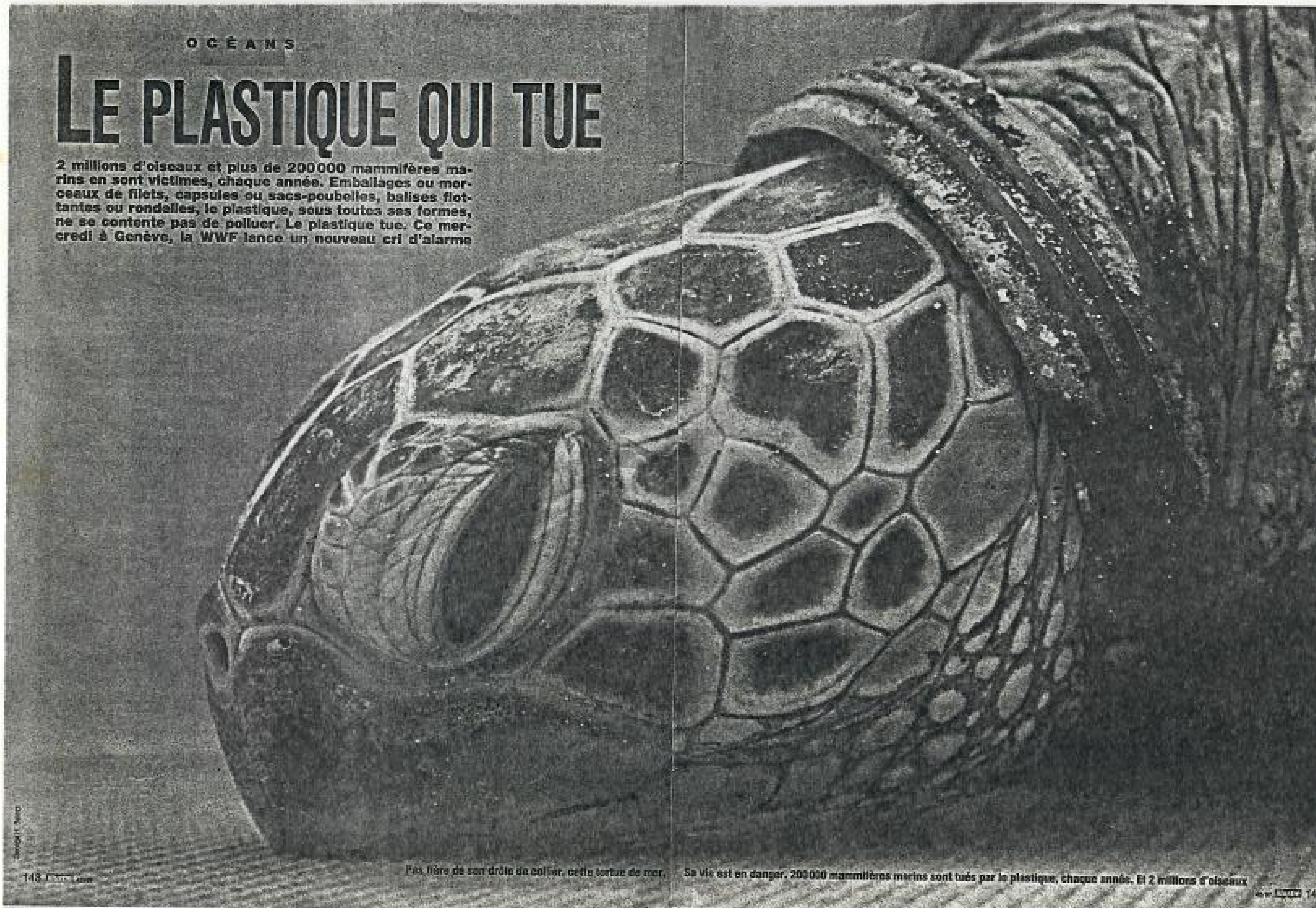
TV Loisirs

M 3638 - 42 - 16 F

OCÉANS

LE PLASTIQUE QUI TUE

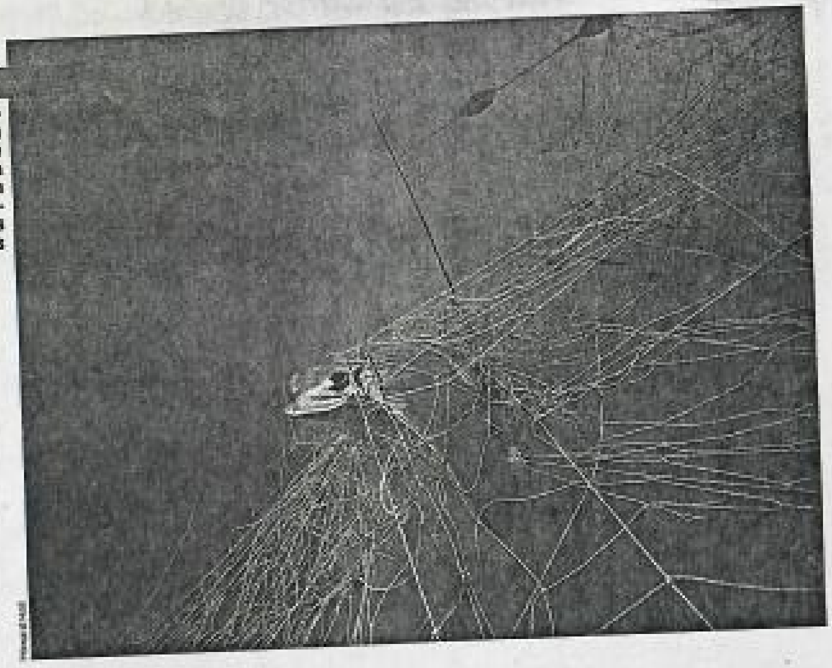
2 millions d'oiseaux et plus de 200 000 mammifères marins en sont victimes, chaque année. Emballages ou morceaux de filets, capsules ou sacs-poubelles, balises flottantes ou rondelles, le plastique, sous toutes ses formes, ne se contente pas de polluer. Le plastique tue. Ce mercredi à Genève, la WWF lance un nouveau cri d'alarme



Pas fière de son drôle de collier, cette tortue de mer. Sa vie est en danger. 200 000 mammifères marins sont tués par le plastique, chaque année. Et 2 millions d'oiseaux

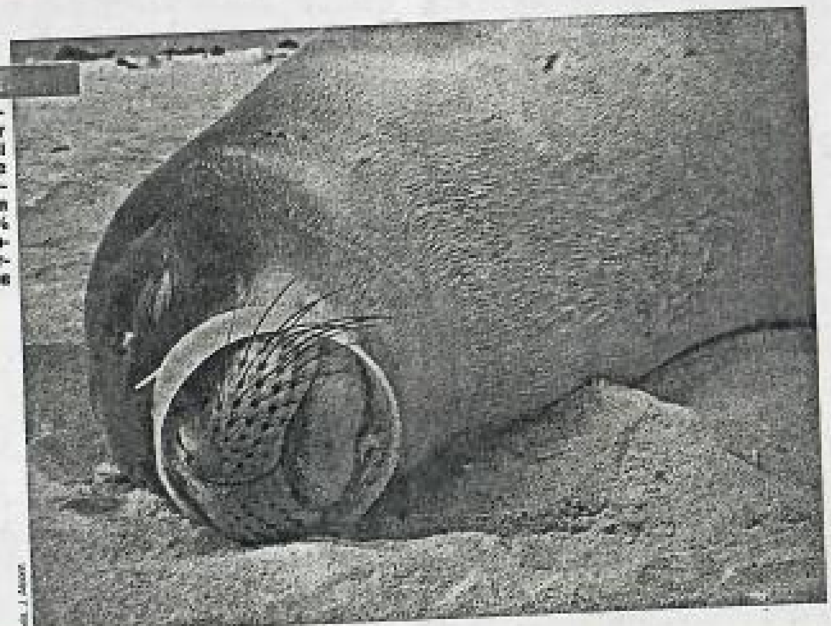
Filets

Une raie Manta prisonnière de filets en haute mer. Dans le Pacifique Nord, on estime que 18 km de ces «filets-fantômes», comme on les appelle, sont perdus chaque jour



Anneaux

Jeune phoque-moine échoué sur une plage d'Hawaii avec un anneau de plastique lui enserrant le museau. En Méditerranée, 30% des poissons auraient des morceaux de plastique dans l'intestin



Porte-boîtes

Un jeune goéland argenté piégé par un porte-boîtes de bières. On évalue à 160000 tonnes de plastique les tombereaux de déchets déversés en mer par la marine marchande, chaque année

Tubes

Biennies vivipares captives d'un tube de néon sur une côte de la mer du Nord. Les océans deviennent de vastes poubelles et la pollution par les déchets rejetés par notre civilisation prend d'innombrables formes

La mer n'est pas un dépotoir

Les océans sont pleins de tueurs. Et les pires ne sont pas ceux qu'on croit. Le plastique, par exemple. Matière hautement civilisée et d'apparence inoffensive, le plastique cause chaque année la mort de 2 millions d'oiseaux et de 200000 mammifères marins. Chiffre énorme? Encore en dessous de la réalité, selon Alan Reichman de l'Organisation Greenpeace: *«Beaucoup de morts d'animaux passent inaperçues et nul ne connaît le chiffre exact. Tout ce qu'on sait, c'est qu'il donne le vertige.»*

Sacs, balises flottantes, capsules, rondelles, emballages ou filets, il peut prendre bien des formes, le plastique. Quand il tue, c'est en général par «entanglement» comme disent les Anglais, mot difficile à traduire qui signifie: être empêtré dans... prisonnier de quelque chose. Le problème est si grave que le WWF, Greenpeace et une vingtaine d'autres organisations écologistes ont mis sur pied une sorte de «Comité international contre l'empêtrement»: le «Entanglement Network». *«C'est un danger sérieux pour l'environnement et trop négligé,»* dit Alan Reichman. *Nous n'avons cessé de prendre les mers pour des dépotoirs. Aujourd'hui, les mers débordent de plastique.»*

Un poisson sur trois a du plastique dans le ventre

Des chiffres? Chaque jour, les navires de la flotte marchande balancent à la mer 600000 «sacs, boîtes ou emballages de plastique», sans parler des boîtes de conserve (4 millions) et des bouteilles (300000). Les bateaux de pêche industrielle et les autres ne sont pas en reste: on estime qu'ils perdent ou rejettent à la mer l'équivalent de 160000 tonnes de plastique par année sous forme de balises, de filets, ou de lignes. 160000 tonnes!

Comment tout ce plastique peut-il tuer? Encore quelques chiffres. En Méditerranée, on estime que 30% des poissons ont des morceaux de plastique dans l'intestin. En 1984, un cachalot malade échoué sur une côte de l'Adriatique avait une cinquantaine de sacs plastique coincés dans le tube digestif. Les tortues de mer prennent les sacs plastique pour des méduses et se retrouvent avec des occlusions intestinales qui peuvent les faire mourir. Les phoques, les dauphins, les loutres de mer et même les baleines se retrouvent pris dans des filets de pêche à l'abandon et de nombreux oiseaux ont été retrouvés à demi-morts d'inanition, une bande de plastique enserrant leur bec dans un étau.

Autre coupable, cœur du dossier d'accusation: les filets de pêche. Par exemple, les innombrables filets perdus en mer, filets-fantômes comme on les surnomme, qui continuent indéfiniment à piéger leurs proies sous-marines.

Il y a pire encore: les «drift nets», les filets-traînants de la pêche industrielle en haute mer. Ils sont conçus pour flotter juste au-dessous de la surface et, entraînés par les courants, peuvent dériver ainsi sur des distances considérables. Les plus grands de ces filets-traînants peuvent atteindre 30 km de long. Dans le Pacifique Nord, les bateaux industriels de la pêche au saumon et au calmar déploient chaque nuit l'équivalent de 29000 km de filets. Sur ce chiffre, 18 km sont perdus chaque jour, ce qui, fait, par saison, environ 2500 km. 2500 km de danger à la dérive, causant chaque année la mort d'un demi-million d'oiseaux marins.

Car les filets-traînants sont faits d'un monofilament de nylon qui est non seulement moins cher, mais aussi moins visible que la fibre des filets classiques. Les oiseaux marins aperçoivent la masse grouillante de poissons au-dessous d'eux, mais ne peuvent distinguer le filet. Fondant sur leurs proies, ils se prennent les ailes ou les pattes dans les mailles de nylon. Ils sont pris au piège comme le sont des milliers de dauphins dont les radars acoustiques détectent mal les filaments de nylon.

A quand l'obligation de ramener les déchets

Ces fragments de filets qui partent à la dérive peuvent parcourir des centaines de kilomètres, tuant quasi indéfiniment. Dans la zone surexploitée de la mer de Bering, 1300 tonnes de débris de filets ont été perdus, rien qu'en 1980. On estime qu'ils ont causé la mort de 50000 otaries à fourrure. Ils ont une responsabilité énorme dans la baisse de population de ces charmants animaux: une chute de 8% par an!

Au large des côtes norvégiennes, on retire chaque année 4000 cadavres de phoques des filets tueurs. «Ghost nets» pour les Anglais. Filets-fantômes. Bigrement plus réels et autrement dangereux que les vaisseaux hantés, les serpents de mer et les sirènes! Ce qui ne signifie pas, malheureusement, que les instances internationales les prennent plus au sérieux.

Face à cette inertie, le groupe de travail international – Entanglement Network – mis sur pied pour combattre le fléau avance des solutions très pratiques. On pourrait, par exemple, exiger des bateaux qu'ils ramènent dans les ports un certain quota d'ordures calculé en fonction de leur tonnage, afin qu'ils cessent de confondre la mer avec une décharge publique. On pourrait aussi offrir des primes aux pêcheurs qui ramèneraient leurs filets usagés plutôt que de s'en débarrasser au large.

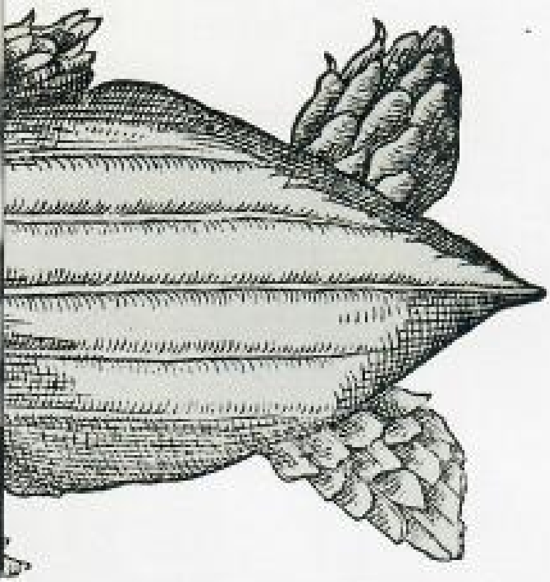
Autres possibilités: équiper les filets de mécanismes sonores à l'intention des mammifères marins ou y pratiquer des systèmes permettant «l'évasion» des tortues de mer ou des dauphins captifs. Ces moyens existent, ils ont été testés avec succès, mais leur introduction se concilie mal, selon toute apparence, avec la frénésie de profit à court terme de l'industrie de la pêche. Et le plastique-fantôme continuera, sans doute, longtemps encore, de hanter les océans et de tuer.

Bill Johnson

Photo Museum de La Rochelle

Tortue luth capturant une méduse Rhizostoma pulmo *(Pointe d'Arçay - 22.7.78).*

les spécimens américains. Lors de son activité alimentaire, la tête complètement immergée, la tortue peut être confondue avec une barque de pêcheurs renversée. Considéré comme sourde bien qu'ayant des organes auditifs fonctionnels, il est facile à ce moment-là, de la toucher sans l'effaroucher à condition de rester hors de sa vue. Effrayée par la proximité de l'embarcation, elle plonge rapidement en effectuant des plongées de 7 à 8 minutes. A la recherche de sa nourriture, l'animal se déplace par courtes plongées de 1 à 3 minutes dans les bancs de méduses : *Rhizostoma pulmo* qui constituent l'essentiel sinon la totalité de son régime alimentaire. La morphologie de ses machoires et le revêtement particulier de son œsophage muni d'épines cornées confirment un régime hautement spécialisé. Et la présence dans les contenus stomacaux de quelques débris de crustacés et de quelques fragments d'algues semble plutôt le fait du hasard. A priori, la valeur nutritive de cette méduse, comportant 97 % d'eau peut paraitre négligeable. La consommation de *Rhizostoma pulmo* serait de 10 par heure d'activité alimentaire. Les méduses ingérées fourniraient 8 à 10 kg de protéines par jour. Sachant que le métabolisme des reptiles nécessite moins d'énergie que celui des mammifères l'absorption presque exclusive de *Rhizostoma* suffirait aux besoins de *Dermochelys*. Le déplacement de ces méduses dû aux courants de marée conditionne les allées et venues des tortues. Le manque de jugement de cet animal semble à l'origine de sa perte. Sans doute trompée par la ressemblance entre sa proie et les sacs en plastique de plus en plus nombreux flottant entre deux eaux près de nos côtes, elle en ingère une grande quantité qui va s'entasser au fond de l'estomac sans franchir le pylore en entraînant une occlusion mécanique à l'origine de dénutrition puis de mort. Sur huit autopsies réalisées en période estivale, sept individus avaient avalé des fragments de plastique. Mais le cas le plus frappant que nous ayons rencontré est celui d'une femelle venue spontanément s'échouer près du phare des Baleines dans l'Ile de Ré. Aucune blessure externe ne semblait handicaper l'animal qui paraissent dénutri et exténué. Remis à l'eau, quelques heures plus tard, cet individu revenait sur les graviers de la plage. C'est après avoir passé 24 heures dans un



Rondelet (1558)
Museum
de La Rochelle.

Papilles cornées de l'œsophage d'une tortue luth mâle (Croix de vie - 21.7.78).

de Chassiron. Par la suite la présence des tortues luths dans les Pertuis Charentais a été rapportée à maintes reprises. En 1968, R. Duguy Directeur du muséum d'histoire naturelle et du musée océanographique de la Rochelle a montré dans une première note qu'elles venaient régulièrement l'été, fréquenter la côte charentaise. Depuis 1977 des travaux se poursuivent annuellement au Musée océanographique de la Rochelle pour préciser les caractères biologiques de cette espèce. Le comportement en mer, le régime alimentaire ont pu être définis par M. Duron (thèse 1978).

Il apparait clairement qu'un nombre important de tortues-luths se trouvent amenées chaque année à fréquenter ce secteur précis des côtes atlantiques françaises au cours de leur cycle biologique.

La tortue luth mène une vie solitaire (Pritchard, 1974). Ce sont pour la plupart des individus isolés que l'on va rencontrer à partir de la fin juin jusqu'en octobre sur le littoral de la Vendée et de la Charente-maritime.

Le nombre d'observations annuelles collectées met en évidence une préférence de ces individus pour l'un des Pertuis Charentais : le Pertuis Breton. En 1978 les 43 individus signalés fréquentaient le Pertuis Breton, en 1979, 2 seulement sur 55 relevaient leur présence dans le Pertuis d'Antioche. Le nombre des individus recensés ne peut pas refléter avec exactitude la population présente dans les Pertuis pour plusieurs raisons. L'animal est d'autant plus difficile à observer que la mer est agitée ; d'autre part l'information est rarement transmise par les pêcheurs pour qui cette apparition pour le moins curieuse devient banale et, par les plaisanciers qui s'étonnent de cette rencontre, mais oublient souvent d'en faire part au Muséum malgré trois campagnes d'information et de nombreux documents distribués. Lors d'une observation, il est possible de les différencier, en notant le dessin que laisse la pigmentation crânienne et le sexe. Facilement reconnaissable à la mer, le mâle possède un appendice caudal beaucoup plus développé que la femelle, lequel dépasse d'une vingtaine de centimètre la pointe de la carapace. Si en Guyane, seules les femelles sont observées, sur le littoral charentais, les deux sexes se côtoient sur des fonds de l'ordre de six à dix mètres. La vitesse moyenne estimée de chaque individu s'élève à 3 nœuds. Chacun d'eux paraît plus maigre en comparaison avec

SCIENCE

ol. 87 — Friday, February 11, 1938 — No. 2250

SCIENCE: A Weekly Journal devoted to the Advancement of Science, edited by J. McKeen Cattell and published every Friday by

THE SCIENCE PRESS

New York City: Grand Central Terminal
Lancaster, Pa. Garrison, N. Y.

Annual Subscription, $6.00 Single Copies, 15 Cts.

SCIENCE is the official organ of the American Association for the Advancement of Science. Information regarding membership in the Association may be secured from the office of the permanent secretary, in the Smithsonian Institution Building, Washington, D. C.

SURFACE MOTION OF WATER INDUCED BY WIND

By Dr. IRVING LANGMUIR

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On August 7, 1927, when about 600 miles from New ork on an Atlantic crossing to England I noticed that ere were large quantities of floating seaweed, most f which was arranged in parallel lines with a somehat irregular spacing ranging from 100 to 200 eters. These lines, parallel to the wind direction, hich I shall call streaks, often had lengths as great s 500 m. Between these larger streaks, which conained vast quantities of seaweed forming continuous ands 2 to 6 m wide, there were smaller streaks which ere made up of detached masses of seaweed along early straight lines. At this time the wind was from he north with a velocity of approximately 10 m/sec 22 miles/hr) and the waves roughly 4 m high.

A day later the waves were larger and the streaks f seaweed were still abundant. On the afternoon of his day a sudden change of wind direction occurred (of about 90°); within 20 min all the seaweed was arranged in new streaks parallel to the new wind direction, although the waves continued to move in the old direction.

It was clearly not cohesion between masses of seaweed that held them together in the streaks. At that time it seemed to me that the only reasonable hypothesis was that the seaweed accumulated in streaks because of transverse surface currents converging toward the streaks. The water in these converging currents descends under these streaks. Between the streaks rising currents, upon reaching the surface, flow out laterally toward the streaks.

The action of the wind on the water sets up longitudinal surface currents in the direction of the wind. The effect of the wind is thus to produce a series of alternating right and left helical vortices in the water having horizontal axes parallel to the wind. If we face in the direction toward which the wind blows we should observe that the water between two adjacent streaks forms a pair of vortices: The water on the right-hand side of the vertical plane halfway between the streaks has a clockwise rotation (right helix), that on the left a counter clockwise rotation (left helix).

During the years 1928 and 1929 I made a large number of experiments on Lake George, near Bolton, New York to test this hypothesis of helical motion and to make observations on other water currents produced by wind.

This lake and the location chosen have many advantages for such studies. The depth is about 50 m and the water so clear that white objects at 8 m depth can be seen. Since the lake lies between two parallel mountain ridges, rising from 300 to 700 m above the lake surface, the wind usually dies down completely at night and during the day blows only in one of two directions (southwest or northeast). Most of the experiments were made at a point about 1 km from the nearest land with a clear fetch of from 4 to 7 km in the direction from which the wind was coming.

With wind velocities of 4 m/sec or more, streaks become visible because of the accumulation of traces of oil from motor boats, floating leaves or bubbles. Streaks are usually much more prominent in rivers contaminated by industrial oils or by organic matter from swamps.

A gram of oleic acid or olive oil applied to the surface of the lake spreads out to form a monolayer, covering about 1,000 square meters, and this area, because of the damping and elimination of capillary ripples, is sharply distinguishable from the surrounding uncontaminated surface by its smoother surface. After the oil has spread to its maximum area, however, it soon becomes invisible and no longer retards the formation of ripples. Oxidized lubricating oil after spreading to its maximum area leaves a still visible film which accumulates in the streaks and is thus more effective in rendering them visible.

In the autumn floating leaves are particularly useful to show the downward motion of the water under the streaks, for it can be seen from a motor boat brought over a streak that a large number of leaves are gradually carried down and disappear from sight under the streaks. The number of such descending leaves seems to be far too great to be accounted for by leaves which have gradually become denser than water. Some of the leaves placed on the water halfway between streaks reach the streaks, 6 to 10 m away, in about 5 min.

In November, 1929, further study of those motions was made by pouring 50 ml of a 2 per cent. fluorescein solution into the water from a bottle on the end of a bamboo pole. The motor boat was then moved away a suitable distance to prevent disturbance of the surface, and after definite time intervals the boat was brought over the place to observe the motion. It was found that when fluorescein was introduced at the center of a well-defined streak with a wind velocity of 6 m/sec it gradually moved downwards, taking 5 min to go 4 to 6 m. This corresponds to a vertical motion of about 1.6 cm/sec. The horizontal motion of the water on the surface was 15 cm/sec and 10 cm/sec at a depth of 3 m.

When fluorescein was similarly placed in the clear water between the two well-defined streaks it spread out irregularly over the surface and gradually moved toward the two neighboring streaks. The motion could not be followed as far as the streaks, as the fluorescein gradually became very diffuse, showing that although the motion was very slow it was very turbulent.

In other experiments a white cord 2 mm in diameter having small fragments of cork along its length at 10 cm intervals was floated on the surface of the lake in a straight line perpendicular to the wind direction. After 10 min this cord had developed well-defined waves, being displaced forward in the direction of the wind in the streaks and backward in the spaces between them, indicating that the forward velocity of the water was greater in the streaks than in the spaces between them. The water rising from deeper levels has a low forward velocity, but this increases steadily through the action of the wind so that when the water reaches the streak it has its maximum velocity.

A few measurements were made of the vertical components of motion by means of a large square sheet of aluminum suspended in a horizontal plane from a small lamp bulb so weighted as to give practically zero buoyancy. This device was calibrated in quiet water to determine the rate of descent or ascent when small weights were added or removed. This apparatus was lowered a few meters below the surface and attached by a light horizontal cord, 2 m long, to a lead weight suspended at an equal depth from a bulb floating on the surface. In this way the tendency of the aluminum plate to rise or fall could be observed without fearing the loss of the apparatus and without subjecting it to appreciable horizontal or vertical forces. In the streaks it was thus found that two meters below the surface there were descending currents of about 2 to 3 cm/sec and rising currents of from 1 to 1.5 cm/sec midway between adjacent streaks. This method appears particularly promising for future investigations.

To measure currents in the lake set up by wind, at depths from 5 to 30 m, some umbrellas, 60 cm diameter, were tilted 90° from their normal positions and suspended, with proper counter weights to hold them in this position, by light cords from small lamp bulbs floating on the surface. A painted bulb floating on the surface attached to a lead weight resting on the bottom served as a marker buoy. By placing umbrellas at different depths close to the marker buoy and observing the motion of their floats the velocities and directions of the currents at different depths could be determined. The distances traversed by the floats were measured by the time required to cover the distance from the marker buoy to the float by a motor boat moving at a known speed.

In experiments on October 6, 1929, it was found that a "velocity indicator" at depths less than 5 m gradually drifted under a streak, but one suspended 10 m deep had no tendency to do so. Perhaps at a greater depth the indicator would move into a position midway between streaks, since there must be horizontal currents which converge under the rising currents between the streaks.

Between September, 1926, and August, 1929, on 28 separate days well distributed throughout the years, I measured the water temperatures at different depths (0 to 58 m) with an electric resistance thermometer.

When the lake freezes over, usually about January 10, the temperature at depths from 3 to 58 m is very uniform at about 1.2° C. By the end of March the temperature at the bottom rises to about 2.2°; but the increments are smaller at lesser depths.

This warming is due to the absorption of the sun's rays which penetrate the ice. The warmed water, being denser, sinks to the bottom and slowly flows to the deeper parts of the lake. Measurements have shown that in parts of the lake which have a depth of 5 to 10 m there is often a layer of warm water of 3 to 4° C. of 1 m thickness close to the bottom.

By the time the ice breaks up, about the middle of April, the temperature is again rather uniform, and is about 3° C., except for a thin layer of cold water under the ice. The rapidity of the breaking up and disappearance of the ice, which often takes only 10 to 20 hrs, is due to the warm underlying water stirred up by the wind as patches of open water are formed.

After the ice breaks up and while the water is within 1° or 2° of the temperature which gives maximum density (4° C.), the temperature on windy days is the same at all depths and rises at a rate of about 4° per month. At this time of the spring overturn, however, the temperatures on quiet days are especially non-uniform over different parts of the lake. In shallow places the temperature rises far more rapidly than in deep parts, for there are then no appreciable density differences to equalize the temperatures.

In 1926 the maximum temperature at 58 m was 9.6°, which occurred about November 10. In 1927 the temperature at 58 m depth rose at a gradually decreasing rate from 7° on June 1 to a maximum of 10° on November 15. During 1928 on June 1 the temperature at the bottom was only 5.3° and rose at a steady rate of only 0.7° per month until August 1. On October 20 the bottom temperature was 8.4°, which had been reached the previous year early in July. In 1929 a bottom temperature of 8.4° was reached as early as June 15, and it was 9.2 on July 6.

Examination of the temperature-distribution curves at different depths shows that between May and November a few quiet sunny days cause the development of a nearly uniform temperature gradient of as much as 0.7°/m which may extend to 10 or 15 m depth. A windy day causes the temperature gradient to disappear down to a certain depth, but produces a very sharp temperature gradient (as much as 5°/m) at the lower limit of the isothermal layer (thermocline). After alternating warm and windy periods the topmost 15 m of water may contain several of these isothermal layers (or epilimnions) with intervening thermoclines. The most marked gradients have always been observed at depths between 10 and 15 m.

I believe this represents the maximum depth to which the helical vortices descend with the wind velocities ordinarily occurring during the summer months.

When the surface temperature falls during the autumn the cooled water sinks to the level of water already of similar temperature. Thus the depth of the epilimnion increases during late September and October and reaches the bottom of the lake and produces the maximum bottom temperature about the middle of November. During this cooling the thermocline disappears, for the gradient below the bottom of the epilimnion is usually less than 0.3°/m.

Measurements with the velocity indicators have shown that longitudinal currents set up by wind extend to very different depths at different seasons. On June 20, 1929, at 9:00 A.M. when there was a 2 m thick, sharply defined, isothermal layer of water at 22°, overlying 16° water, a wind having an estimated velocity of 2 to 3 m/sec set the whole epilimnion into motion at 30 cm/sec. This lasted all day and continued for a couple of hours after the wind died down in the evening. The epilimnion was still 22° but had increased in depth to over 4 m.

Observations showed that after windless nights the water velocities at various depths were usually of the order of 2 to 3 cm/sec (rarely as high as 6) and had different directions at different depths. Within less than an hour after a wind of 4 to 8 m/sec springs up the water near the surface is set in motion parallel to the wind direction with velocities of 10 to 20 (rarely as high as 30), but the velocity and direction of the currents at depths greater than 10 m usually remains unchanged for at least 6 hours.

On July 27, 1929, the epilimnion (21.8°) had a depth of 6 m; the temperature gradient in the thermocline was 1.0°/m to a depth of 15 m (12.5°). Below that, in the hypolimnion the gradient was only 0.07°/m. After a windless night a southwesterly breeze of 2 m/sec started about 8:00 A.M. (E.S.T.) and gradually increased to a velocity of 6 m/sec at noon, reached a maximum of 7m/sec at 2:00 P.M. and fell to 5 at 4:00 P.M. and to 1.5 at 7:00 P.M.

At a depth of 10 m the velocity during the whole afternoon was about 5 cm/sec in a direction 90° to the left of the wind direction, but at depths from 12 to 15 m the velocity was about 1 cm/sec in a direction which was 30° to the right of the wind. At depths less than 6 m the motion of the water was parallel to the wind. The momentum delivered to the water by the force of the wind must therefore be distributed within a layer 6 m deep.

At 12:30 P.M. the velocity of the surface was 20 cm/sec, and this rose to 24 at 3:20 and then increased slowly to 27 at 5:00 and decreased to 15 at 7:00 P.M. and was still 14 at 7:30 P.M. 20 min after the wind had died down completely. At a depth of 3 m the velocity was 14 at 4:00 P.M. and 10 cm at 7:30 P.M. At 6 m it was 9 at 4:30 and decreased to 7 at 6:00 P.M. and to 5 at 7:0 P.M. The velocities were also frequently measured at 1.3 m depth and were approximately halfway between those observed at depths of 0 and 3 m.

A rough estimate of the increase of momentum of the water which was caused by the wind was made by integrating $(v - v_0)dx$ from the surface down to a depth $x = 600$ cm, where the velocity remained approximately 6 during the day. The momentum/cm² of lake surface rose from about 6,000 (g. cm^{-1} sec^{-1}) at 4:00 P.M. to a maximum of about 7,000 at 5:00 P.M. and then slowly fell to 3,000 at 7:30 P.M. The maximum occurred about 3 hours after the maximum wind velocity and at a time when the wind velocity was only half its maximum velocity.

If we consider an infinite body of water the momentum per unit area due to the wind should be equal to $\int F dt$ where F is the horizontal force per unit area exerted by the wind. To estimate the order of magnitude of F we may assume that a momentum of 7,000 was delivered by wind acting for 3 hrs and so get $F = 0.65$ dynes/cm for a wind velocity of 5 m/sec (measured 2 m above the lake surface).

It is very evident from the measurements that the momentum does not increase steadily in proportion to $\int F dt$. There must then be some mechanism by which the momentum is transferred to the shores of the lake. A current of 10 cm/sec is only 0.36 km/hr, so that with a wind sweep of 5 km it should take 14 hrs for the effect of the shores to make themselves felt.

An unusual opportunity to study the effect of wind on the momentum of the water occurred on August 2, 1929, when there was a sudden reversal in the wind direction. At 9:00 A.M. on this day there was no wind and the surface water had a velocity of 2.9 cm/sec. By 10:00 A.M. there was a wind of 5.6 m/sec and the azimuth of the wind direction was 140°. The surface water was then moving 11 cm/sec (145°) and at 3 m depth the velocity was 6.3 (225°). At 12:20 the wind had increased to 8 m/sec, 120°, and at 2:50 P.M. had fallen to 3.5 m/sec, (90°), and the surface water was then moving 22 cm/sec in the same direction as the wind.

At 2:50 P.M. the wind suddenly reversed its direction. At 2:55 P.M. the wind velocity was 4, and the direction was 240°. The velocity decreased to 3.3 at 3:30 and rose to 7.0 at 3:45, the direction staying constant at 240°.

The surface water had a velocity of 13 at 3:12 P.M. and 18.5 at 3:35, the direction being 210° at both times. At 3:12 the velocity was 5.3 (185°) at 3 m depth and at 3:35 it was 3.2 (240°) at 6 m depth. Using these rather meager data, but assuming that the depth distribution curves were similar to those found on other occasions, I estimate that at 2:50 P.M. the momentum per cm² was about 6,000 in a direction at 90° and it was 4,000 (200°) at 3:12 and 6,500 (220°) at 3:35. This would mean a change of momentum of 8,300 in the first 22 min after the wind reversal and a further change of 3,000 during the next 23 min. A change of 8,300 in 22 min means $F = 6.3$ dynes/cm², a value 10 times as great as given by the data of July 27, although the wind velocity was lower than on that occasion. The rate of increase of momentum, however, rapidly decreased during the next 20 min.

On August 4 after 28 hrs of strong wind, 8 to 15 m/sec, of steady direction, the surface water had a velocity of 24 cm/sec, while the wind velocity ranged from 8 to 10 m/sec. This is a much lower velocity than was produced in June by a wind of only 2 to 3 m/sec.

On August 24 after 8 hrs of strong northeast wind the water velocities were 30 on the surface, 20 at 2.1 m and 19 cm/sec at 4.6 m depth, while the wind velocity was 11 m/sec 2 m above the surface.

Temperature measurements were made on the morning of August 25 after this storm had died down. The epilimnion (19.9°) had a depth of 10.1 m and the gradient in the thermocline was 1.4°/m to a depth of 14.6 m.

The velocities observed on September 2, 1929, with an isothermal layer (20.2°) of 11.5 m showed several interesting features. There was no wind until 9:30 A.M. and the wind velocity rose to 3.5 at 10:30, 5.0 at 11, 6.5 at noon, 9 at 1:00 P.M.; the velocity then decreased slowly to 5 at 3:00 P.M. Between 3:00 and 5:00 P.M. the wind was somewhat variable but averaged 5 m/sec. It then decreased gradually to 3 at 6:00 P.M.

The velocity at 0.2 m depth was 11 cm/sec at 11:00, reached a maximum of 16 at noon, and decreased to 14 at 4:00 P.M. to 11 at 5:00 P.M. and to 4 at 6:00 P.M., although there was still a wind velocity of 3 m/sec.

At a depth of 1.3 m the velocity was only about 1.5 cm/sec less than at 20 cm. At 3 m depth the velocities decreased gradually from 10 cm at noon to 2 cm at 6:00 P.M. At 6 m the velocities ranged from 4 to 2.

The marked decrease in water velocity during the afternoon after 3:00 P.M. in spite of a nearly steady wind is in striking contrast to the observations earlier in the year in which currents were observed to continue with little decrease for hours after the wind died down. The falling off of velocities in September is undoubtedly due to the cooling of the isothermal layer by radiation into a clear afternoon sky which induces instability and causes the surface water to sink to the bottom of the isothermal layer, carrying its longitudinal momentum with it.

There is thus every reason to believe that the helical vortices set up by the wind extend to the depth of the epilimnion but do not penetrate through the thermocline. The surface of the lake is a free surface in the sense that there is no frictional force to restrain horizontal motion. The thermocline, however, is practically a fixed surface like that of a lake bottom, for it is not set in motion by the overlying layers. The longitudinal and transverse velocities of the water in the vortices have their maximum values at the surface and gradually decrease to zero at the thermocline. Thus the vortices are unsymmetrical in respect to depth, being increasingly diffuse at greater depths.

Observations of the streaks at different seasons show that in May and June, especially after quiet days when the epilimnion is shallow or is not strictly isothermal, the streaks are close together (5 to 10 m), while in October and November well-defined streaks usually have spacings of 15 to 25 m. The spacings are presumably approximately proportional to the depths to which they penetrate. Quantitative measurements of the streak spacings are difficult because between the well-defined streaks there are numerous smaller and less well-defined streaks. Just as large waves have smaller waves upon them, it appears that the surfaces of the larger vortices contain smaller and shallower vortices. The patterns of streaks on the lake surface are slowly changing; some growing, others dying out. On some days the streaks are much more regular than on others.

During the spring and fall overturns in April and early December when the whole lake is isothermal, the vortices may extend to the bottom of the lake, but they would then be very diffuse in their lower portions. On clear, cold windy nights in October the lower parts of the vortices should have their greatest velocities, since large-scale turbulence would then be stimulated by the descent of masses of denser water cooled by exposure on the surface at temperatures sufficiently above 4° C. to give a reasonably large coefficient of thermal expansion.

The helical vortices set up by wind apparently constitute the essential mechanism by which the epilimnion is produced. The currents thus set up at the bottom of the epilimnion may sweep off the upper part of the thermocline, making it thin and of increased gradient.

I have never observed in Lake George any reverse flow in the lower part of the epilimnion, but have frequently found an increase in the depth of the epilimnion at one end of the lake and a corresponding decrease at the other due to the wind. The return flow apparently usually takes place slowly at night and is not accompanied by the turbulence associated with the helical vortices and so does not give vertical velocity components which alone can give thermal transport to the deeper layers.

I have not made any search of the literature on this subject, but conversations with many students of turbulent flow and oceanography have indicated that the helical vortices induced by wind are not commonly recognized.

Professor C. Harold Berry has called my attention to a paper by James Thomson[1] in which he explains calm lines seen on a rippled sea" as the lines of convergence of surface currents. There is no suggestion, however, that the streaks seen with strong winds are caused in this way.

H. Jeffries[2] shows that there must be transverse circulation in streams with straight channels. He draws this conclusion from the fact that the greatest longitudinal velocity is observed at a certain depth below the surface near the middle of the stream. There are thus descending currents near the center and rising currents near the shores. Jeffries was not able to explain these transverse currents on the basis of hydrodynamical theory. Undoubtedly the mechanism is similar to that which causes helical vortices on the surfaces of lakes.

In 1933 I made numerous studies of the growth of waves under the influence of wind. I have found that the momentum carried by the waves and delivered to the shore as a radiation pressure accounts satisfactorily for the fact that the momentum of the water increases rapidly at first (before the waves have had time to build up) and then remains nearly constant. I expect to give an account of this work in another publication.

[1] *Phil. Mag.*, 4th series, 24: 247, 1862.
[2] *Proc. Camb. Phil. Soc.*, 25: 20, 1929.

Translation No. 83

U.S. DEPARTMENT OF COMMERCE
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Turtles to attracted to drifting objects to feed upon other marine life attracted to it? school themselves to attract food?

From Suisan Sekai, Vol. 30, No. 2, p. 78-81, February 1981.

FISHING SKIPJACK TUNA SCHOOLS ASSOCIATED WITH SHOALS AND DRIFTING OBJECTS
(Se-tsuki, ki-tsuki katsuo-gun no sogyo)

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LOG-ASSOCIATED SKIPJACK TUNA

Skipjack tuna are known to associate with various kinds of drifting objects. They have been seen with drifting logs, around the body of a dead sperm whale, with various wooden objects, and at times, even accompanying drifting vessels. However, this is not to say that skipjack tuna can always be found whenever such drifting objects are present. In reality, there are many more drifting objects that are not associated with any skipjack tuna. In other words, it does not seem that skipjack tuna are searching for drifting objects. Rather, it seems that during the course of their migrations, the schools encounter these objects through chance and then decide to form the association.

Thus, the drifting objects per se do not have the effect of attracting skipjack tuna schools. In areas where skipjack tuna schools are nonexistent, the drifting objects will not be able to attract any fish. On the other hand, in an area where the oceanographic conditions (e.g., water temperature, water color, etc.) are generally suitable as a habitat for skipjack tuna, and if such an area should fall within the migratory pathway of the skipjack tuna, then a skipjack tuna school would have an excellent chance of encountering a drifting object to form such an association.

Furthermore, because a skipjack tuna school has been attracted to an object does not necessarily mean that the association will continue for very long. Even when the object is adrift in an area suitable for skipjack tuna, the school may not remain with the object for more than a few days. Thus, the association can generally be considered to be quite temporary.

The most representative of drifting objects is the drifting log ("ryuboku" in Japanese, or simply, "boku").

Translated from the Japanese by Tamio Otsu for the Southwest Fisheries Center Honolulu Laboratory, National Marine Fisheries Service, NOAA, Honolulu, Hawaii 96812, July 1983.

A. What characteristics are essential in an effective drifting log?

1) The larger logs are more effective than the smaller ones.

2) Even those drifting objects such as pieces of wood or other wooden objects are more effective if they are large.

3) The more effective drifting objects are those that have been adrift for a long time.

4) The surface of an effective drifting object is generally covered with barnacles and other marine growths.

5) The object should have lost much of its buoyancy from being waterlogged and should appear on the verge of sinking to be most effective. Those that are bobbing buoyantly on the sea surface are generally "too green" to be effective.

6) Those drifting logs that are in a vertical position are far more effective than those that are drifting in a horizontal position.

B. Fishing log-associated skipjack tuna schools.

A drifting log associated with a large concentration of skipjack tuna is generally one that has been adrift a very long time and is in a vertical position with only its tip bobbing at the surface. Thus, such a log is most difficult to locate. It would be unreasonable to expect fishermen to purposely search for such logs. Instead, the general practice is for the fishermen to locate and fish a school while watching for certain signs to indicate the presence (or absence) of a log in the vicinity.

What are the signs indicating that a drifting log is present? First, when the fishing vessel is stopped over the school and the first fish caught are dolphinfish, Coryphaena hippurus, or rainbow runner, Elagatis bipinnulata, instead of skipjack tuna, then the presence of a drifting log must be suspected. Then, if continued fishing results in a catch consisting of a mixture of small yellowfin tuna (kimeji) and small bigeye tuna (daruma) along with the skipjack tuna, then there is no longer any doubt that a drifting log is present in the vicinity. Another important evidence pointing to the presence of a drifting log is the occurrence of a large number of triggerfish in the vicinity of the vessel.

If these signs are present, the fishing master must determine the location of the drifting log as quickly as possible. Unlike other types of schools, a log-associated skipjack tuna school may be expected to resume biting even after it once stops biting and therefore should not be too quickly abandoned. And as will be discussed later, daruma which are generally not caught during daylight hours can be taken in large numbers in predawn hours. Thus, it is important that the special characteristics of log-associated schools be thoroughly understood if the fishing vessel is to carry out a successful operation.

Once a log-associated school stops biting, a vessel may abandon it prematurely even though there is a very good chance that it will provide good fishing later. Thus, because of the lack of understanding of these schools, a vessel may foolishly abandon an opportunity for a good harvest by leaving the school too soon.

When a log-associated school is fished, the school will slowly move with the vessel as fishing progresses, and soon it may be a considerable distance from the drifting log. The school may then break away from the vessel to return to the vicinity of the drifting log. When this happens, fishing will suddenly turn poor. The vessel should then return to the vicinity of the log so that it would be in the midst of the fish school once again, but to do so, the location of the log must be known. If not, there is a good chance that the log would be lost.

Especially in bad weather, but also under most circumstances, proper precautions should be taken to prevent the loss of productive drifting logs. When working with a "good" log, it is important that it is immediately marked with a bamboo pole and flag. By marking the log in this manner, it will easily be kept in sight even after the school has sounded and the vessel has stopped to await the return of the school to the surface. Even when engrossed in fishing, the fishing master need not fear losing the drifting log if the marker flag is kept in view.

When there is only one vessel fishing a log-associated school, this vessel will make every effort to fish the school so carefully as not to disrupt its integrity in any way. This is to assure that the same school will remain productive for as long as possible. However, when there is more than one vessel fishing the same school, there is often excessive competition between the vessels, and each would try to outdo the other without regard to the integrity of the school. The vessels may maneuver close to the drifting log and try to take as many fish as possible by making repeated passes at the school. This can result in very quickly disrupting the school so that it would no longer respond to any further chumming.

Even a school that has been disrupted to such an extent should not be abandoned too quickly, as discussed below.

C. Method of fishing for daruma around a drifting log.

The most important consideration in fishing a log-associated school is not to abandon it as soon as biting slows. The reason is that almost always large numbers of daruma are at greater depths below a drifting log which provides good skipjack tuna fishing during the day. Thus, a light should be attached to the bamboo pole to mark the position of the drifting log during hours of darkness. The daruma will remain deep during the day and will ascend toward the surface at night. Therefore, they should be fished during hours of darkness.

About 2 hours before daybreak, two or three live baitfish are tossed intermittently into the water near the vessel. Soon, if a splashing sound is heard, this would indicate that the daruma are at the surface and feeding. As soon as this happens, the crew is placed on standby. Since it is still very dark, the deck lights are turned on while the fishermen take their places in the fishing rack. The chumming then commences, and the water spray is turned on. As expected, 7- to 10-kg daruma will begin biting furiously.

Since daruma are not caught during daylight hours, it is almost unbelievable that they are taken so easily in the very same area. An effective artificial jig used in fishing daruma is made of a piece of copper pipe and black and yellowish-brown bird feathers.

When there are other vessels nearby, and they are also waiting for the first signs of daruma, your vessel must try to get the jump on the others. Thus, at the first sign of fish at the surface, the crew must be alerted quietly, all in total darkness, and the crew must take their places in the dark. To prevent accidents, the deck lights are turned on but only after fishing commences. When the other vessels realize what has happened, it is already too late since by the time they can get ready to fish the school, the first vessel would already have caught a large amount of fish from the school. By then, dawn would be breaking and the daruma would be starting their descent into deeper waters.

This still does not end fishing around the drifting log. The fishermen should keep a close lookout for evidence of fish just after the break of dawn. While the catch of daruma is being stored away and the decks are being washed down, the sun will be slowly rising over the horizon. About an hour later, there may be excitement once again as a skipjack tuna school surfaces near the log causing ripples to spread over the area. The chances are that this school will again provide excellent fishing. The reason that many vessels catch more daruma than skipjack tuna is only because they tend to pay greater attention to the predawn daruma fishing than to the subsequent skipjack tuna fishing after sunrise.

Because bigeye tuna characteristically surface at night to feed, this knowledge can also be applied by the tuna longline fishery to increase the catches of bigeye tuna. This can be done by adjusting the operations so that a larger portion of the longline gear is hauled in during darkness.

There are research reports indicating that better catches of tunas are made during the daytime than at night. However, from long years of experience in tuna fishing, there is no question in my mind that the catch rates of bigeye tuna are higher at night. Furthermore, the several fishing masters I have consulted have all confirmed that as far as bigeye tuna are concerned, their catches are best during the hours of darkness.

D. Why do tuna schools associate with drifting objects?

1) Protection

When skipjack tuna are pursued by their predators, they instinctively seek protection under these drifting objects.

2) Wave action produced by drifting objects

The wave action produced by the drifting object may be perceived by the skipjack tuna as the swimming movements of a school of small fish.

3) Feeding

Since the drifting object is providing shelter to many small fishes, the larger fishes (e.g., skipjack tuna) will gather to prey on these small fishes.

4) Curiosity

It is clear from watching the fish-finder that when a vessel passes over a school of fish, the school has the tendency to chase after the vessel, and in so doing, will ascend toward the surface. This same behavior, which probably could be termed, "curiosity," may apply to a school of skipjack tuna approaching a drifting object.

The above are some possible explanations for fish aggregations around drifting objects. However, it must be remembered that these explanations are based only on how we humans perceive the situation. It may be that the fish are the only ones that know the real reason for their attraction to drifting objects.

E. Other "drifting objects" with which skipjack tuna schools associate.

I remember a time when we fished near some killer whales (shachi) and soon found a very dense school of skipjack tuna around our vessel. The skipjack tuna school remained with the vessel for many hours. The fishing turned out to be exceptional and the vessel was able to obtain a full load on this occasion. The school was lost only after the vessel began to move away from the area. It was believed that the school had been driven to the vessel by the killer whales and could not move away from the security offered by the vessel.

On another occasion, in the Indian Ocean, a large school of skipjack tuna approached a drifting vessel right after it had completed setting longline gear. The school remained with the vessel for several hours and many fish were taken by pole-and-line gear. Here also, the school appeared to be avoiding predators by seeking the protection of the vessel.

In addition, it is well known that skipjack tuna schools associate with whale sharks. We have also had several experiences catching large quantities of skipjack tuna from around the carcass of a dead sperm whale.

F. Artificial drifting log.

With the knowledge that skipjack tuna schools are commonly associated with drifting logs, there are fishery research vessels involved in experimenting with artificial drifting logs to improve their catches. Unfortunately, however, we have not yet heard any reports indicating that artificial drifting logs have increased fishing efficiency. Perhaps this apparent lack of success is simply a testimony that artificial drifting logs cannot be made to match the effectiveness of natural drifting logs. There is a report, however, that a considerable amount of skipjack tuna had gathered under an artificial drifting log 2 days after it was set adrift.

FLOATING FISH SHELTERS

By utilizing the knowledge that fish schools commonly associate with shoals and drifting objects, various types of artificial floating fish shelters have been developed to aggregate fish schools. The "shiira-zuke" (method of fishing for dolphinfish by aggregating them under rafts) in Japan is well known. Off Sashikiji on Oshima Island, large numbers of skipjack and yellowfin tunas are regularly found around the floating radio tower which serves as a fish shelter in the area. Floating fish shelters are found not only in Japan but also in various other localities such as in the Philippines and in the southern-water tuna fishing grounds near Papua New Guinea. Floating objects known as payaos are firmly anchored to the sea bottom. The raft of the payao is made of wood or bamboo from which coconut fronds and other material are suspended to provide additional shelter to the fish. The payao is generally installed where there is little current and where the sea bottom is suitable for its placement. These payaos are very effective in attracting fishes and good catches of skipjack and yellowfin tunas are being made around them.

When traversing the Sulu Sea or the Makassar Strait, a vessel encounters numerous current boundaries. In the vicinity of these boundaries, one can often see large tree stumps or other large drifting objects, on which birds are perched, and which look very much like small boats from the distance. These objects are often accompanied by schools of skipjack or yellowfin tunas. Judging by this, the payaos should serve as very effective fish shelters, providing that the various conditions are met.

At present, many purse seiners in the southern-water fishing grounds are installing payaos and making sets around the skipjack and yellowfin tunas that aggregate under them. The catches range from a few tons to 10 tons per set, with some catches as high as 100 tons. On the average the sets around these payaos produce 20-30 tons.

At present, the payaos are being installed by purse seiners in the Sulu Sea in the Philippines, in southern waters north of the Solomons and north of Papua New Guinea, and off the west coast of the United States. The interest in payaos is spreading since Japan has received requests for the manufacture and installation of payaos from places such as Fiji.

The purse seine method of fishing may be thought of as an indiscriminate fishing method, and one that can cause considerable damage to the resources. Fish taken in purse seines are also not as fresh as those taken by some other methods. In spite of these shortcomings, however, there is no question about purse seining being a very efficient fishing method. Provided that the resource is efficiently managed, purse seining must be accepted as an excellent fishing method.

Tiny Turtles' Big Secret, a Mysterious and Perilous Journey, Is Discovered

By ERIC PACE

THE mystery of where baby sea turtles spend their first months of life has been partly solved, a Florida biologist who has been studying the puzzle for more than 30 years reports.

But in finding the answer to where the newborn reptiles go after they dash from their eggs on the beach to the ocean, researchers have also discovered hazards from pollutants that imperil the turtles while they are still smaller than a human hand.

The biologist, Dr. Archie Carr of the University of Florida in Gainesville, first became intrigued by what he called "the lost year mystery" in 1961. Sixteen years later he was still puzzled, reporting in his book about sea turtles, "So Excellent a Fishe," that "nothing is known about baby turtles once they have entered the sea."

But now, Dr. Carr said in an interview, their secret hideaway has been discovered, at least in areas along the Caribbean coasts of Panama and Costa Rica and the Atlantic shores of Florida and Georgia.

© So Excellent A Fishe

A yearling hawksbill turtle.

"There's no question whatever," he said, "that in many cases, when they leave their hatching grounds," the tiny turtles swim miles out to sea and hitch a ride on rafts of floating seaweeds called sargassum, where for months they feed off the small shrimp, crabs and jellyfish that also congregate there.

Turtles found crawling or lodged in the seaweeds range from three to six inches long, Dr. Carr said, and he acknowledged that it might seem unlikely that such "little, helpless creatures at that tender age are getting out into the open sea and living there for a year" before moving, in maturity, closer to shore, where they feed off the sea bottom.

But the evidence, he continued, "has accumulated to the point that nobody is going to doubt that the sargassum rafts are an important habitat for baby turtles in at least some of their range."

The turtle babies, notably of three varieties, loggerhead, hawksbill and green turtle, are able to swim as much as 50 miles before reaching a raft because they take nourishment on the way from yolk, carried in their bellies, left over from the eggs they hatched from.

Quirks of the ocean currents in some areas, notably offshore from prime sea turtle nesting grounds in Costa Rica and Panama as well as in Florida and Georgia, bring many large rafts together in more or less continuous masses that can extend for 100 miles or more along the shore.

The turtle-bearing rafts range from the size of a football to the size of a football field, and they are found at distances of from a mile to hundreds of miles from any hatchery.

In the past few years, Dr. Carr said, "there have been some spectacular discoveries of quite a number of little turtles in sargassum rafts at distances of as much as 150 miles from the nearest nesting shore." And he said he has come to believe that in some cases the turtles travel on the rafts for thousands of miles. Much of his research on the "lost year" problem has been supported by the World Wildlife Fund and the National Marine Fisheries Service.

?

Once on board a seaweed raft, Dr. Carr said, a turtles' life "is very tricky, but it's certainly better than living in the open sea with no shelter and no food supply."

The life is dangerous, in part because storms sometimes tear the seaweed masses and mats apart, depriving the turtles of food and refuge.

Also, "Sharks, groupers and other fish prey on the baby turtles as they swim to the sargassum rafts and once they get there," Dr. Carr said, and frigate birds, pelicans and seagulls attack from above.

"Everybody likes to eat little turtles," he said.

In addition, the same ocean current patterns that form the seaweed masses also stud them with pollutants, including fragments of styrofoam, droplets of heavy oil and gobs of tar.

"The baby turtles are charming but really a bit dumb," Dr. Carr said, "and they bite practically anything. So they bite these things, and their jaws get glued together, and they die."

Mortality Rate Is Growing

Dr. Carr said he has concluded that the mortality rate of the little turtles in the sargassum rafts has been growing in recent years in correlation to the increase in pollutants. There is no way of knowing what percentage of the turtles survive the sargassum-raft phase of their lives, Dr. Carr said, but as they mature the survivors reach what turtle experts informally call "the dinnerplate size."

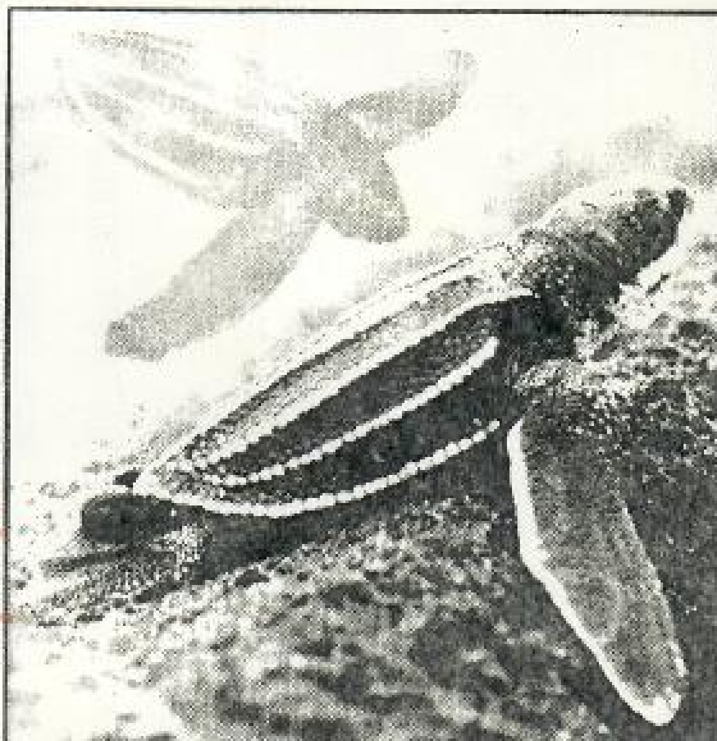
Some dinnerplate-sized sea turtles gravitate to areas where they can feed on small crustaceans and mollusks that live on the bottom within their reach. But dinnerplate-sized green turtles become vegetarians and move to areas where they can feed on aquatic plants, he said.

The breeding size of both green turtles and loggerheads is around 200 or 300 pounds, but both varieties reach weights of up to 600 pounds.

All sea turtles are classified either as threatened or endangered through most of their ranges by the International Union for the Conservation of Nature and under the United States Endangered Species Act.

Dr. Carr, who is chairman of the international union's sea turtle committee, said "it seems to me very, very difficult" to attack the problem that pollution poses for the baby turtles in their seaweed rafts.

"What you have to say," he observed, "is, 'stop polluting the ocean.'"



Dr. Archie Carr; © So Excellent A Fishe

Scientists say they know where the baby sea turtles go.

Figure 2 After a heavy storm, the same drainage ditch is completely filled with sediment. See Chapter 5 for details. (Reproduced with the permission of Dr. R. Turner)

Figure 1 Drainage ditch in Tallahassee, Florida under normal dry weather conditions. (Reproduced with the permission of Dr. R. Turner)

PCB's

AQUATIC POLLUTION

EDWARD A. LAWS

University of Hawaii
Honolulu, Hawaii

1981

482pp.

A WILEY-INTERSCIENCE PUBLICATION
JOHN WILEY & SONS
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Continued on back cover

acre with some spots rising to much higher levels and some spots having less.

EXAMINER SWEENEY: *Is that difference of between 13 pounds and an average of one to three pounds a significant difference, in your opinion?*

DOCTOR WOODWELL: *Oh, Yes.*

MR. O'CONNOR: *Mr. Sweeney, I move to strike this article as misleading.*

EXAMINER SWEENEY: *No, I don't think so. They have offered it as an exhibit and I think the testimony will show what this Doctor has said regarding this article. I think it should stay in.*

POLYCHLORINATED BIPHENYLS

Polychlorinated biphenyls (PCBs) are complex mixtures of chlorine substituted biphenyls (see Figure 10.9). Although PCBs are not pesticides, their similarity in many ways to chlorinated hydrocarbon pesticides makes their inclusion in this chapter appropriate. PCBs are no longer produced in the United States, but they were manufactured by the Monsanto Corporation from 1929 to 1977. As of 1975, nine different PCB formulations were being produced by the company (Boyle, 1975, p. 20), but all were sold under the trade name Askarel. PCBs are exceptionally stable compounds, which are nonflammable and highly resistant to strong reagents and heat. Destruction by burning requires a temperature of over 1300°C (Martin, 1977, p. 1). Because of these characteristics, PCBs have been used in a variety of industrial applications. Prior to 1970, the principal uses of PCBs were for dielectric fluids in capacitors, as plasticizers in waxes, in transformer fluids and hydraulic fluids, in lubricants, and in heat transfer fluids. Foreign imports of PCBs have generally accounted for only a few percent of PCB use in the United States, and have been used primarily as plasticizers.

Problems with PCBs

PCBs have been found to display a degree of toxicity to certain organisms comparable to that displayed by some pesticides. For example, we previously noted that Peakall (1970b) had found PCBs to be even more potent inducers of liver enzymes in birds than DDE, and Peakall and Peakall (1973) found that PCBs at 10 ppm in feed significantly lowered reproduction in ring doves. In fact, there is good evidence that PCBs interfere with the reproduction of a variety of organisms, including rodents, fish, fowl, and primates (Maugh, 1975). For example, the reproduction of mink is completely halted

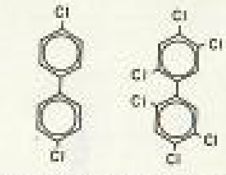

Figure 10.9 Two polychlorinated biphenyl compounds.

if the PCB concentration in their food exceeds 5 ppm (Maugh, 1972). In experiments at the University of Wisconsin, eight female rhesus monkeys were given a diet containing 2.5 ppm of Aroclor 1248 (a PCB formulation) for 6 months. The females were than bred to healthy males. Two of the females subsequently resorbed their fetuses, and one suffered a stillbirth. The five babies born to the other females were all undersized, and two died while still nursing. According to Boyle (1975, p. 20), the remaining three juveniles have shown signs of being hyperactive. In experiments with chickens, hens were fed a diet containing 20 ppm of certain PCB formulations for 5 weeks. Only 8% of the fertilized eggs hatched, and many of the embryos exhibited teratogenic abnormalities. However, this effect on the hens appeared to be specific to only certain PCB formulations (Maugh, 1972).

PCB concentrations in the oceans are quite low in most areas. Harvey et al. (1973) reported mean PCB concentrations in the upper 200 m of the North Atlantic Ocean to be about 20 parts per trillion. However, Fisher et al. (1974) found that PCB concentrations as low as 100 parts per trillion could cause substantial disruption of phytoplankton communities grown in continuous culture. Thus there is some reason to be concerned over PCB concentrations as low as even 20 parts per trillion, and Harvey et al. (1974) report measuring PCB concentrations as high as 100 parts per trillion in some North Atlantic waters. As was the case with DDT residues, one would really like to know the correlation between PCB levels *in the phytoplankton* and physiological effects. Harvey et al. (1974) report that PCB levels in North Atlantic plankton lipids were as high as several parts per thousand in samples rich in phytoplankton. Whether PCB levels this high in phytoplankton might be affecting photosynthetic rates is unknown, because the appropriate laboratory studies have never been done.

PCB concentrations in marine fish seem not to be a serious problem, at least insofar as commercial utilization of marine fish is concerned. PCB levels in the muscle tissue of fish such as cod, haddock, and halibut sampled by Harvey et al. (1974) ranged between 2 and 190 ppb, compared to the Food and Drug Administration (FDA) guideline for edible fish flesh of 5 ppm. These results seem to be typical for marine fish (Martin, 1977). Unfortunately the same statement cannot be made for freshwater fish. PCB levels exceeding the 5 ppm FDA guideline have been found in fatty fish such as lake trout and coho and chinook salmon, as well as in anadromous species such as striped bass (Martin, 1977, p. 1). Freshwater systems that appear to be particularly contaminated include the Great Lakes, and the Hudson and Mississippi rivers.

How dangerous PCBs may be to human beings is not clear. In Yusho, Japan, PCB-contaminated rice oil was implicated in 1291 cases of poisoning including 29 deaths over a 2-month period in 1968. The PCB concentrations in the rice oil averaged 2500 ppm, and persons affected by the sickness were estimated to have ingested about 2000 mg of PCBs. However, the rice oil was later found to have contained 5 ppm of chlorinated dibenzofurans, which are estimated to be several orders of magnitude more toxic that PCBs (Martin, 1977, p. 2). Thus it was not clear to what extent PCBs affected the persons who consumed the contaminated oil.

A group of Michigan sport fisherman who had been consuming on the order of 10 kg of PCB-contaminated fish per year over a 2-year period exhibited no adverse health effects, though PCB levels in their blood were higher than normal. The fishermen were estimated to have consumed about 46.5 mg of PCBs per person per year (Martin, 1977, p. 2). These results are reminiscent of the experimental results of Hayes et al. (1971) in feeding DDT to human volunteers. However, in both cases it is possible that the PCB or DDT contaminated food might have induced long-term effects that did not become apparent during the course of the study.

Workers using PCBs to make capacitors at two General Electric plants near Albany, New York, have complained of allergic dermatitis, nausea, dizziness, eye irritation, and asthmatic bronchitis (Maugh, 1975). Although it is not clear to what level of PCBs these workers were exposed, some of these symptoms have been produced in rhesus monkeys fed a diet containing 300 ppm PCBs (Allen and Norback, 1973).

PCBs have been implicated as causing cancer in laboratory rats in experiments conducted by the U.S. Public Health Service. Malignancies developed when the rats were given food containing 100 ppm PCBs over a 21-month period. However, the PCBs were later found to have been contaminated with chlorinated dibenzofurans and other possible carcinogenic compounds (Martin, 1977, p. 12). Thus the carcinogenic potential of PCBs remains something of a question mark.

Persistence of PCBs

One of the chief concerns over PCBs has been their high degree of persistence in the environment. Because of this persistence, it has been feared that serious environmental contamination with PCBs would be difficult to reverse in a short time, since the compounds would continue to cycle in the ecosystem for perhaps many years. Some indication of the persistence of PCBs is evident from the extensive sampling by Harvey et al. (1974) in the North

Table 10.9 PCB Loading from a Total of Five Sewer Outfalls Discharging to the Southern California Bight

Year	Total PCB Loading (kg/yr)
1972	19,4000
1973	3,400
1974	5,400
1975	2,600

Source. Young et al. (1975).

Atlantic Ocean. Based on estimates of DDT and PCB production and loss rates to the environment, Harvey et al. (1973) estimated that the ratio of PCBs to DDT residues in the environment should be about 0.1. However, Harvey et al. (1974) found the ratio to be about 30 in the marine atmosphere, surface seawater, and plankton of the North Atlantic. Based on these figures, the persistence of PCBs would appear to be about 300 times greater than that of DDT residues.

Realizing the potential seriousness of the PCB contamination problem, the Monsanto Chemical Corporation voluntarily restricted its manufacture of PCBs in 1971 to include only uses in electrical capacitors and transformers. The company reasoned that PCB leakage to the environment from capacitors and transformers would be much less of a problem than PCB leakage from such previous sources as discarded lubricants and hydraulic fluids. There is good evidence that this restriction on PCB usage greatly reduced the extent of environmental loading with PCBs. Table 10.9 lists annual discharge rates of PCBs into the southern California bight from five major sewer outfalls in the Los Angeles–San Diego area (Young et al., 1975). The discharge rate declined by a factor of at least 7.5 between 1972 and 1975. Ultimately these PCBs will presumably either be degraded in the water column or buried in sediments. Elder and Fowles (1977) have discovered that sinking of zooplankton fecal pellets may be the major mechanism for transporting PCBs to the ocean floor. Presumably a similar mechanism is operative in freshwater systems, although recycling of PCBs from the sediments of shallow freshwater systems would undoubtedly be more efficient than the recycling of PCBs from the bottom of most parts of the ocean. In this respect, it is noteworthy that there has been little change in the PCB concentrations of Great Lakes fish since 1971, despite the fact that Minnesota, Michigan, Indiana, and Wisconsin banned the use of PCBs altogether during the early 1970s (IJC, 1977).

Recently a strain of bacteria was produced that is capable of metabolizing PCBs. According to Martin (1977, p. 2), the bacteria were able to reduce the PCB content of sewage sludge from 300,000 ppb to 19 ppb in 1 week.

Although 1 week is certainly much longer than a municipal sewage treatment plant could be expected to treat sewage, further developments in this area perhaps could make bio-oxidation of PCBs a feasible treatment method for at least some wastes. In this context, it is noteworthy that municipal sewage discharges accounted for the majority of the PCB loading to the southern California bight in the study by Young et al. (1975).

However, despite voluntary restrictions on PCB production and use in the United States, Maugh (1975) reported that the total amount of PCBs in the environment was continuing to increase. As a result of this discovery and because of the demonstrated toxic effects of PCB formulations, Monsanto voluntarily terminated all manufacture of PCBs in 1977, and the EPA, under authorization of the Toxic Substances Control Act, banned the manufacture, processing, distribution in commerce, and use of PCBs in the United States effective July 2, 1979. The EPA ruling allowed the continued use of PCBs in existing enclosed electrical equipment under controlled conditions, but as this equipment is phased out PCB use in the United States will gradually drop to zero. The greatest economic impact of the ruling will presumably fall on the electrical utilities, who are obliged to pay the disposal costs for burning PCB-contaminated mineral oil used in transformers and large capacitors. The total first year cost of the ruling was expected to be somewhere between $58 million and $105 million, but the annual costs were expected to decline to $34 million by 1985 and to continue declining as PCB use is phased out (EPA, 1979). Considering the toxicity and persistence of PCBs, the EPAs ruling seems a reasonable course of action.

REFERENCES

Allen, J. R., and D. H. Norback. 1973. Polychlorinated biphenyl- and triphenyl-induced gastric mucosal hyperplasia in primates. Science *179:* 498–499.

Anderson, A. D., and R. March. 1956. Inhibitors of carbonic anhydrase in the American cockroach, *Periplaneta americana* (L.). Can. J. Zool. *34:* 68–74.

Anderson, D. W., and J. J. Hickey. 1970. Oological data on egg and breeding characteristics of brown pelicans. Wilson Bull. *82:* 14–28.

Anderson, D. W., J. R. Jehl, R. W. Risebrough, L. A. Woods, L. R. Deweese, and W. G. Edgecomb. 1975. Brown pelicans: Improved reproduction off the southern California coast. Science *190:* 806–808.

Anderson, D. W., R. M. Jurek, and J. O. Keith. 1977. The status of brown pelicans at Anacapa Island in 1975. Calif. Fish Game *63:* 4–10.

Bitman, J., H. C. Cecil, S. J. Harris, and G. F. Fries. 1969. DDT induces a decrease in eggshell calcium. Nature *224:* 44–46.

Bitman, J., H. C. Cecil, and G. F. Fries. 1970. DDT-induced inhibition of avian shell gland carbonic anhydrase: A mechanism for thin eggshells. Science *168:* 594–595.

Bledsoe, T., D. P. Island, R. L. Ney, and G. W. Liddle. 1964. An effect of *o,p'*-DDD on the extra-adrenal metabolism of cortisol in man. J. Clin. Endocr. *24:* 1303–1311.

Blus, L. J., R. G. Heath, C. D. Gish, A. A. Belisle, and R. M. Prouty. 1971. Eggshell thinning in the brown pelican: Implication of DDE. Bioscience *21:* 1213–1215.

Blus, L. J., C. D. Gish, A. A. Belisle, and R. M. Prouty. 1972a. Logarithmic relationship of DDE residues to eggshell thinning. Nature *235:* 376–377.

Blus, L. J., C. D. Gish, A. A. Belisle, and R. M. Prouty. 1972b. Further analysis of the logarithmic relationship of DDE residues to eggshell thinning. Nature *240:* 164–166.

Boyle, R. H. 1975. The spreading menace of PCB. Sports Illustrated, Dec. 1. Pp. 20–21.

Burdick, G. E., et al. 1964. The accumulation of DDT in lake trout and the effect on reproduction. Trans. Am. Fish. Soc. *193:* 127–137.

Bush, G. L., R. W. Neck, and G. B. Kitto. 1976. Screwworm eradication: Inadvertent selection for noncompetitive ecotypes during mass rearing. Science *193:* 491–493.

Butler, P. A. 1971. Testimony consolidated DDT hearings. Environmental Protection Agency, Washington, D.C.

Carson, R. 1962. *Silent Spring*. Fawcett, Greenwich, Conn. 304 pp.

Carter, L. 1976. Pest control: NAS panel warns of possible technological breakdown. Science *191:* 836–837.

Cecil, H. C., J. Bitman, and S. J. Harris. 1971. Effects of dietary *p,p'*-DDT and *p,p'*-DDE on egg production and egg shell characteristics of Japanese quail receiving an adequate calcium diet. Poultry Sci. *50:* 657–659.

Conney, A. H., R. M. Welch, R. Kuntzman, and J. J. Burns. 1967. Effects of pesticides on drug and steroid metabolism. Clin. Pharmacol. Ther. *8:* 2–10.

Cox, J. L. 1970. DDT residues in marine phytoplankton: Increase from 1955 to 1969. Science *170:* 71–72.

Dvorchick, B. H., M. Istin, and T. H. Maren. 1971. Does DDT inhibit carbonic anhydrase. Science *172:* 728–729.

Edwards, J. G. 1971. Effects of DDT. Chem. Eng. News *49:* 6, 59.

Ehrlich, P. F. 1969. Eco-catastrophe. Ramparts *8*(3): 24–28.

Elder, D. L., and S. W. Fowler. 1977. Polychlorinated biphenyls: penetration into the deep ocean by zooplankton fecal pellet transport. Science *197:* 459–461.

EPA. 1979. EPA bans PCB manufacture; phases out uses. Environmental News. April 19, 1979. 3 pp.

Evans, G. 1978. Dutch Elm Disease: "Fighting a holding action." TWA Ambassador Magazine. August. Pp. 70, 72.

Fisher, N. S., E. J. Carpenter, C. C. Remsen, and C. F. Wurster. 1974. Effects of PCB on interspecific competition in natural and gnotobiotic phytoplankton communities in continuous and batch cultures. Microbial Ecol. *1:* 39–50.

Fitzhugh, O. G. and A. A. Nelson. 1947. The chronic oral toxicity of DDT. J. Pharmacol. *89:* 18–30.

Fleming, W. E., and W. W. Maines. 1953. Persistence of DDT in soils of the area infested by the Japanese beetle. J. Econ. Entomol. *46:* 445–449.

Giam, C. S., A. R. Hanks, R. L. Richardson, W. M. Sackett, and M. K. King. 1972. DDT, DDE and polychlorinated biphenyls in biota from the Gulf of Mexico and the Caribbean Sea—1971. Pestic. Monit. J. *6:* 139–143.

Goldberg, E. D., P. Butler, P. Meier, D. Menzel, G. Paulik, R. Risebrough and L. F. Stickel. 1971. Chlorinated hydrocarbons in the marine environement. Report prepared by the panel monitoring persistent pesticides in the ocean, National Academy of Sciences, Washington, D.C. 42 pp.

Gunn, D. L. 1976. Alternatives to chemical pesticides. In D. L. Gunn and J. G. R. Stevens (Eds.), *Pesticides and Human Welfare*. Oxford University Press, Oxford. Pp. 240–255.

Gutowska, M. S., and C. A. Mitchell. 1945. Carbonic anhydrase in the calcification of the egg shell. Poultry Sci. *24:* 159–167.

Hamelink, J. L., R. C. Waybrant, and R. C. Ball. 1971. A proposal: Exchange equilibria control the degree chlorinated hydrocarbons are biologically magnified in lentic environments. Trans. Am. Fish. Soc. *100:* 207–214.

Harvey, G. R., W. G. Steinhauer, and J. M. Teal. 1973. Polychlorobiphenyls in North Atlantic ocean water. Science *180:* 643–644.

Harvey, G. R., H. P. Miclas, V. T. Bowen, and W. G. Steinhauer. 1974. Observations on the distribution of chlorinated hydrocarbons in Atlantic ocean organisms. J. Mar. Res. *32:* 103–118.

Hayes, W. J. Jr. 1959. Pharmacology and toxicology of DDT. In P. Muller (Ed.), *DDT: The Insecticide Dichlorodiphenyltrichloroethane and its Significance*. Birkhauser Verlag GMBH, Basel. Vol. 1, pp. 9–247.

Hayes, W. J. Jr., W. E. Dale, and C. I. Prinkle. 1971. Evidence of safety of long-term high, oral doses of DDT for man. Arch. Environ. Health *22:* 119–135.

Hazeltine, W. 1972. Disagreements on why brown pelican eggs are thin. Nature *239:* 410–411.

Heath, R. G., J. W. Spann, and J. F. Kreitzer. 1969. Marked DDE impairment on mallard reproduction in controlled studies. Nature *224:* 47–48.

Hickey, J. J., and D. W. Anderson. 1968. Chlorinated hydrocarbons and eggshell changes in raptorial and fish-eating birds. Science *162:* 271–273.

Holcomb, R. W. 1970. Insect control: Alternatives to the use of conventional pesticides. Science *168:* 456–458.

Hunt, E. G., and A. I. Bischoff. 1960. Inimical effects on wildlife of periodic DDD applications to Clear Lake. Calif. Fish Game *46:* 91–106.

Ide, F. P. 1956. Effect of forest spraying with DDT on aquatic insects of salmon streams. Trans. Am. Fish. Soc. *86:* 208–219.

IJC (International Joint Commission). 1977. Great Lakes Water Quality. 1977 Annual Report. Windsor, Ontario. 89 pp.

Innes, J. R. M., B. M. Ulland, M. G. Valerio, L. Petrucelli, L. Fishbein, E. R. Hart, A. J. Pallotta, R. R. Bates, H. L. Falk, J. J. Gart, M. Klein, I. Mitchell, and J. Peters. 1969. Bioassay of pesticides and industrial chemicals for tumorigenicity in mice: A preliminary note. J. Nat. Cancer Inst. *42:* 1101–1114.

Jukes, T. H. 1970. DDT and tumors in experimental animals. Int. J. Environ. Stud. *1:* 43–46.

Jukes, T. H., 1971. DDT, human health and the environment. Environ. Affairs *1:* 534–564.

Jukes, T. H. 1974. Insecticides in health, agriculture, and the environment. Naturwissenschaften *61:* 6–16.

Keller, H. 1952. Die Bestimmung Kleinster Mengen DDT auf enzymanalytischem wege. Naturwissenschaften *39:* 109.

Knipling, E. F. 1953. The greater hazard—insects or insecticides. J. Econ. Entomol. *46:* 1–7.

Laws, E. R. 1967. Men with intensive occupational exposure to DDT. Arch. Environ. Health *15:* 766–775.

Laws, E. R. 1971. Evidence of antitumorigenic effects of DDT. Arch. Environ. Health *23:* 181–184.

Lichtenstein, E. P. 1957. DDT accumulation in midwestern orchard and crop soils treated since 1945. J. Econ. Entomol. *50:* 545–547.

Ling, L., F. W. Whittemore, and E. E. Turtle. 1972. Persistent insecticides in relation to the environment and other unintended effects. Food and agriculture organization of the United Nations, Misc. Publ. No. 4, Rome, May, 1972.

Lockie, J. D., D. A. Ratcliffe, and R. Balharry. 1969. Breeding success and organochlorine residues in golden eagles in west Scotland. J. Appl. Ecol. *6:* 381–389.

MacPhee, A. W., D. Chisholm, and C. R. MacEachern. 1960. The persistence of certain pesticides in the soil and their effect on crop yields. Can. U. Soil Sci. *40:* 59–62.

Maren, T. H. 1967. Carbonic anhydrase: Chemistry, physiology, and inhibition. Physiol. Rev. *47:* 595–781.

Martin, R. G. 1977. PCBs—polychlorinated biphenyls. Sport Fishing Institute Bulletin No. 288, Sept. pp. 1–3.

Marx, J. L. 1977. Applied ecology: showing the way to better insect control. Science *195:* 860–862.

Maugh, T. H., II. 1972. Polychlorinated biphenyls: Still prevalent, but less of a problem. Science *178:* 388.

Maugh, T. H., II. 1975. Chemical pollutants: Polychlorinated biphenyls still a threat. Science *190:* 1189.

Odum, E. P. 1971. *Fundamentals of Ecology*. Saunders, Philadelphia. 574 pp.

Ottoboni, A. 1972. DDT: The world has been doused with it for 25 years. With what results? California's Health *27*(2): 1–2.

Peakall, D. B. 1970a. *p,p'*-DDT: effect on calcium metabolism and concentration of estradiol in the blood. Science *168:* 592–594.

Peakall, D. B. 1970b. Pesticides and the reproduction of birds. Sci. Amer. *222*(4): 73–78.

Peakall, D. B. 1971. Effect of polychlorinated biphenyls (PCBs) on the eggshell of ring doves. Bull. Environ. Contam. Toxicol. *6:* 100–101.

Peakall, D. B., and M. L. Peakall. 1973. Effect of a polychlorinated biphenyl on the reproduction of artificially and naturally incubated dove eggs. J. Appl. Ecol. *10:* 863–868.

Pocker, Y., W. M. Beug, and V. R. Ainardi. 1971. Carbonic anhydrase interaction with DDT, DDE, and dieldrin. Science *174:* 1336–1338.

Porter, R. D., and S. N. Wiemeyer. 1969. Dieldrin and DDT: Effects on sparrow hawk eggshells and reproduction. Science *168:* 199–200.

Ratcliffe, D. A. 1970. Changes attributable to pesticides in egg breakage frequency and eggshell thickness in some British birds. J. Appl Ecol. *7:* 67–107.

Risebrough, R. W. 1973. 6th Berkeley Symposium on mathematical statistics and probability, MS as exhibit Int. EDF 29 at Public Hearing on DDT, Washington, D.C.

Rudd, R. L. 1964. Pesticides and the living landscape. Univ. of Wisconsin Press, Madison. 320 pp.

Sakauchi, N., et al. 1969. A case of adrenocortical cancer treated with o,p'-DDD. Endrocr. Jap. *16:* 287–290.

Schmidt, T. T., R. W. Risebrough, and F. Gress. 1971. Input of polychlorinated biphenyls into California coastal waters from urban sewage outfalls. Bull. Environ. Contam. Toxicol. *6:* 235–243.

Simmons, S. W. 1959. In P. Muller (Ed.) *DDT: The Insecticide Dichlorodiphenyltrichloroethane and Its Significance.* Birkhauser, Basel. Human and Veterinary Medicine, Vol. 2, p. 251.

Sobelman, M. 1972. DDT and pelicans. Nature *241:* 225.

Sokal, R. R. and F. J. Rohlf. 1969. *Biometry.* Freeman, San Francisco.

Southren, A. L., S. Tochimoto, L. Strom, A. Ratuschni, H. Ross, and G. Gordon. 1966. Remission in Cushing's syndrome with o,p'-DDD. J. Clin. Endocr. *26:* 268–278.

Spitzer, P. R., R. W. Risebrough, W. Walker, R. Hernandez, A. Poole, D. Puleston, and I. C. Nisbet. 1978. Productivity of ospreys in Connecticut-Long Island increases as DDE residues decline. Science *202:* 333–335.

Straus, O. H., and A. Goldstein. 1943. Zone behavior of enzymes. J. Gen. Physiol. *26:* 559–585.

Taylor, T. G. 1970. How an eggshell is made. Sci. Amer. *222*(3): 88–95.

Torda, C., and H. Wolff. 1949. Effects of convulsant and anticonvulsant agents on the activity of carbonic anhydrase. J. Pharmacol. Exp. Ther. *95:* 444–447.

Wiemeyer, S. N., and R. D. Porter. 1970. DDE thins eggshells of captive American kestrels. Nature *227:* 737–738.

Wilson, A. J. Jr., J. Forester, and J. Knight. 1970. Chemical assays. In U.S. Dept. of Interior Circular 335 (Gulf Breeze Lab., Florida, Progr. Rep. F. Y. 1969). Pp. 18–20.

Woodwell, G. M., and F. T. Martin. 1964. Persistence of DDT in soils of heavily sprayed forest stands. Science *145:* 481–483.

Woodwell, G. M., C. F. Wurster, and P. A. Isaacson. 1967. DDT residues in an east coast estuary: A case of biological concentration of a persistent insecticide. Science *156:* 821–824.

Woodwell, G. M. 1972. Testimony, consolidated DDT hearings, Environmental Protection Agency, Washington, D.C.

World Health Organization. 1971. The place of DDT in operations against malaria and other vector-borne diseases. Off. Rec. World Health Organization. No. 190, Geneva. p. 176.

Wurster, C. F. 1968. DDT reduces photosynthesis by marine phytoplankton. Science *159:* 1474–1475.

Young, D. R., D. J. McDermott, and T. C. Heeson. 1975. *Polychlorinated biphenyl inputs to the southern California bight.* Southern California Coastal Water Research project. Background paper prepared for the National Conference on Polychlorinated Biphenyls, 19–21 November 1975. 50 pp.

Made in United States of America
Reprinted from THE AUK
Vol. 98, No. 4, October 1981

Ingestion of Plastics by Laysan Albatross

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Ingestion of plastic particles by seabirds has been reported for the Laysan Albatross (*Diomedea immutabilis*) by Kenyon and Kridler (1969), Fork-tailed Storm-Petrels (*Oceanodroma furcata*), Horned Puffins (*Fratercula corniculata*), and Parakeet Auklets (*Cyclorrhynchus psittacula*) from the Aleutians (Ohlendorf et al. 1978), adult and nestling Leach's Storm-Petrels (*Oceanodroma leucorhoa*) from Newfoundland and New Brunswick (Rothstein 1973), and in regurgitated gull and tern pellets from Long Island Sound, New York (Hays and Cormons 1974). In addition, Common Puffins (*Fratercula arctica*) from Britain have been reported to ingest rubber thread cuttings (Parslow and Jeffries 1972). A recent study by Day (1980) revealed that 15 of 37 species of marine birds in Alaska contained plastic, although the origin of ingested plastics was not determined. The observations of Laysan Albatross presented here suggest that a quantity of ingested plastic may have a harmful effect.

During our recent stay (6 November 1979 to 26 March 1980) on Midway Islands (28°13′N, 177°23′W), we fed small telemetry pills to two incubating adult Laysan Albatross to record body temperature. These plastic-coated, cylindrical transmitters (Mini-Mitter Company, Inc.) were 11.5 mm long and 7.5 mm in diameter. After recording body temperature continuously for 30 and 50 days in two separate birds, these plastic pills were passed from the adults by regurgitation to their chicks. The Mini-Mitters continued to transmit body temperature data from the chicks for 3 and 31 days, respectively. At the time of our departure, 40 days later, neither pill was found regurgitated around the nest, and we presumed it was still lodged in the digestive tract. Retention of the relatively small, smooth-surfaced pill indicates that even small, hard objects do not readily pass through the proventriculus and gizzard of adult birds to enter the lower digestive tract. We never observed plastic fragments in the excreta of any albatross.

Further proof of regurgitation of plastics to chicks was obtained during post-mortem examination of four young birds that appeared to have died of natural causes. Plastics were found in the stomach in each case. In one of these, the large amount of indigestible matter contributed to intestinal obstruction. A mass of stomach oil and regurgitated food (about 1 liter) was found in the stomach of a 6-week-old chick but none in the intestines. Another young albatross had bulky plastic materials and squid beaks in the proventriculus and ulcerations of the mucosa.

Imprinted brand names and labels on bottle and tube caps, toys, etc. found in regurgitated pellets and dead albatross carcasses suggested that 108 of 109 identifiable plastic items were manufactured in Japan. There was a single plastic cap from an American-made product. In a study by Fisher and Fisher (1972) the mean distribution of banded adult albatross recaptured at the beginning of the nesting season was east of Japan, in an area defined by 32–36°N and 145–155°E. This zone has particularly rich food supplies due to the turbulence of the colliding cold Oyashiro Current and the warmer Kuroshio Current. During the first 3 months of chick-rearing, the mean distribution of recaptured banded adults was from an area closer to Midway defined by 30–35°N and 150–175°W. It is likely that prevailing winds and the North Pacific Current transported the plastic objects eastward and that the birds picked up the flotsam just north of Midway.

How do Laysan Albatross ingest these items at sea? The best explanation may lie in an examination of their diet and foraging habits. Midway's Laysan Albatross obtain most of their food from squid (70% by volume), fish, and flying fish (Family Exocoetidae) ova (Harrison and Hida 1980). Flying fish lay their eggs at the surface, especially on flotsam. Plastics buried within regurgitated egg masses have been recovered from Laysan Albatross (C. Harrison pers. comm.). There is also a possibility that the plastic litter ingested by albatross resembles in color the marine animals upon which they feed. Japanese tuna fishermen using lines and plastic squid and fish lures are known to catch many Laysan Albatross each year (Fisher and Fisher 1972). The Black-footed Albatross (*Diomedea nigripes*) has been widely reported to scavenge trash thrown overboard and will follow ships for long distances (Fisher 1973). Plastics may be consumed in this manner, but there are no specific reports to confirm this mode of ingestion. It should be noted that on 11 February 1980 a dead Parakeet Auklet was found washed up on a Midway beach. An autopsy of this bird revealed eight small black plastic spherules (3–4 mm) in the esophagus similar to those described elsewhere (Ohlendorf et al. 1978, Rothstein 1973, Hays and Cormons 1974). Apparently, seabirds are unable to adapt to the widespread occurrence of indigestible, floating, plastic litter. Before the appearance of plastic-particle pollution, most surface objects were probably edible, and thus natural selection could not have favored seabirds that avoided nonedible materials (Rothstein 1973).

Some albatross regurgitate the plastic items along with squid beaks, lenses, and bones in "castings" without any apparent harmful effects. The incidence of such castings among fledgings is unknown, but fresh albatross castings collected from French Frigate Shoals in the Northwestern Hawaiian Islands had a mean weight of 96.6 g ± 37.1 (SD), $n = 5$. These castings generally appear as fledging birds begin wing-stretching exercises and may lighten the final fledging weight considerably. Castings contained many whole squid beaks; the mean number was 81.7 ± 40.4 (SD), $n = 15$, which may reflect, in part, the feeding history of the chick.

The long-term effects of plastic ingestion are difficult to evaluate. With the help of stomach contractions, the plastics exert a grinding force upon each other during the period of retention. If pollutant chemicals are entering the blood by pinocytotic digestion of microscopic particles in the intestines, then appreciable residues of pollutants may be present. Polychlorinated biphenyls (PCBs) have been found on the surface of polystyrene spherules, apparently absorbed from seawater, in a concentration of five parts per million (Carpenter et al. 1972), and it may be assumed that organochlorines are associated with other oceanic plastic items. Measurable residues of DDT, DDE, and PCBs were detected in visceral fat from Black-footed and Laysan albatross on Midway (Fisher 1973). Although the origin of such ingested pollutants may be in the North Pacific food chain, it may also be associated with plastics ingested by albatross.

Our stay on Midway Islands was supported by a National Science Foundation Grant (PCM 12351-A01) administered by Dr. G. C. Whittow. We are grateful to CDR Kuhneman, Commanding Officer, for assistance during our stay at the U.S. Naval Air Facility, Midway Island. Special thanks to ENS Immel and the base game warden staff for invaluable aid and transportation to Eastern Island. We thank Elizabeth Flint, Department of Biology, U.C.L.A., for collecting fresh castings on French Frigate Shoals and G. H. Balazs for the use of unpublished data. We also thank Craig Harrison for his critical review of the manuscript.

Literature Cited

Carpenter, E. J., S. J. Anderson, G. R. Harvey, H. P. Miklas, & B. B. Peck. 1972. Polystyrene spherules in coastal waters. Science 178: 749–750.

Day, R. H. 1980. The occurrence and characteristics of plastic pollution in Alaska's marine birds. Unpublished M.S. thesis, College, Alaska, Univ. Alaska.

Fisher, H. I. 1973. Pollutants in North Pacific albatrosses. Pacific Sci. 27: 220–225.

———, & J. R. Fisher. 1972. The oceanic distribution of the Laysan Albatross, *Diomedea immutabilis*. Wilson Bull. 84: 7–27.

Harrison, C. S., & T. S. Hida. 1980. *In* Proc. Status Resource Investigations in the Northwest Hawaiian Islands (R. W. Grigg and R. T. Pfund, Eds.). Honolulu, Hawaii, Sea Grant, Univ. Hawaii.

Hays, H., & G. Cormons. 1974. Plastic particles found in tern pellets, on coastal beaches and at factory sites. Mar. Pollut. Bull. 5: 44–46.

Kenyon, K. W., & E. Kridler. 1969. Laysan albatross swallow indigestible matter. Auk 86: 339–343.

Ohlendorf, H. M., R. W. Risebrough, & K. Vermeer. 1978. Exposure of marine birds to environmental pollutants. Washington, D.C., U.S. Dept. Interior, Fish and Wildlife Service, Wildlife Research Report 9.

Parslow, J. L. F., & D. J. Jeffries. 1972. Elastic thread pollution of puffins. Mar. Pollut. Bull. 3: 43–45.

Rothstein, S. I. 1973. Plastic particle pollution of the surface of the Atlantic Ocean: evidence from a seabird. Condor 75: 344–366.

Received 9 February 1981, accepted 21 April 1981.

forming, however, generally is limited to a cloth-based special type of phenolic laminated sheet. Moldings are machined for greater dimensional precision. In general the same machining technique as used on metals is applicable to plastics.

Moldings

A large portion of all plastics reaching the consumer does so in the form of moldings. These are made on presses—compression, injection, transfer or extrusion—as described in Chapter 6. The term "molding" has been broadened to cover extrusion although the end products of an extrusion press have little resemblance to the products of other molding presses. Extruded items include strips, tubes, and wire coatings while molded items usually are complex shaped units of which a telephone receiver is typical.

The raw material for both molded items and extrusions is molding powder, although a special grade is often specified for extrusions. Moldings are often designed with metal inserts, and in some cases these determine whether compression or injection presses are to be used. It is simpler to handle the flow of the melted plastic around inserts in compression presses. In general, thermosetting materials are molded on compression presses and thermoplastic materials on injection presses. There are about 1300 molders and 260 extruders in the United States.

Molding Powder

This term is so familiar in the plastics industry that a description might seem unnecessary. Nevertheless there are many types of molding powder and the physical form is significant as well as the chemical composition. The material actually may be a powder (i.e., composed of fine grains) or it may consist of small cubes or other shapes ranging in size up to one-eighth inch or more. To produce variegated effects the powder (particles or granulations) may be supplied in several colors to be mixed by the molder.

Various effects may also be secured by using different batches, each with a different degree of flow. Wavy effects are produced by using powder components of a different hardness but of the same color.

A popular form of molding powder for extrusion consists of small cylinders, perhaps 3/16 in. in diameter and 5/16 in. long. These are made by extruding thin rods and then running them through a properly timed chopper. In this way scrap may be reused—perhaps mixed with some virgin material.

Plasticizers

Most resins are plasticized by heat, solvents, or plasticizers. The latter, while not strictly a form of plastic, are nevertheless, an important component of the industry. Solvents are also important but being more familiar and common to other industries they are omitted here. Solvents often disappear in processing and so are not present in the end product. Plasticizers, on the other hand, are relatively non-volatile compounds which impart some permanent characteristics to the end products of which they form a part.

As a rule, plasticizers are low-melting solids or high-boiling organic liquids. Their use is increasing as also is their variety. Literally thousands of plasticizers are available. They are used to improve flexibility or toughness or to better the flow of a plastic. Some resins, polyvinyl chloride, for example, may be compounded with a plasticizer at an elevated temperature. Without plasticizers most resins could not be processed into films, sheets, and fibers. Two types of plasticizer—chemical and oil types—are used in plastics.

Some common chemical plasticizers	Some common oil plasticizers
tributyl phosphate	castor oil
dibutyl phthalate	treated tung oil
butyl stearate	brown soya oil

Plywood

This is a specialized type of laminate which deserves individual comment. Custom has gradually given the term a specific meaning. It refers to a type of wood ply construction, which has an odd number of plies, of which any two adjacent plies must have the grain direction at right angles. Construction must be balanced, that is, there must be as many plies on one side of a core piece (if it has a core piece) as on the other.

Different bonding materials are used which give a variation in over-all properties. Phenolic is the customary bond for outdoor grades of plywood, and sometimes surfacing with a phenolic resin impregnated paper increases weather resistance. Metal clad plywood is also available. Many other designs have been used, one of which has a core of honeycomb material to give thickness and stability. The core is then faced with standard plies.

Bonding agents for plywood have been improved to such an extent in recent years that the previous objections to veneers have all but disap-

Plastics at Sea

The pollution of oceans and beaches with plastic materials is on the rise, and sea birds, marine turtles, whales, and seals are suffering as a result

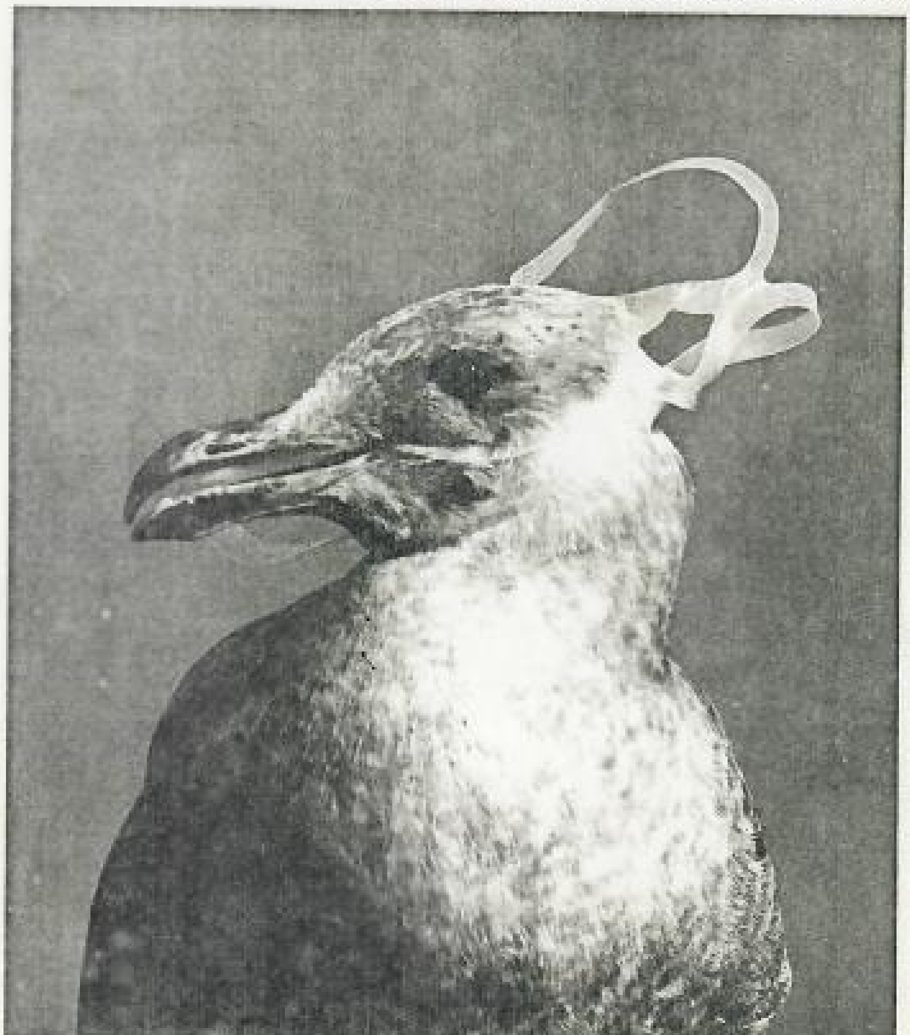
by D.H.S. Wehle and Felicia C. Coleman

Throughout the 1970s, a number of biologists studying the feeding habits of sea birds in different oceans of the world recounted the same story: the birds were eating plastic. Similar reports of plastic ingestion and of entanglement in plastic debris began to surface for other marine animals—fish off southern New England, turtles off Costa Rica and Japan, whales in the North Atlantic. At the same time, plastic particles turned up in surface plankton samples from both the Atlantic and Pacific oceans; plastic debris was retrieved by benthic trawls in the Bering Sea and Britain's Bristol Channel; and plastic pellets washed ashore in New Zealand in such large numbers that some beaches were literally covered with "plastic sand." By the close of the decade, marine scientists around the world had become aware of a new problem of increasing ecological concern—plastics at sea.

Two forms of plastic exist in the marine environment: "manufactured" and "raw." Manufactured plastic material along beaches and adrift at sea is primarily refuse from transport, fishing, and recreational vessels. In 1975, the National Academy of Sciences estimated that commercial fishing fleets alone dumped more than 52 million pounds of plastic packaging material into the sea and lost approximately 298 million pounds of plastic fishing gear, including nets, lines, and buoys.

Raw plastic particles—spherules, nibs, cylinders, beads, pills, and pellets—are the materials from which products are manufactured. These particles, about the size of the head of a wooden match, enter the ocean via inland waterways and outfalls from plants that manufacture plastic. They are also commonly lost from ships, particularly in the loading and unloading of freighters. Occasionally, large quantities are deliberately dumped into the sea.

Plastics turn up everywhere. Along portions of the industrialized coast of Great Britain, concentrations of raw particles have reached densities of about 2,000 pieces per square foot in benthic sediments. Near Aukland, New Zealand, 100,000 pieces of plastic were found for ?



Gulls often get caught in six-pack straps Townsend P. Dickinson every three lineal feet of beach. Particles have also washed ashore on beaches in Texas, Washington, Portugal, Colombia, Lebanon, and at such remote sites as the Aleutian and Galápagos islands.

Much of what we know about the distribution patterns and abundance of raw plastic in the world's oceans comes from plankton sampling of surface waters. Between 1972 and 1975, for example, the Marine Resources Monitoring, Assessment, and Prediction Program, a nationally coordinated program of the National Marine Fisheries Service, recorded plastic particles in plankton samples collected between Cape Cod and the Caribbean Sea. The majority of the particles were found to have entered the ocean from the coast of southern New England, and the highest concentrations were usually in coastal waters. Raw plastic, however, was ubiquitous in the open ocean and especially common in the Sargasso Sea. This suggests that winds and currents are instrumental in redistributing and concentrating particles in certain oceanographic regions.

Inevitably, many animals foraging in the marine environment will encounter and occasionally ingest these widely distributed plastic materials. One of the first records of plastic ingestion appeared in 1962 for an adult Leach's storm petrel collected off Newfoundland. Four years later, researchers in the Hawaiian Islands found that the stomach contents of young Laysan albatrosses contained plastic, apparently fed them by their parents.

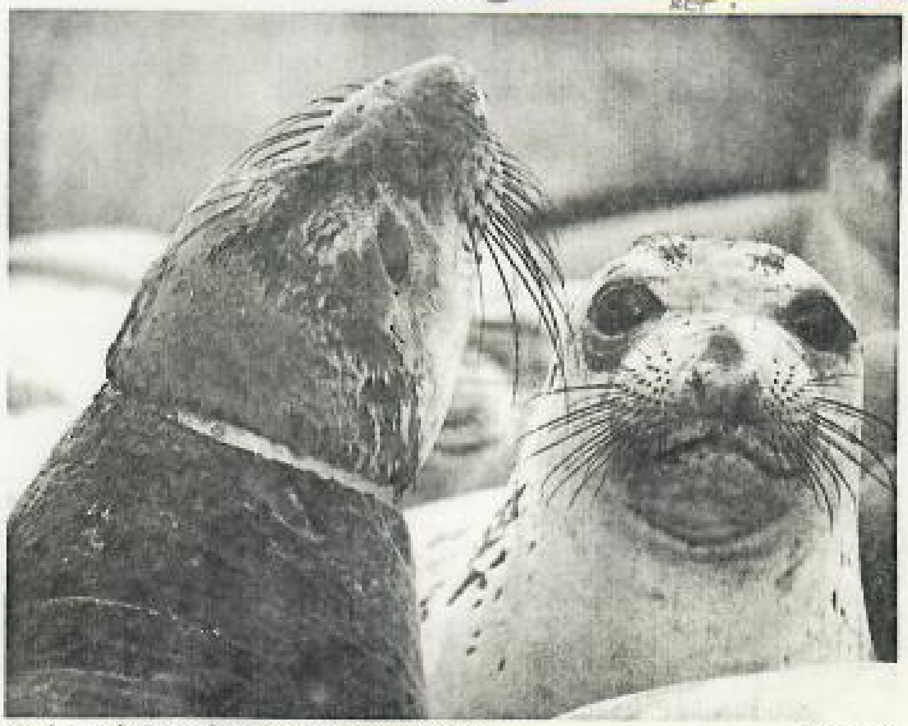
For the most part, these early reports were treated as curious anecdotes in- (3) cluded in studies of the feeding ecology of a few sea birds. During the 1970s and early 1980s, however, with the proliferation of such anecdotes, biologists began paying closer attention and were surprised to find how frequently plastic occurred in the stomach contents of certain procellariids from the North Pacific and the North Atlantic (short-tailed shearwaters, sooty shearwaters, and northern fulmars) and alcids from the North Pacific (parakeet auklets and horned puffins). Lower frequencies were reported for other Northern Hemisphere sea birds, including phalaropes, gulls, terns, and also other procellariids and alcids. The feeding habits of marine birds in southern oceans have not been studied as extensively, but plastic ingestion has been documented for several species of procellariids (petrels, shearwaters, and prions) in the South Atlantic, South Pacific, and subantarctic waters. To date, approximately 15 percent of the world's 280 species of sea birds are known to have ingested plastic.

Sea birds choose a wide array of plastic objects while foraging: raw particles, fragments of processed products, detergent bottle caps, polyethylene bags, and toy soldiers, cars, and animals. Marine turtles, on the other hand, consistently select one item—plastic bags. In the past fifteen years, plastic bags have been found in the stomachs of four of the seven species of marine turtles: leatherbacks from New York, New Jersey, French Guiana, South Africa, and the coast of France; (2) hawksbills on the Caribbean coast of Costa Rica; greens in the South China Sea and in Jap- Ref?

Plumice, gloves, sticks,

NO, need to correct

Ref?



As this seal grows, the plastic band will tighten

not necessarily!

Frans Lanting

ref?

Ref?

wrote and asked about this 10-29-84 (both authors)

anese, Australian, and Central American coastal waters; and olive ridleys in the Pacific coastal waters off Mexico. Evidence points to plastic ingestion in loggerheads as well, based on liver samples containing high concentrations of a plasticizer (a chemical compound added to plastic to give it elasticity). Polystyrene spherules have been found in the digestive tracts of one species of chaetognath (transparent, wormlike animals) and eight species of fish in southern New England waters. They have also turned up in sea snails and in several species of bottom-dwelling fishes in the Severn Estuary of southwestern Great Britain.

? ref

Marine mammals are not exempt from participation in the plastic feast. Stomachs of a number of beached pygmy sperm whales and rough-toothed dolphins, a Cuvier's beaked whale, and a West Indian manatee contained plastic sheeting or bags. In addition, Minke whales have been sighted eating plastic debris thrown from commercial fishing vessels. Curiously, plastic has not been found in any of the thousands of ribbon, bearded, harbor, spotted, ringed, or northern fur seal stomachs examined from Alaska.

The obvious question arising from these reports is, Why do marine animals eat plastic? In the most comprehensive study to date, Robert H. Day of the University of Alaska maintains that the ultimate reason for plastic ingestion by Alaskan sea birds lies in plastic's similarity—in color, size, and shape—to natural prey items. In parakeet auklets examined by Day, for example, 94 percent of all the ingested plastic particles were small, light brown, and bore a striking resemblance to the small crustaceans on which the birds typically feed.

Marine turtles also mistake plastic objects for potential food items. Transparent polyethylene bags apparently evoke the same feeding response in sea turtles as do jellyfish and other medusoid coelenterates, the major food item of leatherbacks and subsidiary prey of greens, hawksbills, loggerheads, and ridleys.

Sea birds, marine turtles, and marine mammals all eat plastic. So what? Perhaps ingesting plastic is inconsequential to their health. After all, cows are known to retain nails, metal staples, and strands of barbed wire in their stomachs for more than a year with no ill effects. For marine animals, however, the evidence is growing that in some cases at least, ingested plastic causes intestinal blockage. George R. Hughes of the Natal Parks Board, South Africa, extracted a ball of plastic from the gut of an emaciated leatherback turtle; when unraveled, the plastic measured

CL- 1600w 340kg

697 well devel. eggs,

I see no evidence for "emaciation" being stated.

9'x12'

nine feet wide and twelve feet long. There is little doubt that the plastic presented an obstruction to normal digestion. Similarly, a mass mortality of green turtles off Costa Rica has been attributed to the large number of plastic banana bags eaten by the turtles.

Cornelius cited Carr per. comm

The twenty dead red phalaropes discovered on a beach in southern California, all with plastic in their digestive tracts, present a less clear case. Did the birds suffer an adverse physiological response after eating plastic or were they already under stress because of a reduced food supply and eating the plastic in a last-ditch effort to prevent starvation? The same question applies to other instances of emaciated animals that have eaten plastic. At this time, we don't have an answer.

We do know that plastic is virtually indigestible and that individual pieces may persist and accumulate in the gut. Ingested plastic may reduce an animal's sensation of hunger and thus inhibit feeding activity. This, in turn, could result in low fat reserves and an inability to meet the increased energy demands of reproduction and migration. Plastic may also cause ulcerations in the stomach and intestinal linings, and it is suspected of causing damage to other anatomical structures. Finally, ingestion of plastic may contribute synthetic chemicals to body tissues. Some plasticizers, for example, may concentrate in fatty tissues, their toxic ingredients causing eggshell thinning, aberrant behavior, or tissue damage. When highly contaminated tissues are mobilized for energy, these toxins may be released in lethal doses.

Publication of data on plastic ingestion is in its infancy. As the problem gains notoriety, it will certainly be revealed to be even more widespread than is now recognized. There are already several known instances of secondary ingestion, in which plastic consumed by animals feeding at low trophic levels shows up in higher-level consumers. The remains of a broad-billed prion, together with the plastic pellets it had ingested, were found in the castings of a predatory South Polar skua in the South Atlantic; plastic pellets found in the Galápagos Islands were traced from transport vessels in Ecuadorean ports through a food chain involving fish, blue-footed boobies, and, finally, short-eared owls.

A more obvious effect of plastic pollution is the aesthetic one. Whether we venture deep into the woods, high atop a mountain, or out on the ocean to escape the trappings of civilization, our experience of the natural world is often marred by the discovery of human litter. Even more disturbing to the spirit is the sight of a young pelican dangling helplessly from its nest by a fishing line, a whale rising to the surface with its flukes enshrouded in netting, or a seal nursing wounds caused by a plastic band that has cut into its flesh. Unfortunately, such observations are becoming more and more common, another consequence of plastics at sea.

During the last twenty years, fishing pressure has increased dramatically in all the world's oceans, and with it, the amount of fishing-related debris dumped into the sea. In addition, the kind of fishing equipment finding its way into the ocean has changed. Traditionally, fishing nets were made of hemp, cotton, or flax, which sank if not buoyed up. These materials disintegrated within a relatively short time and, because of the size of the fibers, were largely avoided by diving sea birds and marine mammals. With the advent of synthetic fibers after World War II, however, different kinds of nets came into use. These new nets were more buoyant and longer-lived than their predecessors, and some of them were nearly invisible under water.

The result of these changes in net materials has been a tragic increase in mortality of air-breathing animals. A few examples are sufficient to give an idea of the magnitude of the problem. During the heyday (1972–76) of the Danish salmon fishery in the North Atlantic, the incidental catch of thick-billed murres amounted to three-quarters of a millon birds annually; in 1980, 2,000 sea turtles off the southeastern coast of the United States drowned when incidentally caught in shrimp trawl nets. Incidental catch refers to nontarget animals that are accidentally caught in an actively working net. Another kind of net-related mortality is known as entanglement and refers to any animal caught in a net that has been lost or discarded at sea. Some government officials estimate that about 50,000 northern fur seals currently die in the North Pacific each year as a result of entanglement in fishing gear. Unlike working nets, which fish for specific periods of time, these free-floating nets, often broken into fragments, fish indefinitely. When washed ashore, they may also threaten land birds and mammals: in the Aleutians Islands, for example, a reindeer became entangled in a Japanese gill net.

Plastic strapping bands—used to secure crates, bundles of netting, and other cargo—are another common form of ship-generated debris. Discarded bands are often found girdling marine mammals, which are particularly susceptible to entanglement because of their proclivity for examining floating objects. The instances of seal entanglement in plastic bands has increased so remarkably in the past two decades that fur seal harvesters in Alaska and South Africa now monitor the number of ringed animals.

Sea birds that frequent recreational waters or coastal dumps are also subject to ringing by the plastic yokes used in packaging six-packs of beer and soda pop. Gulls with rings caught around their necks are sometimes strangled when the free end of the yoke snags on protruding objects. Similarly, pelicans, which plunge into the water to feed, run the risk of diving into yokes. If the rings become firmly wedged around their bills, the birds may starve.

Not all encounters with plastic prove harmful to marine organisms. Some animals are incorporating the new material into their lives. Algae, hydrozoans, bryozoans, polychaetes (marine worms), and small crustaceans attach to plastic floating at sea; bacteria proliferate in both raw and processed plastic refuse. Plastic provides these organisms with long-lived substrates for attachment and transport; in some cases, hitching a ride on floating pieces of plastic may alter an organism's normal distribution. Several species of tube-dwelling polychaetes construct their tubes of raw plastic particles present in benthic sediments. Other invertebrates, such as sand hoppers and periwinkles, find temporary homes in aggregates of plastic particles they encounter on beaches. Marine birds all over the world incorporate plastic litter into their nests, but in this case, the use of plastic may be harmful because chicks can become entangled in the debris and die.

Plumme

Instances of marine animals adapting to this new element in their environment do not alter the predominately negative effect of plastics at sea. The problem is global and its solution will require international cooperation. Historically, the high seas have, in many respects, been considered an international no-man's land. Recently, however, perception of the ocean as a finite and shared resource has caused many nations to express concern for its well-being.

In 1970, the U.S. Congress passed the National Environmental Policy Act, which, among other things, pledged to "encourage productive and enjoyable harmony between man and his environment." Subsequently, a number of laws on waste disposal were adopted, two of which affect pollution by plastics: the Federal Water Pollution Control Act (commonly known as the Clean Water Act) and the Marine Protection, Research, and Sanctuaries Act (Ocean Dumping Act). The Clean

Water Act does not specifically address the problem of persistent plastics but does require all significant polluters of U.S. waterways to obtain a federal permit, under which limits are set on, among other things, discharges of solid matter. The Ocean Dumping Act prohibits the deliberate dumping of significant amounts of persistent plastic materials at sea. Having these laws on the books, however, does not immediately solve the problem. Small-scale refuse disposal on the high seas is difficult to regulate; fishermen who claim to have unintentionally lost their nets at sea cannot be held responsible; and illegal large-scale dumping at sea is hard to detect. Granted, laws must be tightened, but enforcement is really the bigger problem.

On the international level, the problems of water pollution and litter in the oceans were highlighted at the United Nations Conference on the Human Environment held in Stockholm in 1972. The conference, with 110 nations represented, defined the need for international policy on marine pollution among coastal and maritime nations. Treaties to implement such a policy soon followed: the 1972 London Convention on the Prevention of Water Pollution by Dumping of Wastes and Other Matter (Ocean Dumping Convention), a part of which specifically prohibits marine dumping of persistent plastic material; and the 1973 London International Convention for the Prevention of Pollution from Ships (Marine Pollution Convention), which is broader in scope and regulates the control of oil pollution, packaged substances, sewage, and garbage. While neither of these treaties has been adopted by all nations, they represent a start toward global control of marine pollution.

In the meantime, the quantity of plastics in the world's oceans will undoubtedly continue to mount. Ironically, the very characteristics that make plastic appropriate for so many uses—its light weight, strength, and durability—lead to the majority of problems associated with its presence at sea. As organic material, plastic is theoretically subject to degradation by mechanical, oxidative, or microbial means. Owing to the strength of most plastics, however, mechanical degradation by wave action is generally restricted to the breaking of large pieces into smaller ones. Photooxidation and microbial action are limited by plastic's high molecular weight and its antioxidants, ultraviolet light stabilizers, and biocide additives, which effectively immunize it against degradation. The longevity of plastics in seawater is not known, but on the beach, particles may last from five to more than fifty years.

Given plastic's long life and projected annual increases in production, one thing is clear—the rate of plastic deposition in the marine environment will continue to be higher than the rate of disappearance. In a study of the accumulation of plastic on the beaches of Amchitka Island, Theodore R. Merrell, Jr., of the National Marine Fisheries Service, recorded that 550 pounds of plastic litter were added to less than a mile of beach in one year. He also found an increase of more than 250 percent in both the number and the weight of plastic items washed ashore over a two-year period.

Outside the realm of laws and treaties, solutions to the problem can come from both inside and outside the plastic industry. The technology to manufacture biodegradable plastics is available. In fact, one of the beauties of plastic is that its properties can be altered and its life expectancy prescribed. Alaska has already taken steps toward reducing plastic litter by requiring that plastic six-pack yokes be made of a self-destructing compound. Another, but perhaps less workable solution, given the logistics and expense involved and the degree of business and public cooperation required, lies in recyclable plastics. At the very least, all countries should require that the discharge of raw plastic particles from industrial plants be reduced by filtering outflow before it enters waterways. A recent decline in the uptake of plastic by marine organisms in southwestern England has been attributed, in part, to the efforts of one of the major contaminating plants to filter, collect, and reuse raw particles present in its effluent.

Consumers share with industry the responsibility to reduce the amount of plastic in the sea. Recreational boaters, beachgoers, and commercial fishermen all discard plastic refuse. Preferably, no trash plastic—bands, netting, or other debris—should ever be tossed overboard or left on a beach. If six-pack yokes or strapping bands must be discarded at sea, the rings should be cut first so that they pose less of a threat to marine animals.

The first step in combating plastic pollution is to alert both industry and the general public to the gravity of the problem and the need to do something about it soon. Education alone cannot solve the problem but it is a beginning. Public awareness of a problem, combined with the resolve to correct it, can bring dramatic results.

Both D.H.S. Wehle and Felicia C. Coleman are free-lance writers and artists and teach at Cornell University's Shoals Marine Laboratory on Maine's Isles of Shoals during the summer.

Turtles Eat Plastic Bags As Jellyfish

Newport, R.I.

Endangered giant leatherback sea turtles are killing themselves by eating discarded plastic bags they mistake for jellyfish, according to scientists and environmentalists.

"Autopsies of leatherbacks have revealed stomachs and intestines blocked by plastic sandwich bags, potato chip bags, trash bags and other plastic items," said Robert C. Schoelkopf, director of the Marine Mammal Stranding Center in Atlantic City, N.J.

The International Center for Endangered Species here and a team of scientists have been capturing, labeling and tracking the turtles off the Rhode Island coast for the past two summers.

Leatherback turtles, so named for a mosaic of small bones imbedded in thick, leathery skin that forms a flexible shell, are among the largest existing reptiles.

They can grow to more than 6 feet long and weigh more than 700 pounds on a diet that consists mainly of jellyfish.

"These plastic bags are transparent and they look like jellyfish in the ocean. That's what they're going for," said Chris Luginbuhl, International Center director.

Luginbuhl said the center is making an international plea to all plastic manufacturers for cooperation in publicizing the problem.

"The first step could be a massive campaign to place posters in marinas all over the world warning boaters about the consequences of dumping this non-biodegradable material in the oceans and rivers," he said.

The center also plans to investigate "the strong possibility" that leatherbacks aren't the only marine creatures eating plastic, Luginbuhl added.

The center's conclusions about leatherbacks are corroborated by the research of Samuel S. Sadove, research director at the Okeanos Foundation in Hampton Bays, N.Y.

Sadove said 11 of 15 dead leatherbacks that washed ashore on Long Island during a two-week period last summer had plastic bags "totally blocking their stomach openings."

Ten of the beached turtles had four to eight quart-sized bags in their stomachs. One had eaten 15, Sadove said.

Sadove added that he has seen turtles swimming around transparent plastic bags in the ocean with their mouths open, as if they thought the discarded plastic was their favorite meal.

The turtles found on Long Island were too badly decomposed for full autopsies, but "the plastic bags either contributed to the cause of death or may have been the cause of death," he said.

Nicholas Mrosovsky of the University of Toronto's zoology department said worldwide data indicate that approximately 40 percent of the leatherbacks in the oceans have plastic in their stomachs.

C. Robert Shoop, professor of zoology at the University of Rhode Island, estimated there are thousands of the turtles alive. Although they are considered endangered, they are not in danger of extinction.

Shoop said the turtles are threatened most by the loss of their nesting grounds through poaching or development of beaches where they nest.

Associated Press

Don't dump your throw-away plastic bags in the sea!

Dead leatherback turtles in large numbers have been washing ashore for many years along the New Jersey coast. Autopsies have revealed "stomachs and intestines blocked by plastic sandwich bags, potato chip bags, trash bags and other trash items," reports Robert Schoelkopf, Director of the *Marine Mammal Stranding Center* in Atlantic City.

Leatherbacks are a highly endangered species and are believed to be the largest of all marine reptiles. The eminent sea-turtle expert Nicholas Mrosovsky, University of Toronto Zoology Department, says he has data from all over the world indicating that around 44% of leatherbacks in the open ocean today have plastic materials in their stomachs. So — when at sea, don't dump unwanted plastic bags and wrappings overboard. Take them home with you!

The Animal Welfare Institute Quarterly
Vol. 31 no. 4 Winter 1982/83 p. 3

Discussion

The dual phase nature of dumped dredger spoil has been noted by other workers in this field. Gordon (1974) reported a turbulent jet that was found to accompany spoil dumping and the Hydraulics Research Station (1971) observed twin phase behaviour in sludge deposited by a dredger in Liverpool Bay.

A cloud of suspended sediment was also observed by Nittrouer & Sternberg (1975) during dredger dumping in Puget Sound, Washington. The formation of mud 'pebbles' or 'balls' has been noted by Kornicker *et al.* (1958) and by Hellier & Kornicker (1962) who concluded that the presence of mud pebbles in sediments was a definite indication of dredger spoil dumping.

The production of a turbid cloud of suspended particulates of high mobility may even result in the re-silting of the harbour from which the spoil was obtained, should the currents at the time of dumping be in an unfavourable direction. During the course of this study, in Autumn 1976, the Lowestoft Harbour Authorities reported an accelerated silting of the dock which suggested that this might indeed be the case. This evidence was supported by current meter records and calculations of the suspended sediment flux off the Lowestoft coast, Joyce (1976), which showed a transport of suspended silt towards the harbour mouth and confirmed by the Hydrographer for the Navy who demonstrated a southerly tide residual towards the harbour mouth. On the recommendations produced by this project the dump site was subsequently re-located once again to a site some 1500 m south of the Old Newcome Channel site (position B on Fig. 1). It has been recommended that, wherever possible, dumping should take place on a south-going tide so that the turbid cloud of suspended solids that is produced will be carried safely away from the harbour mouth.

Clearly the need can be seen for a greater understanding of the mechanism of inshore spoil dumping and for the identification of the forces operating on both phases of the dredger spoil once it is introduced into the marine environment.

Cloet, R. L. (1963). Hydrographic analysis of the sandbanks in the approaches to Lowestoft Harbour. Admiralty Marine Science publication No. 6. (Hydrographic dept. Admiralty 1963).

Davies, C. M. (1972). Aspects of suspended sediment transport in Swansea Bay. Unpublished Ph.D. thesis, University College of Swansea.

Gordon, R. B. (1974). Dispersion of dredge spoil dumped in nearshore waters. *Estuarine Coastal Mar. Sci.*, 2, 349–358.

Hellier, T. Jnr. & Kornicker, L. S. (1962). Effects of hydraulic dredging on sedimentation. *Publ. Inst. Mar. Sci. Univ. Texas*, 8, 147–150.

Hydraulics Research Station. (1971). Sludge disposal in Liverpool Bay. H.R.S. Yearly Report, pp. 54–57.

Joyce, J. R. (1976). Properties of fine sediments in relation to marine spoil dumping. Unpublished Ph.D. thesis, University of East Anglia.

Kirkby, R. & Parker, W. R. (1974). Seabed density measurements related to echo sounder records. *Dock and Harbour Authority*, 54, 423–424 (March 1974).

Kornicker, L. S., Oppenheimer, C. H. & Conover, J. T. (1958). Artificially formed mud balls. *Publ. Inst. Mar. Sci. Univ. Texas*, 5, 148–150.

Nittrouer, C. A. & Sternberg, R. W. (1975). The fate of a fine grained dredged spoils deposit in a tidal channel in Puget Sound, Washington. *J. Sed. Petrol.*, 45, 160–170.

Smith, D. B., Parsons, T. V. & Cloet, R. L. (1965). An investigation into the silt movement in an ebb channel, Firth of Forth, 1965. A.E.A.E. Technical Report No. R5080.

Marine Pollution Bulletin, Vol. 10, pp. 160–162

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Surface Circulation and the Distribution of Pelagic Tar and Plastic

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Pelagic tar and plastic have been measured along 158°W in the North Pacific. Maxima in the abundance of tar are associated with convergent meso scale and with small scale surface circulation features observed at the same time. There is no significant correlation between abundance of tar and that of plastic. It appears that this difference in distributions is the result of different input patterns or residence times.

The occurrence of pelagic tar and plastic in the world ocean has been repeatedly documented in the past decade (*inter alia:* Sleeter *et al.*, 1976; Shekel & Ravid, 1977 and references therein). Three lines of evidence suggest that much of this tar is introduced by human activity (National Academy of Sciences, 1975). First, abundant tar occurs in regions of heavy oil transport. Second, the normal alkane distribution of most tar balls is bimodal, a characteristic of sludge from tank ship holds. Third, the concentration of iron in most tar balls is higher than for crude oils, indicating contact with steel structures. While the most intense study of pelagic tar and plastic has been in the Mediterranean, Atlantic and Caribbean, several surveys in the North Pacific (Marumo & Kamada, 1973; Wong *et al.*, 1974; Wong *et al.*, 1976; Shaw, 1977) have indicated that the major source of tar in this region is the tanker route southwest of Japan and that tar moves around the North Pacific through the Kuroshio–subtropical gyre system.

All studies have shown a large degree of patchiness in tar and plastic distribution. A dramatic example of the patchiness of pelagic tar comes from sequential samplings at a station near Bermuda in the Sargasso Sea (Butler *et al.*, 1973). There it was observed that the abundance of tar could change by a factor of 100 in 2 weeks and by a factor of 10 in 2 h. In this note we report the abundance of pelagic tar and plastic in the North Pacific along a transect extending roughly between the islands of Kodiak and Hawaii. Furthermore, we relate these abundances to simultaneously observed surface circulation features to elucidate some of the causes of the observed patchiness.

Patchiness in the pelagic environment is a well recognized phenomenon (Parsons & Takahashi, 1973). For plankton, patchiness has been observed on scales ranging from meters to thousands of kilometers and a variety of biological and physio-chemical causes have been investigated. One of the reasons that patchiness of organisms remains incompletely understood is that it is the result of many variables (light, temperature, salinity, advection, reproduction, behavior, competition, etc.) acting together. However, for inanimate pelagic material such as tar and plastic it is possible to ascribe patchiness to currents, winds and geographically non-uniform inputs.

Methods

Seston tows for tar and plastic were made in October and November, 1976, as the R/V *Moana Wave* proceeded south along 158° west longitude. Twenty-eight tows were made between 56° and 22° north latitude during a 2-week period. For each tow a seston sampler made to the design of Sameoto and Jaroszynski (1969) was deployed for one nautical mile (1.85 km) thereby sampling 740 m^2 of sea surface. Tar and plastic were picked from the catch. In the laboratory on shore weights of tar and plastic, including encrusting organisms if any, were determined and for six tar samples gas chromatographic (GC) profiles were obtained. For these a portion of tar was taken up in hexane, insoluble residue removed by centrifugation and an aliquot of the solution chromatographed on an OV-101 support coated open tubular column with temperature programming and flame ionization detection.

Results and Discussion

Figure 1 shows the abundance of tar and plastic as a function of latitude together with 0–1000 dbar dynamic topography determined from hydrographic data collected during the same cruise (Royer, 1978). Negative slope in the dynamic topography signifies westward flow and positive slope eastward flow. Thus the large hydrographic features are the westward flowing Alaska Stream from 55.5° to 54° N and the eastward flowing North Pacific Current between 54° and 22° N. Several regions of current reversal (negative slope) are embedded in the North Pacific Current. The mesoscale (400–600 km) features south of 35° N have been identified as eddies by Bernstein (1974). Roden (1977) has documented the continued presence of these eddies and discussed their origin. Four regions of smaller scale (75 km) eddies at approximately 38°, 43°, 47° and 51° N have been identified by Royer (1978).

A relationship exists between tar abundance and the mesoscale eddies south of 35° N. It has been shown that a cyclonic eddy results in surface convergence (Schmitz & Vastano, 1975) while an anticyclonic eddy produces surface divergence (Schmitz & Vastano, 1976). For discussion we assume that the dynamic topography shows anticyclonic, divergent eddies centres at 24°, 27° and 30° N. (The alternate assumption of cyclonic, convergent eddies at 25.5°, 28.5° and 32° N leads to exactly the same conclusions.) The zones of divergence correspond to local minima in tar abundance (Fig. 1). This is eminently reasonable; the divergent surface flow at 24°, 27° and 30° N sweeps seston out of those areas and causes it to accumulate at adjacent latitudes, i.e., 25.5°, 28.5° and 32°.

Small scale eddy regions identified by Royer at 47° and 38° N also coincide with local maxima in tar abundance. However, the scale of these eddies is too small, relative to the scale of tar sampling, to allow detailed correlation of maxima and convergences.

In keeping with the primary North Pacific pelagic tar source southwest of Japan and the dispersal of that tar by the Kuroshio-subtropical gyre system, Wong *et al.* (1974) found that along 35° N in the Pacific, peak tar concentrations were associated with subtropical water while low tar abundance was associated with subarctic

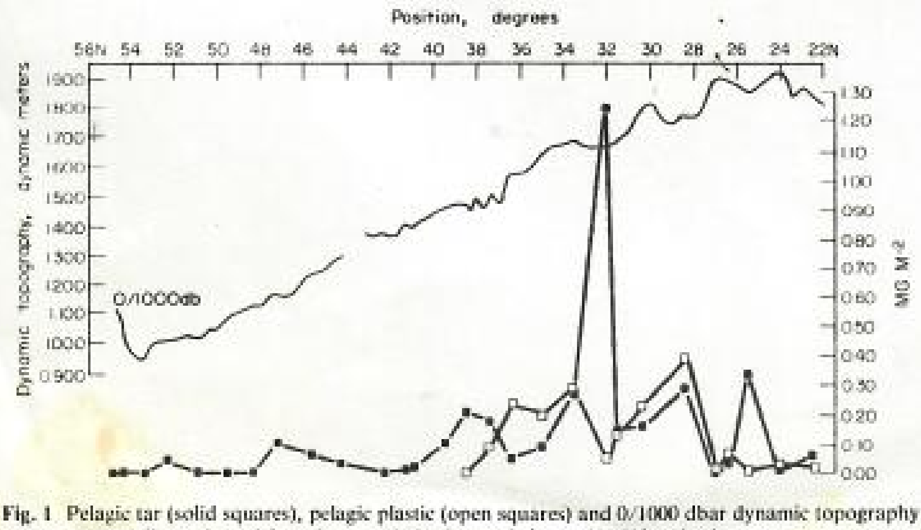

Fig. 1 Pelagic tar (solid squares), pelagic plastic (open squares) and 0/1000 dbar dynamic topography (smooth line, adapted from Royer, 1978) observed along 158° W longitude.

water. The surface boundary between subarctic and subtropical water on our north to south transect is indistinct because of seasonal surface cooling at the time of sampling; however the boundary is in the region 39° to 43°N (Royer, personal communication). Relatively little tar and no plastic whatsoever was found to the north of this region. Thus, the association of tar and plastic with subtropical water is confirmed.

The factors controlling the abundance of plastic are more complex than those for the tar just discussed. For the region where plastic was found (i.e., south of 38°N) there is no statistically significant correlation between the abundances of tar and plastic. However, if the data from only two stations (25.5° and 32°N) is rejected, the correlation between the abundances of tar and plastic south of 38°N becomes highly significant.

Because the two suspect stations had the highest abundances of tar of the entire transect, we considered the possibility that some of that tar was 'extra' from some additional source such as a recently passed ship. However, we discarded this hypothesis for two reasons. First, the GC profiles of tar from these stations were similar to others in degree of weathering and bimodal alkane distribution. Second, tar from these stations was, like all tar and plastic collected between 24° and 35°N, encrusted by bryozoans. The alternate hypothesis, that plastic abundances at 25.5° and 32°N are artificially low, is more difficult to evaluate directly, but also appears unlikely. This would require that some plastic-specific removal process operate only at those two locations.

We feel that there is inadequate evidence to firmly reject the two suspect stations and conclude that the differences in the distribution of tar and plastic reflect either different input patterns or different survival times at sea.

Our results along 158°W show a maximum in plastic at about 29°N and relatively low abundances north of 38°N and south of 26°N. Wong and co-workers (1974) found that the maximum plastic abundance along 35°N occurred at 142°W and that very little was present either east of that location or west of 180°. The suggestion (Wong *et al.*, 1974) that plastic accumulates in this region because of low net wind stress appears valid in view of all available results.

The fact that the majority of the plastic occurs more to the south and east than do the highest tar concentrations may, as suggested by Wong, be the result of a significant input of plastic but not tar from Hawaii. The distributions may also reflect a longer lifetime for plastics which enter the system in the Western Pacific along with the tar. Thus, it may be that plastic entering the Western Pacific in low abundance has a long enough residence time on the sea surface to accumulate in the Northeast Pacific.

Conclusions

Our observations indicate that small scale (75 km) and mesoscale (500 km) tar distribution is influenced by surface circulation features. Although the situation is not nearly as clear cut with regard to plastic, surface circulation must be important here too. Wind patterns appear to control the accumulation of plastic in the Northeast Pacific. The lack of a high tar concentration in this area may indicate that the tar's lifetime is not great enough to permit transport from the area of origin southwest of Japan. These advective forces controlling the distributions of tar and plastic in the North Pacific must be among those influencing the patchiness of pelagic organisms in the region.

We thank Professor T. Royer for valuable discussions and access to unpublished results. This study was supported in part under a contract between the University of Alaska and NOAA, Department of Commerce through the Outer Continental Shelf Environmental Shelf Assessment Program to which funds were provided by the Bureau of Land Management, Department of the Interior. This is University of Alaska, Institute of Marine Science contribution number 358.

Bernstein, R. L. (1974). Mesoscale eddies in the North Pacific: Westward Propagation. *Science*, **183**, 71–72.

Butler, J. N., Morris, B. F. & Sass, J. (1973). Pelagic tar from Bermuda and the Sargasso Sea. Special Publ. No. 10, Bermuda Biological Station, St. Georges West, Bermuda. pp. 43–45.

Maramo, R. & Kamada, K. (1973). Oil globules and their attached organisms in the East China Sea and Kuroshio area. *J. Ocean. Soc. Japan*, **29**, 155–158 (in Japanese).

National Academy of Sciences (1975). *Petroleum in the Marine Environment*. Washington, D.C. pp. 48–53.

Parsons, T. R. & Takahashi, M. (1973). *Biological Oceanographic Processes*. Pergamon, New York. pp. 30–35.

Roden, G. I. (1977). On long-wave disturbances of dynamic height in the North Pacific. *J. Phys. Oceanogr.*, **7**, 41–49.

Royer, T. C. (1978). Ocean eddies generated by seamounts in the North Pacific. *Science*, **199**, 1063–1064.

Sameoto, D. D. & Jaroszynski, L. O. (1969). Otter surface sampler: A new neuston net. *J. Fish. Res. Bd. Can.*, **25**, 2240–2244.

Schmitz, J. E. & Vastano, A. C. (1975). Entrainment and diffusion in a Gulf Stream cyclonic ring. *J. Phys. Oceanogr.*, **5**, 93–97.

Schmitz, J. E. & Vastano, A. C. (1976). On entrainment and diffusion in a Gulf of Mexico anticyclonic ring. *J. Phys. Oceanogr.*, **6**, 399–402.

Shaw, D. G. (1977). Pelagic tar and plastic in the Gulf of Alaska and Bering Sea: 1975. *Sci. Total Environ.*, **8**, 13–20.

Shekel, Y. & Ravid, R. (1977). Sources of tar pollution on Israeli Mediterranean coast. *Environ. Sci. Technol.*, **11**, 502–505.

Sleeter, T. D., Morris, B. F. & Butler, J. N. (1976). Pelagic tar in the Caribbean and equatorial Atlantic, 1974. *Deep Sea Res.*, **23**, 467–474.

Wong, C. S., Green, D. R. & Cretney, W. J. (1974). Quantitative tar and plastic waste distributions in the Pacific Ocean. *Nature*, **247**, 30–32.

Wong, C. S., Green, D. R. & Cretney, W. J. (1976). Distribution and source of tar in the Pacific Ocean. *Mar. Pollut. Bull.*, **7**, 102–105.