

## THE FIRST SLOVENIAN NAUTICAL CHART – DIGITAL ON WGS 84

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### ABSTRACT:

The Gulf of Koper chart is the first Slovenian nautical chart. This paper contains a description of hydrographic education procedures, geodetic and hydrographic survey, terrain control of aids to navigation, processing of hydrographic fair sheets and digital cartographic design. The chart was produced at a scale of 1 : 12000 in accordance with the hydrographic and cartographic standards of the International Hydrographic Organization. In order to assure satellite navigation, its contents was presented in a Mercator projection on WGS 84 ellipsoid.

### ZUSAMMENFASSUNG:

#### Die erste slowenische Seekarte

Die Karte Golf von Koper ist die erste slowenische Seekarte. In dem Artikel werden die Prozesse der hydrographischen Ausbildung, geodätischen und hydrographischen Vermessung, Kontrolle von Landmarken, Bearbeitung des hydrographischen Originals und digitalen Herstellung der Karte dargestellt. Die Karte wird nach hydrographischen und kartographischen Normen der Internationalen Hydrographischen Organisation hergestellt, im Maßstab von 1:20000. Wegen der Satellitennavigation ist der Inhalt der Karte in Mercatorprojektion auf dem Ellipsoid WGS 84.

**Stichwörter:** nautische Kartographie, hydrographische Vermessung

### INTRODUCTION

The Slovenian sea is a small, but economically and strategically very important part of the northern Adriatic. Daily traffic includes many pleasure-boats, super tankers and merchant ships with dangerous goods. Occasionally there are foreign naval ships, and other contributors to the very dense traffic are the many fishing vessels and of course the proximity of Trieste harbour. International transport in the port of Koper is of vital importance for Slovenia due to its connection to Central Europe by railway and roads.

Slovenian sea has depths up to 30 m, which is deeper than the lowest draft of the larger ships. However, the Koper harbour has depths up to 18 m, which means that some ships are navigating only a few decimeters from the bottom. In addition, especially in the winter, safe navigation is hindered by the wind and fog.

The main reason for the production of nautical charts is safety of navigation. Charts, in combination with modern satellite navigation systems in the ships and harbours, are very important aspect of safe navigation. The production of nautical charts comes under the supervision of the International

Hydrographic Organization (IHO), because just one wrong piece of information on the chart can lead to disaster. A harbour without an official nautical chart is unreliable especially from an insurance point of view.

Until the first Slovenian chart was published, rather outdated charts were in use. The production of nautical charts of Slovenian sea in the past was carried out by Hydrographic Institute of the Yugoslavian Navy. After the independence of Slovenia and Croatia, the legacy of Yugoslavian Hydrographic Institute was carried on by Croatian State Hydrographic Institute. They continued to produce the latest charts use in Slovenia. Slovenia became an associated member of IHO after independence. At this time the Maritime Affairs Office at the Ministry of Transport and Communications was established. Due to the facts mentioned above, the production of our own nautical chart proved necessary.

### HYDROGRAPHIC COURSE

A substantial knowledge of cartography, navigation and hydrography is required for nautical chart production. A number of different courses, organized abroad, provide the appropriate education and

training. With the intervention of the Ministry of Transport and Communications, the Institute of Geodesy, Cartography and Photogrammetry (IGF), as a producer of new nautical charts, was given the opportunity to educate one of its cartographic experts at the International Maritime Academy (IMA) (Karničnik, 1998). Hydrographic education continued last year as it will in the future.

### **HYDROGRAPHIC SURVEY**

A nautical chart is a combination of topographic and hydrographic sections. The topographic section is acquired by a geodetic and photogrammetric survey of the land area of a chart, and is represented quite schematically. The hydrographic part with all navigational data is the most important part and must be complete and made with maximum precision. Hydrographic data are acquired by hydrographic survey. The survey is accomplished by a hydrographic survey vessel in accordance to IHO standards. Slovenian sea is too small for it to be reasonable to have our own equipment for such a demanding survey. From this reason Navoceano (Department of the US Navy, Naval Oceanographic Office) did the first survey of our sea with their survey vessel Littlehales and two HSLs (Hydrographic Survey Launch). During the survey both IGF and the Ministry participated in the survey and provided liaison between the Slovenian Government and Navoceano. A connection was established via Internet between IGF and the vessel. At the same time the team of cartographers was organized to check and archive all the transferred data (Karničnik, Radovan, 1998b).

The first part of the survey was a geodetic survey of all reference points and aids to navigation. A network of five GPS reference points was established on land to provide sufficient support for precise positioning (figure 1). Those points were used for positioning a tide gauge in Koper harbour and all aids to navigation (lighthouses, lights, buoys and landmarks) (figure 2). All lighthouses, lights, buoys and landmarks were documented and for each a photograph was taken. All light characteristics were checked and every aid to navigation was described. For some lighthouses and lights, usually the most important, a VHS videotape panorama was taken.

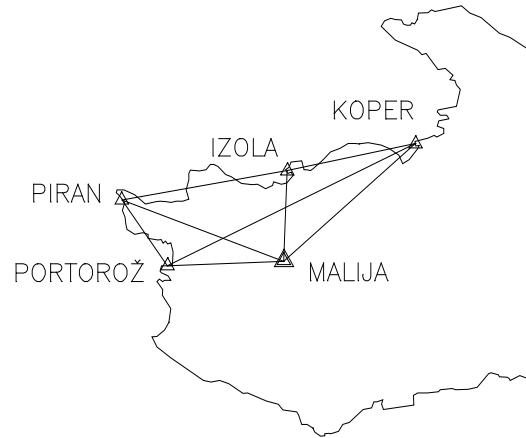


Figure 1: GPS reference network

Nowadays practically all navigation is done by GPS satellite navigation. This involves the use of modern navigational systems with electronic charts directly connected to GPS and positions plotted directly on the screen. The precision of such positioning is increasing every year. That leads the surveyors and hydrographers to conduct a survey of all reference points and aids to navigation to meet these requirements – a high precision survey with direct plotting of ship's position.



Figure 2: GPS positioning of aids to navigation

The hydrographic survey which followed was completed in about one month. In this time the Slovenian sea between the border with Italy and the town of Portorož was surveyed with various instruments (figure 3). The following parameters were surveyed:

- the depths by multibeam sonar (simultaneous acquisition of 32 depths),
- the depths by singlebeam sonar (close to coast),
- side scan sonar survey (checking for possible obstructions between survey lines),
- GPS survey for precise positioning of a vessel on WGS 84 ellipsoid,
- conductivity, temperature and density (CTD) measurements for precise determination of sound velocity,
- sea level monitoring with tide gauge, for establishing the chart datum,
- bottom sampling,
- sub-bottom profiling up to 30m below sea bottom,
- ship's heave, pitch, roll and draft monitoring for precise reduction of soundings,
- Secci disc survey of water transparency,
- still photography of all landmarks, approach channels and panoramas,
- monitoring of sea pollution,
- monitoring of traffic and other activities on the sea.

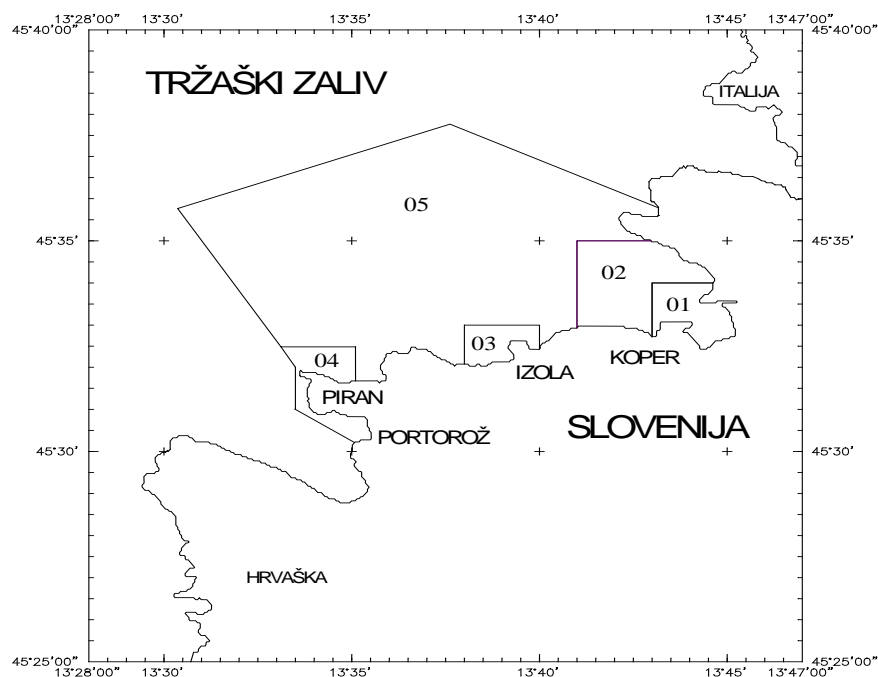


Figure 3: Hydrographic survey area

### POST PROCESSING

All measured parameters were automatically recorded in a hydrographic room on board or on the HSL. The reduction of soundings was done later, partly on board and partly in Navoceano head quarters. Thus IGF received more then 2500 files with digital hydrographic data in the period between October 1998 and March 1999. Depths were surveyed with line spacing from 10m in the port of Koper upto 100m at open sea.

The most important final result of hydrographic survey and post processing was the fair sheet – a

sheet of paper with a great number of soundings (figure 4). Navoceano presented five fair sheets, one at scale 1 : 25 000, two at scale 1 : 7500 and two at a scale 1 : 5000. Experts at IGF and the Ministry of Transport and Communications made the selection of soundings for a final chart, according to IHO standards (Karničnik, Radovan, 1998c). All relevant soundings were selected, taking into account the importance of the area, flatness of the bottom and possible dangers to navigation. This selection was a starting point for the cartographic production of the first nautical chart.

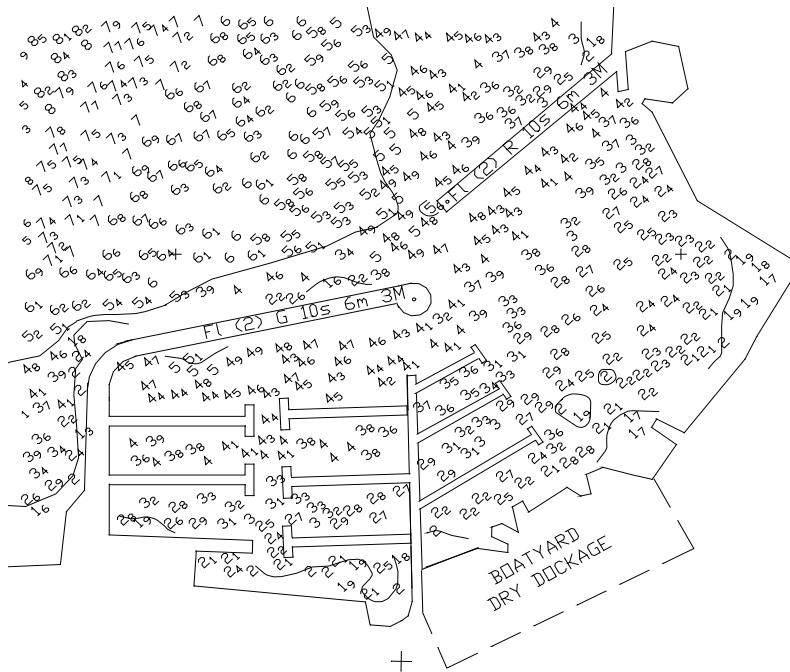


Figure 4: Detail from a fair sheet (Izola Marina)

### CARTOGRAPHIC PROCESSING

Nautical charts can be produced in national or international (INT) version. For verification on production of INT charts, IHO has to be contacted and asked for an INT chart number according to the international scheme of nautical charts. These have to be produced in English and in accordance with IHO standards. Each country decides upon its own national chart scheme and chart numbering in accordance with its needs and possibilities. These can be in accordance with nationally recognized cartographic symbols and language. However, the current trend is for all national symbols to be the

same as international ones. This is the reason that practically all nautical charts look alike.

In May 1999 IGF completed the production of national chart of the Gulf of Koper. It is produced in accordance with IHO standards. The only difference is that it is in the Slovenian language (Karničnik et al., 1999). The paper format of the chart is A0 and covers the area of the Gulf of Koper between Strunjan and Lazaret at a scale 1 : 12 000 (figure 5). It was produced with the help of modern cartographic technology and it is one of the first charts in the Mediterranean produced completely digitally on WGS 84 ellipsoid.



Figure 5: Areas covered by charts Gulf of Koper and Gulf of Piran

The land section is charted in yellow and its appearance differs from usual topographic maps, because for nautical charts the important elements of the land section are landmarks, aids to navigation and type of coast (figure 6). The land section of the Gulf of Koper chart was extracted from vector and raster topographical maps at a scale 1 : 5000 and from colour aerial photographs. All topographical elements were transformed from state coordinate system in Gauss-Krüger projection on Bessel ellipsoid to Mercator projection on WGS 84 ellipsoid. For navigation reasons the Mercator projection is used. Ellipsoid WGS 84 is applied due to the increasing usage of modern navigation equipment – GPS, which is used daily on practically all vessels. There is also a tendency for unique reference ellipsoid all over the world. Furthermore, the IHO's exchange standards S-57 for digital hydrographic data transfer and S-52 for electronic navigational

chart (ENC) production establish WGS 84 as the only legitimate reference ellipsoid.

The maritime section of the chart was transformed from geographic coordinates on WGS 84 ellipsoid to Mercator projection and was joined and matched with the land section. The reference surface for all heights is mean sea level (MSL) while the reference surface for depths is mean lower low water (MLLW). Areas shallower than 10m are charted in blue tint, deeper waters are white. Drying heights are charted in green. All lights and buoys have their light characteristics alongside the symbols. Special attention has been paid to restricted areas: harbour entrance channel, construction area in the harbour, Strunjan nature reserve, the Debeli Rtič natural monument, marine farms in Strunjan and Lazaret and the marina and shipyard at Izola. Also bottom type and wrecks are charted.



Figure 6: Nautical chart Gulf of Koper (Izola Marina section)

### QUALITY CONTROL

Quality control is very important in nautical cartography. Any error on the chart could cause great damage to vessels, environment and people. For this reason the whole chart production process was checked several times. This is also necessary to meet the requirements of IHO standards and high precision of data charted. The following quality controls were conducted:

- participation of cartographer in the hydrographic survey on board,
- crosscheck soundings lines according to IHO specifications,
- checking of tide gauge readings with predicted values,
- fair sheets were checked immediately after the completion of survey,
- selection of soundings was checked by several independent processes,
- cartographic procedures were sequentially checked directly at IGF,
- transformations of coordinates were checked with comparison to other maps and charts,

- light characteristics were checked by Slovenian Port Authority,
- several test prints of the chart were made before the final print,
- printing was supervised by cartographic experts,
- several points on the field were checked with precise (P-coded) GPS receiver in cooperation with Navoceano.

### CONCLUSION

The Gulf of Koper chart was presented at the Mediterranean and Black Seas Hydrographic Commission (MBSHC) in Split, Croatia. This first Slovenian chart is a great step forward for the safety of navigation in the Slovenian part of Adriatic, but there is still a lot of work to do in this field. Already planned are production of the INT version of Gulf of Koper chart, both versions of the Gulf of Piran chart (figure 5) and the Gulf of Trieste chart in cooperation with the Italian and Croatian hydrographic offices. A complete survey of Gulf of Piran is planned for a future date. All data will be processed for electronic navigation chart (ENC) and included in the European

distribution network (Radovan, 1994-98). The Ministry of Transport and Communications is very active in gaining full membership of the IHO and in forming the maritime law. This is all aimed towards full competence of Slovenia in the international maritime society.

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\* Marked projects are in Slovenian language