The role of operational ocean forecasting in e-navigation

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ABSTRACT: Advances in ocean modelling have led to improved performance for operational ocean forecasting and the availability of continuously reliable forecast information for certain ocean regions of the world. Although such forecasts are being increasingly adopted into a wide range of services across the maritime industry they have not yet been considered as candidates to supplement or to substitute conventional tide tables for navigation use. The issue is important in the context of climate change and the added uncertainty now placed on the use of conventional tide table for navigation in complex coastal waters. In the context of e-navigation it is timely to begin to explore the issue and examine how such forecasts might be used and adopted. This requires closer connectivity between ocean forecasting and navigation communities and the involvement of overarching organisations such as IMO and I GOOS. This paper raises the issue and opens the debate.

1 INTRODUCTION

Climate change driven by global temperature rise is producing increasing variability of seasonal weather and a marked increase in the frequency and severity of storms. The consequential impact on the oceans is significant, leading to global sea level rise, abnormal coastal flooding and complex behaviour of tides and currents in coastal waters. For navigation, especially in coastal waters, weather forecasts are becoming increasingly important and the need for a navigator to estimate the deviation of true water levels and true currents from those presented in official tide tables is paramount. The accuracy of model generated ocean forecasts has improved substantially over recent years and operational services are becoming increasingly available especially in context of national flood tide warning, marine search and rescue, port approaches and offshore operations. Advances in satellite based internet broadband directly enable web service delivery of data and information which contributes to a new emerging framework for e-navigation that offers possibility for integrating operational ocean forecasts into onboard ECDIS systems. This paper raises the concept of adopting operational ocean forecasts as a formal component of ECDIS and introduces some of the main issues to be considered.

2 SEA LEVEL AND CLIMATE CHANGE

According to the forthcoming fourth IPCC report (IPCC 2007 WG1 Release, 2007); “at continental, regional and ocean basin scales, numerous long-term changes in climate have been observed. These include changes in arctic temperatures and ice, widespread changes in precipitation amounts, ocean salinity, wind patterns and aspects of extreme weather including droughts, heavy precipitation, heat waves and the intensity of tropical cyclones. Global average sea level rose at an average rate of 1.8 [1.3 to 2.3] mm per year over 1961 to 2003. The rate was faster over 1993 to 2003: about 3.1 [2.4 to 3.8] mm per year. Whether the faster rate for 1993 to 2003 reflects decadal variability or an increase in the longer-term trend is unclear. There is *high confidence* that the rate of observed sea level rise increased from the 19th to the 20th century. The total 20th-century rise is estimated to be 0.17 [0.12 to 0.22] m.” The implication for the next century to 2100 suggests that tropical cyclone intensity and extreme sea level frequency will increase and mean sea level will rise 20 - 60 cm.

3 TIDE TABLES FOR NAVIGATION

The SOLAS 1974 Convention governing *Safety of Life at Sea* provides a comprehensive set of regulations made up of XII chapters. Chapter V – *Safety of Navigation*; identifies certain navigation safety services which should be provided by Contracting Governments and sets forth provisions of an operational nature applicable in general to all ships on all voyages. This is in contrast to the Convention as a whole, which only applies to certain classes of ship engaged on international voyages.

Chapter V was updated in 2000 to take account of new digital technologies and evolution of *Electronic Chart Data Information Systems* ECDIS developments.

SOLAS Ch V/1974 *Regulation 20* pertaining to *Nautical Publications* was revised and updated as SOLAS Ch V/2000 *Regulation 27: Nautical charts and nautical publications, such as sailing directions, lists of lights, notices to mariners, tide tables and all other nautical publications necessary for the intended voyage shall be adequate and up to date. Regulation 27* is supplemented by an *Annex 3: Nautical Data and Publications* which incorporates *Regulation 19.2.1.4* that specifically lists *Tide Tables and Tidal Stream Atlases* as publications required onboard.

Whereas the SOLAS Convention and its Regulations come under the auspices of the *International Maritime Organisation* IMO, the governance of navigation charts and tide tables comes under the auspices of the *International Hydrographic Organisation* IHO with important scientific input addressing mean sea level and tidal monitoring contributed under the auspices of the *International Oceanographic Commission* IOC.

Tide tables themselves are a responsibility of individual countries that are required to ensure adequate provision of information to ensure safety of navigation in their national waters. The UK Hydrograghic Office has traditionally provided a global coverage of tide table data in addition to that for UK waters only. Nowadays, most countries with extensive coastlines have the capacity to produce their own national tide tables with UK and USA providing greater global coverage. However, whereas tables providing tidal height predictions are easily produced, increasingly accurate and readily available, the same is not true for tidal stream atlases which are still based on rudimentary tidal chart data and increasingly outdated content of the important *Pilot* publications.

Currently, the carriage and usage of tide table and tidal stream atlas data by vessels for navigation seems to be very varied with no overall governance pertaining to use of best available data or guidance as to its interpretation. National hydrographic authorities such as USA, UK, Australia and New Zealand are increasingly making their national tide table predictions available freely over the internet and other internet sites such as www.mobilegeographics.com using XTide software can now be found offering tide table predictions on demand for almost any global locations. However, a quick look at freely available predictions for the same port from three different sources show differences that suggests a need to address the question of compatibility and compliance. In congested coastal regions and major port approaches pilotage is already being facilitated by access to real-time readout from regional tide gauges or current meters. In operational engineering environments sensitive to sea state such as offshore construction or large structure tow-out, the provision of numerical model based sea level and current forecasts, allowing for non-tidal effects, is already an established requirement.

The increasing access to a widening range of *tidal predictions* that may be used for navigation is a situation that has to be recognised as a potential problem and one that has to be addressed.

4 OPERATIONAL OCEANOGRAPHY

Advances in ocean modelling have led to radically improved performance for operational ocean forecasting and the availability of continuously reliable forecast information of sea levels and currents for certain ocean regions of the globe. In Europe which is well served by its national forecasting agencies work is advanced in moving towards a unified approach for providing operational ocean forecast coverage for regional European Seas and Atlantic waters. Similar capacity exists amongst national forecasting agencies in other parts of the globe such as USA, China, Japan and Australia. Although such ocean forecast data are being increasingly adopted by industry to meet marine operation needs ranging from search and rescue to ship routing and tow-out they have not yet been considered as candidates to supplement or to substitute conventional tide tables for navigation. Part of the reason may be to do with the complex make-up and uncertain positioning of GOOS *the Global Ocean Observing System*, which is a permanent global system for observations, modelling and analysis of marine and ocean variables to support operational ocean services worldwide. Connectivity between GOOS and IMO/IHO is clearly lacking.

The intergovernmental IOC-WMO-UNEP Committee for GOOS (I-GOOS) was initially established by the IOC Executive Council at its twenty-fifth Session (Paris, March 1992) as the IOC Committee for GOOS (resolution EC-XXV.3), to, *inter alia*, replace the Committee on Ocean Processes and Climate. WMO and UNEP agreed to co-sponsor the Committee in 1993.

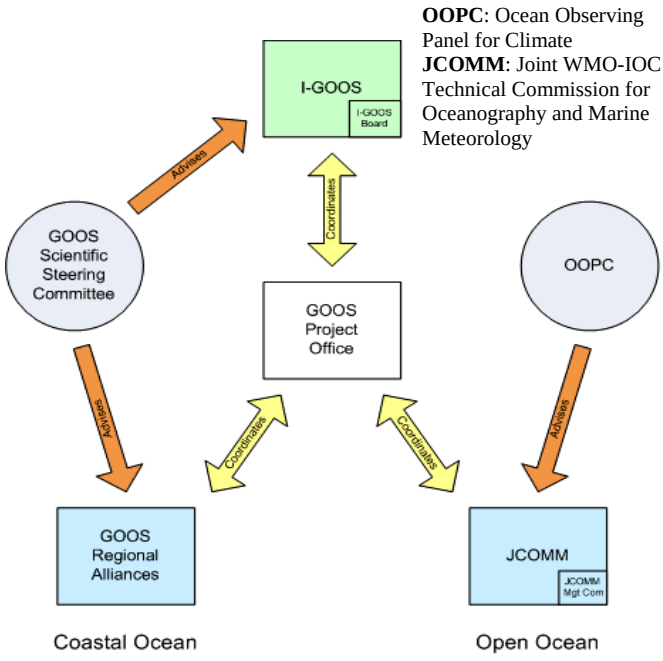
GOOS is not an entity but is a platform for:

- International cooperation for sustained observations of the oceans
- Generation of oceanographic products and services
- Interaction between research, operational, and user communities

GOOS is implemented by:

Member states via their government agencies, navies and oceanographic research institutions working together in a wide range of thematic panels and regional alliances.

The complex structure of GOOS is illustrated in Figure 1 below.



OOPC: Ocean Observing Panel for Climate
JCOMM: Joint WMO-IOC Technical Commission for Oceanography and Marine Meteorology

Fig. 1. Structure of GOOS from www.ioc-goos.org

The GOOS Project Office is the organizational and coordination hub of GOOS. The office is hosted within the IOC/UNESCO headquarters in Paris, France and is funded by UNESCO/IOC, USA, UK, UNEP and WMO.

The nature of GOOS implementation mechanism, as highlighted above in italics, together with the dual domain services vision responsibility, for coastal and open oceans, as indicated in Figure 1, creates a highly confusing picture with regard to figuring out - how the national ocean forecast service providers (mainly the Meteorological Offices) should be connected with the IMO SOLAS navigation requirements? In other words – how to create a suitable IMO-I GOOS-IHO partnership that will help to realise modern tidal navigation needs?

5 E-NAVIGATION

The IMO Maritime Safety Committee (MSC) at its 81st session in May 2006 decided to initiate a high priority item on "Development of an e-navigation strategy", with a target completion date of 2008. The aim is to develop a strategic vision for e-navigation, to integrate existing and new navigational tools, in particular electronic tools, in an all-embracing system that will contribute to enhanced navigational safety while simultaneously reducing the burden on the navigator. E-navigation would thus incorporate new technologies in a structured way and ensure that their use is compliant with the various navigational communication technologies and services, such as ECDIS, that are already available, providing an overarching, accurate, secure and cost-effective system with the potential to provide global coverage for all ships.

E-navigation compliments the emergence of the term *Marine Electronic Highway* MEH (Sekimizu et al 2001, Gillespie 2005) and the initiation in 2006 of a key MEH pilot demonstration project in the Straits of Malacca and Singapore. The four-year regional demonstration project aims to link shore-based marine information and communication infrastructure with the corresponding navigational and communication facilities aboard transiting ships, while being also capable of incorporating marine environmental management systems. IMO state that “The overall system - would also include positioning systems, real-time navigational information like tidal and current data, as well as providing meteorological and oceanographic information …”

Development of an e-navigation strategy by IMO is currently under active discussion with responses now in place for reporting back to the IMO NAV53 meeting in July 2007. As of 20th April 2007 there are 66 response documents posted on the IHO web site, one of which; the *IALA Definition and Vision for E-Navigation*, posted 29th March 2007 (IALA 2007) presents a descriptive model for e-navigation that clearly highlights inclusion of oceanographic predictions as input for creating operational navigation information in an e-navigation context. Key applications identified by IALA are route planning, under keel clearance, berthing and SAR response. Bearing in mind the important role played by IALA *the International Association of Marine Aids to Navigation and Lighthouse Authorities* in driving the adoption of key technology applications such as VTS *Vessel Traffic Systems* and AIS *Automatic Identification of Ships*, its contribution highlighting oceanographic predictions, ie., *operational oceanography*, should be treated with great seriousness and should be considered as the opening to develop

inclusiveness of the GOOS community into the e-navigation framework. It is noticeable that amongst the 66 contributing responses on e-navigation posted on the IHO web site that reflect world-wide participation, I could not identify any representatives of the GOOS community.

6 CONCLUSIONS

The maritime community is currently in the process of establishing a strategy for adoption of e-navigation as an enabling framework for integration of new forms of technology and information to aid and enhance safety of navigation world-wide. A key component for safe navigation is the use of best available tide and current predictions. In the context of climate change and its impact on the seas it is necessary to consider how operational ocean forecasts might supplement or replace onboard tidal publications. The global ocean modelling and forecasting community GOOS is advancing and improving capacity to provide operational forecasts. Currently the GOOS community and the maritime navigation community are not closely connected; it is timely that closer connectivity should be encouraged. The following three recommendations are proposed.

1. In view of the increasing availability of tidal predictions over the internet it seems necessary to develop guidelines governing use of these data for navigation.
2. Consideration should be given to the use of operational ocean forecasts for navigation and a strategy should be developed for their adoption and use.
3. Formal cooperation between the maritime navigation community represented by IMO, IHO and IALA and the operational ocean forecasting community represented by I GOOS should be established as a matter of priority.

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