

(excluding potential defence applications) is in support of such international scientific programs as WOCE, it could be important that R&D collaboration is also international.

With regard to markets, the WOCE project will require research ships making 24,000 precision hydrographic profiles along carefully designed trans-ocean lines. This is equivalent to one of the few first-class oceanographic ships surveying for 15 years [Dr. J. Woods, Director of Marine and Atmospheric Sciences Division, NERC, lecture on "New Technology for Ocean Sciences" — March 1991]. As it is expected that ocean circulation will be monitored routinely for climate prediction in the future, it is believed that the requirements for AUVs such as DOLPHIN, which is expected to undertake surveys at a tenth of the cost, will be enormous.

At an AUTOSUB meeting earlier this year, involving all scientific and industrial participants in the program, a figure of 300 such vehicles was predicted. Assuming a cost/price of \$5 million, this suggests a \$1,500 million market in the medium- to long-term for this area of oceanography alone. This does not include geophysical/geological surveying for scientific or commercial applications. This is obviously a large assumption, but the wider applications and their consequences on ocean exploration cannot begin to be estimated until the technological problems are solved.

4.2 The Marine Environmental Market

It is clear that the marine environment will be the strongest growth market well into the next century. The number of national and Pan-European R&D programs now under way is evidence of this. It is also becoming a fashionable subject for conferences and exhibition, with two major European conferences to be held this year: "Clean Seas '91," in Malta in November, and "Environmental North Sea Europe," in Norway in August.

Before looking at the available market information for this sector, it is useful to look at both the market applications and the types of equipment and services required. The main requirements relate to the monitoring, prevention and control of marine pollution. This can emanate from a number of sources, as follows:

Ships

- accidental leakage or discharge
- collision or explosion
- illegal dumping

Industrial Waste

- discharge into rivers and estuaries

Domestic Waste (Sewage)

- dumping at sea
- coastal outfalls

Mariculture

- accumulation of excess foods and excretion
- use of chemicals as a vaccine
- use of chemicals to dispose of sea-lice (dichlorvos)

Hydrocarbon Exploitation

- oil-based drilling muds
- drill cuttings
- pipeline leakage
- accidental discharge
- discharge of treatment water

Dredge Spoil

Mineral Extraction

Agricultural Run-off Into Streams and Rivers

- nutrients
- fertilizers
- animal slurry and silage
- atmospheric inputs from incinerators, power stations and general air-borne pollutants

The technology requirements include the following:

Services

- consultancy
- modelling (e.g., dispersal of pollutants)
- consultant engineering (e.g., outfalls)
- monitoring (e.g., surveys)
- pollution clean-up
- environmental impact assessment