ARTICLES

FORECASTING WORLD DEMAND FOR TUNA TO THE YEAR 1990

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Total world demand for tuna continues to increase rapidly due to rising populations and expanding per-capita income in the principal tuna-consuming countries, such as the U.S., Japan, and members of the European Economic Community (EEC). EEC comprises Belgium, Luxembourg, France, West Germany and the Netherlands.

Taking into account expected increases in population and standard of living (per-capita income) over the next 20 years, we have forecast that world tuna consumption would approach 5 million metric tons by 1990 if supplies were available. However, this is not possible because maximum sustainable yield of known tuna resources in the world is estimated to be no more than 2.6 million metric tons.

To match consumption with available supplies, it is likely that prices of tuna will increase appreciably in the next 20 years. The increasing pressure of demand makes it especially necessary to consider sound management schemes to reduce the possibility of overfishing and destroying the world's tuna resources.

During recent years, the world demand for tuna has increased rapidly. Tuna and tuna-like fish in this article include: albacore, bigeye, bluefin, bonitos, frigate mackerels, little tunas, skipjack, yellowfin, and tuna-like species.

According to the Food and Agriculture Organization of the United Nations, total world consumption of tuna and tuna-like species (in round weight) increased from 804,700 metric tons in 1956 to 1,330,000 metric tons in 1967. The consumption of raw and canned tuna by selected countries during 1955-66 is shown in Table 1.

If the world demand for tuna continues to increase over the next few decades, as expected, there is serious question whether the world's oceans can provide for this rising consumption. So it becomes increasingly important to have adequate knowledge regarding the demand for tuna over the next 20 years. Forecasts of demand can be used to predict when demand will equal or surpass supply. This has practical significance to all agencies involved in fishery policy and programs, to the commercial fishing industry, and to the public.

For fisheries experiencing added pressure on existing stocks, economic forecasts, plus biological forecasts, can provide basis for identifying areas of potential pressure on prices, and indications of other market adjustments that may take place. Such forecasts also underscore the need for improved management policies.

Dr. Bell is Chief, Division of Economic Research, BCF. This project is part of a Division study on forecasting world demand for fishery products.

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Table 1 - Consumption of Raw and Canned Tuna by Selected Countries, 1956-1966
(Raw is fresh and frozen tuna. Canned has been converted to round-weight basis by increasing it 100 percent.)

Country and degree of processing	1956	1958	1960	1962	1964	1966	1966 as % of total
	------- Thousand metric tons, round weight ----------						percent
U.S.A.							
canned	240.6	281.0	336.2	333.8	350.4	382.8	29.0
Japan							
raw	157.9	217.3	190.6	303.3	243.8	353.0	26.7
canned	48.4	46.8	46.0	39.0	31.8	25.8	2.0
Total	(206.3)	(264.1)	(236.6)	(342.3)	(275.6)	(378.8)	(28.7)
EEC							
canned	71.0	85.2	130.0	142.8	153.8	159.0	12.0
Spain							
raw	5.0	14.0	12.2	17.8	21.5	31.8	2.4
canned	29.0	37.0	25.2	28.4	25.8	37.8	2.9
Total	(34.0)	(51.0)	(37.4)	(46.2)	(47.3)	(69.6)	(5.3)
Peru							
raw	33.0	33.9	59.0	58.6	80.0	50.2	3.8
China (Taiwan)							
raw	16.1	18.5	15.8	29.2	25.0	38.0	2.9
canned	0.6	1.4	1.4	3.0	7.2	6.8	0.5
Total	(16.7)	(19.9)	(17.2)	(32.2)	(32.2)	(44.8)	(3.4)
Turkey							
raw	53.7	25.3	31.7	3.8	11.2	16.0	1.2
Canada							
canned	5.3	4.6	6.9	8.2	8.5	10.2	0.8
U.K.							
canned	12.0	5.6	4.2	5.4	7.8	7.6	0.6
Other							
raw	64.0	130.0	149.8	186.4	160.5	89.0	6.7
canned	68.1	54.4	48.1	83.4	84.7	112.0	8.5
Total	(132.1)	(184.4)	(197.9)	(269.8)	(245.2)	(201.0)	(15.3)
Total							
raw	329.7	439.0	459.1	599.1	542.0	578.0	43.8
canned	475.0	516.0	598.0	644.0	670.0	742.0	56.2
Total	804.7	955.0	1057.1	1243.1	1212.0	1320.0	100.0

Source: Original data from 'FAO Yearbooks of Fishery Statistics' compiled by Liaqat Ali, "World Raw and Canned Tuna Situation," 'Commercial Fisheries Review,' Fish and Wildlife Service, Vol. 30, No. 2, Feb. 1968, pages 24-31.

Table 1A - Data Related to U.S. Demand for Canned Tuna

Year	Per capita consumption of canned tuna	Wholesale price: canned tuna	Wholesale price: canned salmon	Per capita disposable personal income	Consumer price index for meat, fish and poultry	Wholesale price index	Consumer price index
	pounds	cents per pound		dollars	1957-59 = 100		
1947	0.78	78.4	44.5	1,179	84.8	81.2	77.8
1948	0.89	81.7	52.0	1,290	96.2	87.9	83.8
1949	0.89	69.3	39.0	1,264	91.1	83.5	83.0
1950	1.13	64.6	52.9	1,364	95.1	86.8	83.8
1951	1.22	63.1	48.7	1,468	106.1	96.7	90.5
1952	1.27	63.4	45.9	1,518	105.3	94.0	92.5
1953	1.37	67.2	43.8	1,582	99.6	92.7	93.2
1954	1.37	66.4	46.2	1,585	97.6	92.9	93.6
1955	1.43	63.7	51.6	1,666	92.1	93.2	93.3
1956	1.57	61.2	56.5	1,743	88.0	96.2	94.7
1957	1.58	58.4	55.9	1,803	95.4	99.0	98.0
1958	1.77	58.4	51.8	1,831	104.4	100.4	100.7
1959	1.88	56.4	60.7	1,905	100.4	100.6	101.5
1960	2.05	57.3	64.9	1,937	99.1	100.7	103.1
1961	2.08	60.9	66.0	1,983	99.3	100.3	104.2
1962	1.97	62.5	58.5	2,064	101.7	100.6	105.4
1963	1.98	61.7	55.6	2,136	100.2	100.3	106.7
1964	2.01	62.2	53.1	2,280	98.6	100.5	108.1
1965	2.32	65.0	70.4	2,432	105.1	102.5	109.9
1966	2.20	68.5	64.6	2,598	114.1	105.9	113.1
1967	2.32	67.3	73.6	2,744	111.2	106.1	116.3

Source: U. S. Department of the Interior, U. S. Department of Commerce, and U. S. Department of Labor.

FACTORS BEHIND DEMAND FOR CANNED TUNA: U.S. EXPERIENCE

Expressed in round weight, U.S. per-capita consumption of canned tuna increased from 1.56 pounds in 1947 to 4.64 pounds in 1967. What are the factors behind this rapid increase? A statistical analysis was made in which the following factors were related to per-capita consumption of canned tuna:

1. Wholesale price of canned tuna relative to general price level in U.S. economy.

2. Per capita disposable personal income relative to general price level in U.S. economy (standard of living).

3. Wholesale price of canned salmon relative to general price level.

4. Retail price of meat, poultry, and fish as category relative to general price level.

The hypothesis concerning these relationships was: If canned tuna prices go up, per-capita consumption would fall because consumers would substitute other foods or goods for tuna; if per-capita income increases, per-capita consumption of canned tuna would rise because consumers would have a higher standard of living and could enjoy more tuna; if the price of canned salmon were to increase relative to tuna, this would increase canned-tuna consumption as consumers switched from salmon to tuna; and, finally, if the price of meat, poultry, and fish as a category went up relative to tuna, consumers would eat more canned tuna. What did we find?

For the U.S. during 1947-67, per-capita consumption of canned tuna was influenced primarily by the price of canned tuna and per-capita income. The price of canned salmon and the price of meat, poultry, and fish as a category were not statistically important. Figure 1 shows the estimating accuracy of our statistical equation. This related U.S. per-capita consumption of canned tuna to canned tuna prices, per-capita income, canned salmon prices, and the price of meat, poultry, and fish as a category. The estimating accuracy of our equation is very good over the 1947-1967 period.

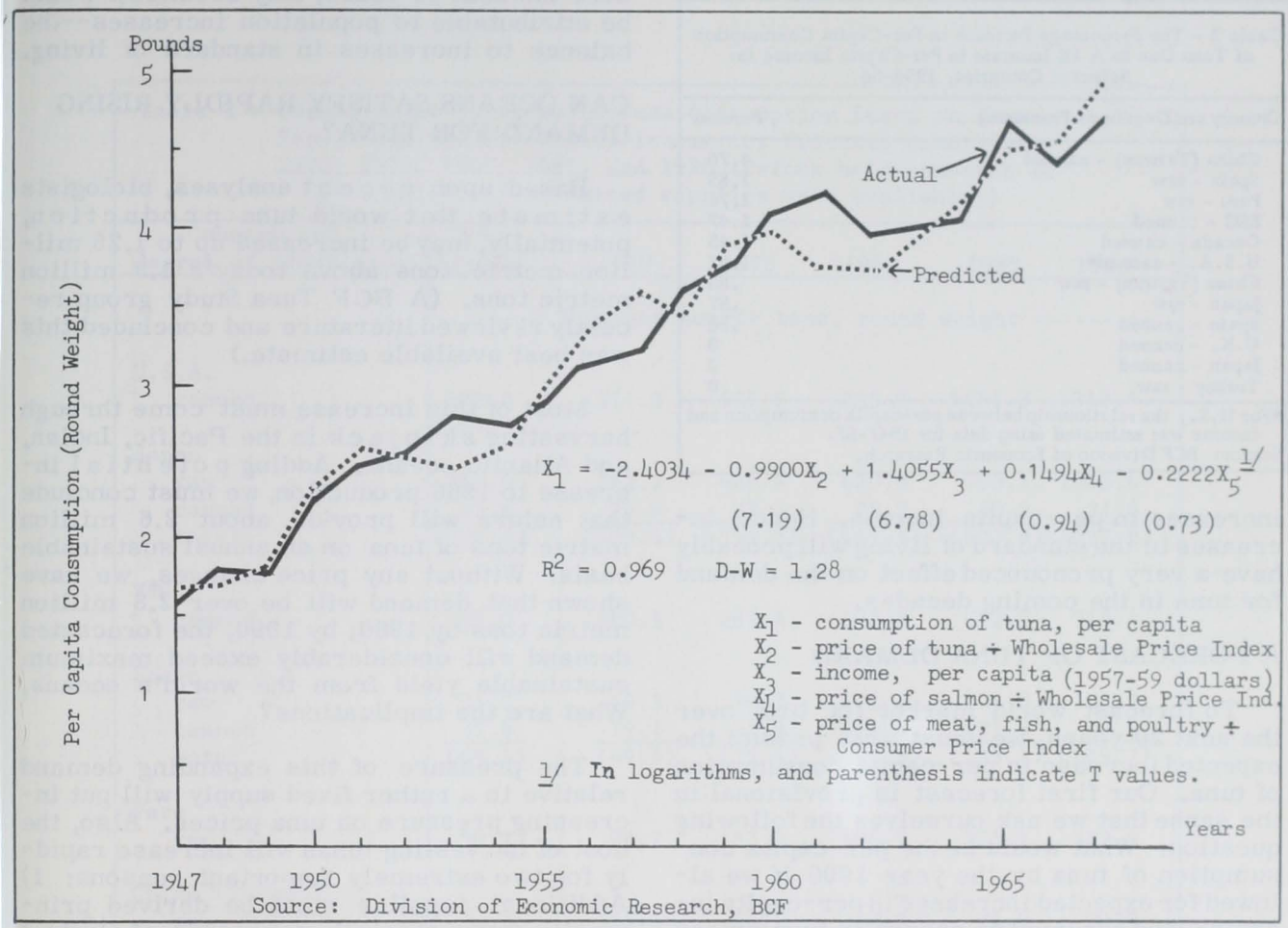


Fig. 1 - Comparison of actual and estimated per-capita consumption of canned tuna, United States, 1947-67.

According to the analysis, a 10% increase in tuna prices would reduce tuna per-capita consumption by approximately 10%. However, a 10% increase in per-capita income would increase per-capita consumption of canned tuna by about 14%. These quantitative relationships allow prediction of the impact of, for example, a 50% increase in per-capita income, or a 20% rise in price of canned tuna on per-capita consumption. These are very important relationships that must be known before reliable forecasts can be made.

DEMAND FACTORS FOR RAW AND CANNED TUNA ABROAD

Analyses of demand factors similar to those carried out for the U.S. were applied to Japan, EEC countries, Spain, Peru, China (Taiwan), Turkey, Canada and the United Kingdom. These and the U.S. account for about 85% of world consumption of tuna. The demand for tuna was divided into raw and canned in some countries where both forms are a significant percentage of consumption. Because of the lack of statistical importance of salmon prices, and meat, fish, and poultry prices found in the U.S. analyses--and the difficulty of obtaining data for other countries--these factors were omitted from the statistical analyses.

For the countries studied, the results indicated that per-capita income and tuna prices were significant factors in explaining changes in per-capita consumption of tuna over the last 11 years. Table 2 shows the percentage response of tuna per-capita consumption in the various tuna-consuming countries to a 1% increase in per-capita income. Of special interest, such culturally similar countries as Canada, the U.S., and EEC members have nearly the same response of per-capita consumption of canned tuna to changes in per-capita income. Only a few countries showed a decline in per-capita tuna consumption with

Table 2 - The Percentage Increase in Per-Capita Consumption of Tuna Due to A 1% Increase in Per-Capita Income for Selected Countries, 1956-66

Country and Degree of Processing	Percent
China (Taiwan) - canned	4.76
Spain - raw	1.85
Peru - raw	1.76
EEC - canned	1.47
Canada - canned	1.45
U.S.A. - canned*	1.41
China (Taiwan) - raw	.85
Japan - raw	.57
Spain - canned	.38
U.K. - canned	0
Japan - canned	0
Turkey - raw	0

*For U.S., the relationship between per-capita consumption and income was estimated using data for 1947-67.
Source: BCF Division of Economic Research.

increases in per-capita income. Hence, increases in the standard of living will probably have a very pronounced effect on the demand for tuna in the coming decades.

A FORECAST OF TUNA DEMAND

To forecast world market for tuna over the next 20 years, we must first predict the expected increase in per-capita consumption of tuna. Our first forecast is provisional in the sense that we ask ourselves the following question: What would be the per-capita consumption of tuna by the year 1990 if we allowed for expected increases in per-capita income--and assumed no change in tuna prices relative to general price level? Using our statistical relationships developed above--with U.S. Department of Agriculture projections to 1990 of per-capita income for principal tuna-consuming countries--we made a forecast of per-capita consumption of tuna. Then, this was multiplied by the population expected to exist by 1990 to obtain the forecasted tuna market.* These provisional forecasts are shown by country in Table 3.

Based on expected increases in population and standard of living (per-capita income), world consumption is expected to reach about 2.8 million metric tons by 1980, and 5 million metric tons by 1990. This is shown in Figure 2 as projection A. In other words, world tuna consumption is expected to double in each of the next two decades--assuming world supplies are adequate and there is no rise in tuna prices. Further, the analysis showed that of the expected increase in tuna demand over the next 20 years, only about 10% would be attributable to population increases--the balance to increases in standard of living.

CAN OCEANS SATISFY RAPIDLY RISING DEMAND FOR TUNA?

Based upon recent analyses, biologists estimate that world tuna production, potentially, may be increased up to 1.25 million metric tons above today's 1.3 million metric tons. (A BCF Tuna Study group recently reviewed literature and concluded this was best available estimate.)

Most of this increase must come through harvesting skipjack in the Pacific, Indian, and Atlantic oceans. Adding potential increase to 1966 production, we must conclude that nature will provide about 2.6 million metric tons of tuna on an annual sustainable basis. Without any price changes, we have shown that demand will be over 2.8 million metric tons by 1980; by 1990, the forecasted demand will considerably exceed maximum sustainable yield from the world's oceans. What are the implications?

The pressure of this expanding demand relative to a rather fixed supply will put increasing pressure on tuna prices. Also, the cost of harvesting tunas will increase rapidly for two extremely important reasons: 1) Additional supplies must be derived principally from skipjack resources of Central Pacific; under known technology, these are extremely difficult to find and harvest. 2) Increased fishing effort on tuna resources in general probably will reduce catch per unit of effort. This would increase cost per pound of fish landed.

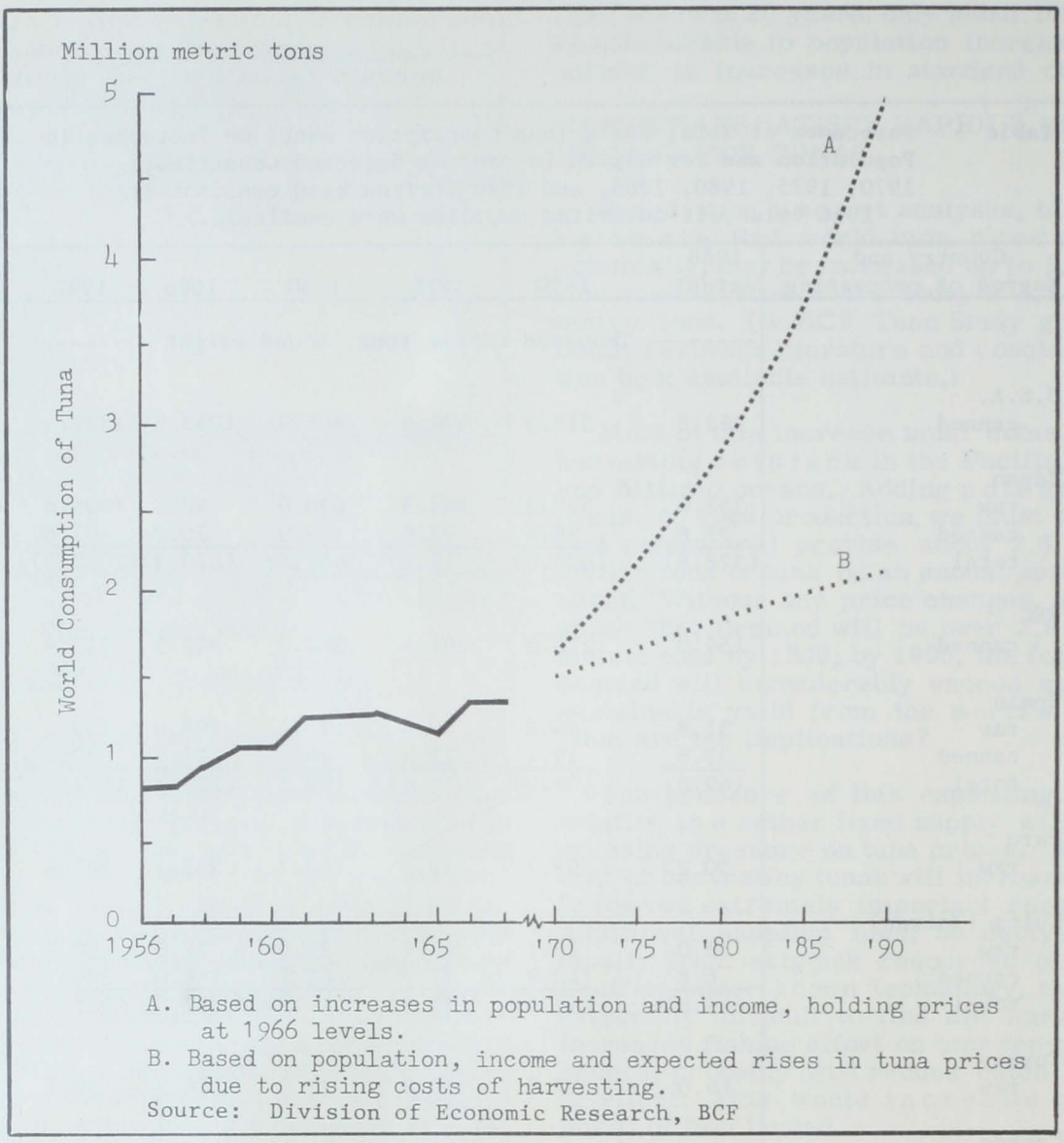
It is quite probable that prices and cost of tuna will double by 1990. For an increase in tuna prices to reduce consumption, it is necessary that these increase more rapidly than general price level. More precisely, we are forecasting that prices of tuna relative to general price level will double by 1990.

The higher price of tuna will reduce consumption. At the higher prices, it is forecasted that world production and consumption of tuna will be equal at about 2.1 million metric tons by 1990. This is shown in Figure 2 in projection B. If we forecast tuna demand to the year 2000, the results indicate tuna prices will probably triple--and that production

*The sum of individual forecasts for each of the 9 country categories was increased by the average percent for rest of world's tuna consumption during 1956-1966. Population forecasts were obtained from U.S. Department of Agriculture.

Table 3 - Forecasts of Total World Tuna Consumption Based on Increases in Population and Per-Capita Income for Selected Countries, 1970, 1975, 1980, 1985, and 1990 (Prices held constant at 1966 value, if unlimited supplies were available.)

Country and degree of processing	1966 Actual	1970	1975	1980	1985	1990
	-------- Thousand metric tons, round weight ---------					
U.S.A.						
canned	382.8	511.3	671.6	845.3	1055.8	1318.4
Japan						
raw	353.0	382.2	486.9	620.6	790.1	1005.6
canned	25.8	26.4	27.6	28.9	30.2	31.6
total	(378.8)	(408.6)	(514.5)	(649.5)	(820.3)	(1037.2)
EEC						
canned	159.0	210.5	281.4	382.8	522.5	713.4
Spain						
raw	31.8	30.3	50.5	73.1	105.8	153.2
canned	37.8	19.1	21.9	24.4	27.3	30.5
total	(69.6)	(49.4)	(72.4)	(97.5)	(133.1)	(183.7)
Peru						
raw	50.2	98.7	137.3	194.7	275.1	387.4
China (Taiwan)						
raw	38.0	35.1	44.1	56.0	71.0	90.3
canned	6.8	12.8	27.7	63.7	146.0	334.7
total	(44.8)	(47.9)	(71.8)	(119.7)	(217.0)	(425.0)
Turkey						
raw	16.0	17.9	20.6	23.5	26.9	30.7
Canada						
canned	9.7	11.6	15.2	19.5	25.0	32.1
U.K.						
canned	7.6	7.4	7.8	8.0	8.3	8.6
Total - selected countries	1118.5	1363.3	1792.6	2340.5	3084.0	4136.5
Grand total (Projected at 120% of total for selected countries.)	1320.0	1636.0	2151.1	2808.6	3700.8	4963.8



A. Based on increases in population and income, holding prices at 1966 levels.
B. Based on population, income and expected rises in tuna prices due to rising costs of harvesting.
Source: Division of Economic Research, BCF

Fig. 2 - Forecasted increases in world demand for tuna.

and consumption will equal maximum sustainable yield for world's tuna resources. This implicitly assumes that as each tuna stock reaches maximum sustainable yield, a regulatory authority is able to prevent overfishing.

A NEED FOR POLICY

We must point out some critical facts. First, tuna demand is extremely strong and is likely to expand greatly over the next 20-30 years. Second, without any increases in tuna prices, consumption would likely exceed the oceans' potential production by a ratio of two to one by 1990--and, possibly, by five to one by 2000. These events will put great upward pressure on tuna prices. Such price increases would relieve demand pressure on fixed and relatively scarce tuna resources by discouraging further consumption increases. Most probably, the mushrooming demand will turn tuna into a luxury good.

The need for policy is unmistakable. With increasing pressure on tuna resources, the possibility of overfishing looms--unless there are significant breakthroughs in other areas, such as tuna aquaculture. A vigorous program of world management must be instituted to avert resource destruction.

Already, the Inter-American Tropical Tuna Commission and the Atlantic Tuna Commission are engaged in this effort. But the astounding pressure of world demand adds urgency to the need for more effective global management than the present scheme permits.

Our forecasts are tentative. We may have to adjust or refine these further when more information on tuna consumption becomes available. For example, the response of tuna consumption to income may diminish over time and dampen, somewhat, the projections. However, at the present time, these estimates are the best available--and certainly useful in identifying areas of concern and in underlining the need for action.

HOW ARE OCEANOGRAPHIC OBSERVATIONS TAKEN BESIDE FROM A SHIP?

Because oceanographic ships are expensive to operate, difficult to anchor in deep water, and limited in speed, continuous observations in one location and surface observations over wide ocean areas can best be accomplished by means other than ships.

Buoys have been used for many years to obtain measurements of surface and subsurface currents and temperatures, as well as to observe meteorological conditions. These observations were mostly made near shore because of the difficulties in deep-sea anchoring and long-distance radio transmission. More recently other measurements have been included, such as of salinity and waves.

There is increasing interest in setting up networks of moored buoys which would transmit oceanographic and meteorological information by radio or satellite relay. The NOMAD (Navy Oceanographic Meteorological Automatic Device) buoys have withstood hurricanes and therefore supplied timely and useful data which could not have been collected by ships.

FLIP (Floating Instrument Package) is a hybrid ship-buoy. It is towed in the horizontal position to its location, where ballast tanks at one end are flooded, thus flipping it to the vertical position. FLIP serves as a stable, manned platform or "buoy" with observation ports extending to a depth of about 300 feet.

Offshore towers have also been used for collection of oceanographic data. Some, such as the Navy Electronics Laboratory tower located a mile off the San Diego, California, coast, have been built specifically for oceanographic research; others, such as the Air Force radar towers (Texas towers), were built for other purposes but also used as observation sites by oceanographers. The Coast Guard is undertaking a significant and extensive oceanographic data collection program on its new offshore towers. These towers, which replace the lightships as outer channel markers to major East Coast and West Coast ports, are being equipped with an impressive array of oceanographic instruments.

Surface data, primarily temperature, have been collected by extremely sensitive sensors on aircraft and satellites. Frequent flights have made it possible to map the meanderings of the Gulf Stream.

Subsurface observations have been made by submersibles and by divers operating either from the surface or from underwater laboratories. ("Questions About The Oceans," U.S. Naval Oceanographic Office.)