

Multidisciplinary  
SCIENTIFIC JOURNAL OF  
MARITIME RESEARCH



University of Rijeka  
Faculty of Maritime  
Studies Rijeka

Multidisciplinarni  
znanstveni časopis  
POMORSTVO

# Proposed improvements in depth contours and sector lights display on nautical charts

Dejan Lovrinčević<sup>1</sup>, Pejo Bročić<sup>2</sup>

<sup>1</sup> Hydrographic Institute of the Republic of Croatia, Zrinsko-Frankopanska 161, 21000 Split, Croatia

<sup>2</sup> Hydrographic Institute of the Republic of Croatia, Zrinsko-Frankopanska 161, 21000 Split, Croatia

## ABSTRACT

The proposal of a new display of depth contours and sector lights symbols on paper navigational charts published by the **Hydrographic Institute of the Republic of Croatia** (HHI) in Split is presented in this paper. Since the symbols on the HHI paper charts are defined in the publication entitled "Symbols and Abbreviations Used on Charts", which is produced by each Member State for its charts by the recommendations of the International Hydrographic Organization (IHO), the proposed displays are in accordance with the specified publication. By studying all versions of the mentioned publication, the historical development of depth contours and sector lights display is presented. By comparing clips from the official paper charts scale of 1:100 000 with a classic display of these symbols and clips from the created samples of paper charts with the proposed display of these symbols, the impact on the readability of other symbols is analyzed and improvements of depth contours and sector lights display are shown.

## ARTICLE INFO

Review article  
Received 2 April 2014  
Accepted 23 April 2014

**Key words:**  
Marine navigation  
Nautical charts  
Navigational symbols display

## 1. Introduction

The basic function of every chart is to serve as a medium for storing spatial information and the most faithful representation of the geographic reality of the area. Except for the faithful representation, a chart must be clear and easily readable and usable. The maritime navigation chart is a cartographic representation of the actual navigation area and is used in maritime navigation. It depicts the depths of the sea, seabed forms and their morphological characteristics, configuration and characteristics of the coastline, dangerous shoals, reefs and rocks, all hazards and warnings for navigation and data on marine lights and other markings for navigation [9]. The main peculiarity of these charts comes from the fact that their main purpose, as a navigational tool, is to ensure that the content related to navigation is of the highest quality. Marine areas are displayed in detail, especially along the coast. The primary task of all displayed objects on a marine chart is the safety of navigation. The main characteristics that define the quality of the chart as a navigational aid are the clarity and readability of the content, particularly of the important navigation symbols. As there are sometimes a lot of symbols in a small navigation area, to achieve a satisfactory clarity of symbols represents a real challenge for marine cartographers.

## 2. Nautical Charts

A nautical chart is a chart specifically designed to meet the requirements of marine navigation, showing the depths of water, nature of the sea bottom, elevations, configuration and characteristics of the coast, dangers and aids to navigation. A nautical chart may be a paper chart, an electronic navigational chart (ENC) or a raster navigational chart (RNC). It can also be called a marine chart, a hydrographic chart, or, simply, a chart [10]:

- RNC – facsimile of official paper charts,
- ENC – a subset of the electronic chart data base held on the vessel. The data base is standardized as to the content, structure and format. The ENC contains all the chart information necessary for safe navigation and may contain supplementary information in addition to that contained in the paper chart (e.g. sailing directions) which may be considered necessary for safe navigation [10]
- Paper Chart – chart printed on a special cartographic paper that is resistant to moisture, folding and other external influences.

The display of symbols on paper charts depends on the method of multiplying or printing the charts. It can be done in two ways: offset printing or plotter printing.

A very important difference between these two methods of chart multiplication for the symbol display on charts is the ability to use colour in different ways. Paper charts in the HHI are printed in five colours: black, yellow, blue, sepia and purple. For the reproduction in offset printing (still the majority of 87 paper charts in HHI), it is necessary to prepare each colour by mixing, and create and control each colour individually, so pre-made colour palettes are used [3]. Paper charts created in this way are often called standard nautical charts. With printing on plotter, there is a possibility of combining colours (making pallets) that are encoded in percentages of the CMYK colour system (Cyan/Magenta/Yellow/Black (Key)) on a computer in the processing software and so a larger number of colour combinations are available. Charts created in this way are called multicolour nautical charts. Theoretically, three colours can be combined in the codes that produce all the other colours, but, in practice, the results are unsatisfactory and are improved by adding black (key). Some hydrographic offices post their combination codes on the IHO website [11].

The necessity for mutual alignment of cartographic symbols on charts especially refers to nautical charts. IHO develops and recommends its member states international symbols and abbreviations. For this purpose, the IHO has developed and maintained a publication, S-4 (Regulations for International (INT) Charts and Chart Specifications of the IHO, edition 4.4.0, September 2013)[11]. The S-4 publication provides detailed descriptions of all cartographic symbols on charts. The Supplemental Document of Part B of S-4 is called INT 1 – Symbols, Abbreviations and Terms Used on Charts (7<sup>th</sup> edition, 2011.) and represents an organizational format that IHO proposes to its member states to create a national publication. All hydrographic offices that are members of the IHO use INT 1 as a reference document for the development of national publications for defining symbols on their national charts [11]. The S-4 publication and INT 1 document can be found on the IHO website [12]. On charts published by the HHI, symbols are defined by the publication called Symbols and Abbreviations Used on Charts. Since its first edition in 1929 to its 6<sup>th</sup> edition in 2013, the publication has been issued by HHI according to the IHO recommendations in accordance with the S-4 publication and INT 1 document. The symbols are divided into 4 groups: general (number of charts, magnetic compass, etc.), topographical (buildings, ports, etc.), hydrographic (depth, depth contours, rocks, reefs, etc.), navigational aids and services (lights, buoys, etc.)[4]. A certain number of symbols, depending on if they are either on standard or multicolour charts, can be displayed in two different ways.

### 3. Depth contours

A depth contour is a line connecting points of equal water depth which is sometimes significantly displaced outside of soundings, symbols, and other chart detail for

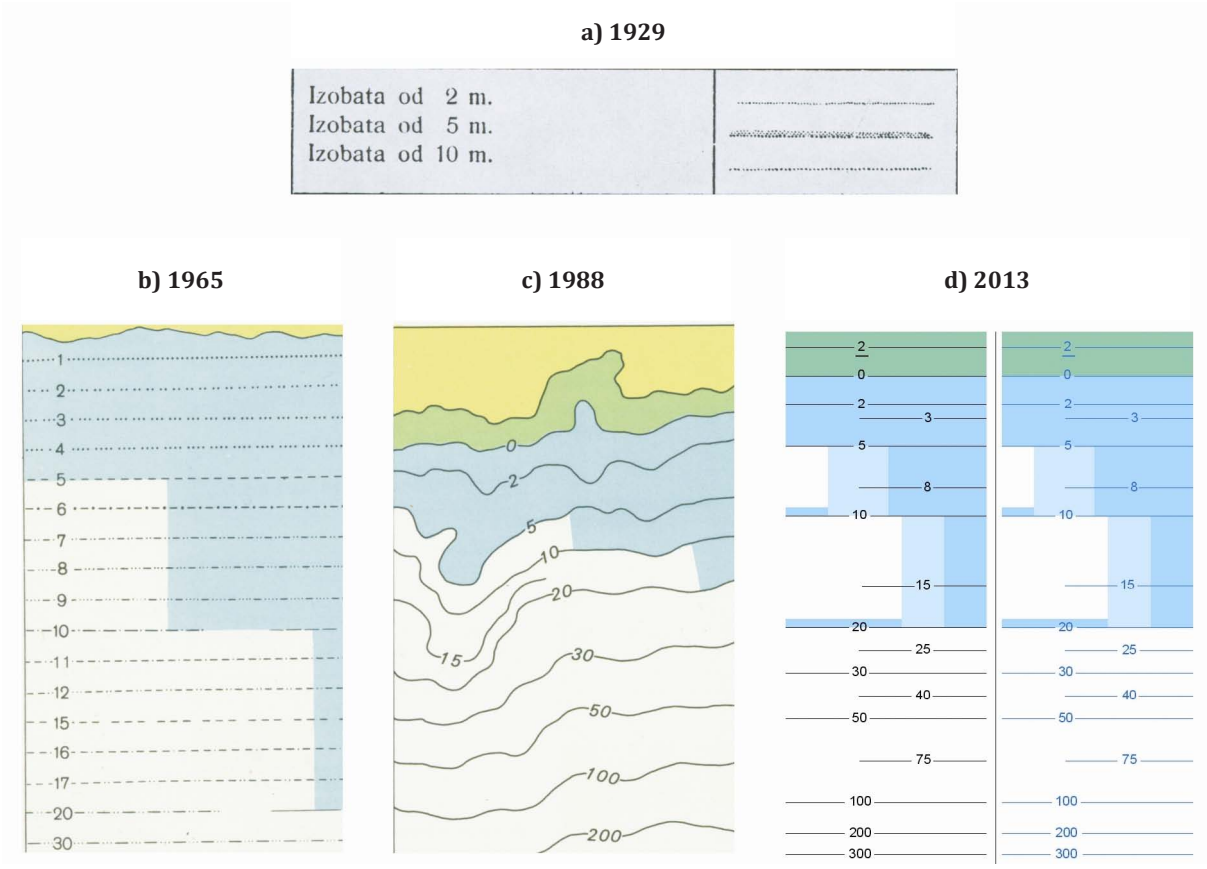
clarity as well as generalization. Depth contours, therefore, often represent an approximate location of the line of equal depth as related to the surveyed line delineated on the source [10]. All depth contours and depths on the chart are not equally important. Depths and depth contours can be classified into three general categories: critical, substantial (significant) and typical. Critical depth contours define the configuration of the bottom of shallow water or wrecks, in the navigable channel, at the harbour gateway, along the coast and in the sailing route (fairway) that is recommended. Significant depth contours show unexpected changes in the relief of the seabed. Typical depth contours and depths display unintended relief and normal slope of the seabed. Because of navigation security, the seabed display by depth contours is denser along the coast, and rarer towards the high seas [1]. For the seabed display on charts, colours are also used. Light blue shows a narrower band, from the coastline to the so-called warning depth contour. The numerical value of the warning depth contour is related to the draft of the ship so that it has changed throughout history.

#### 3.1. Development of the depth contour symbol display

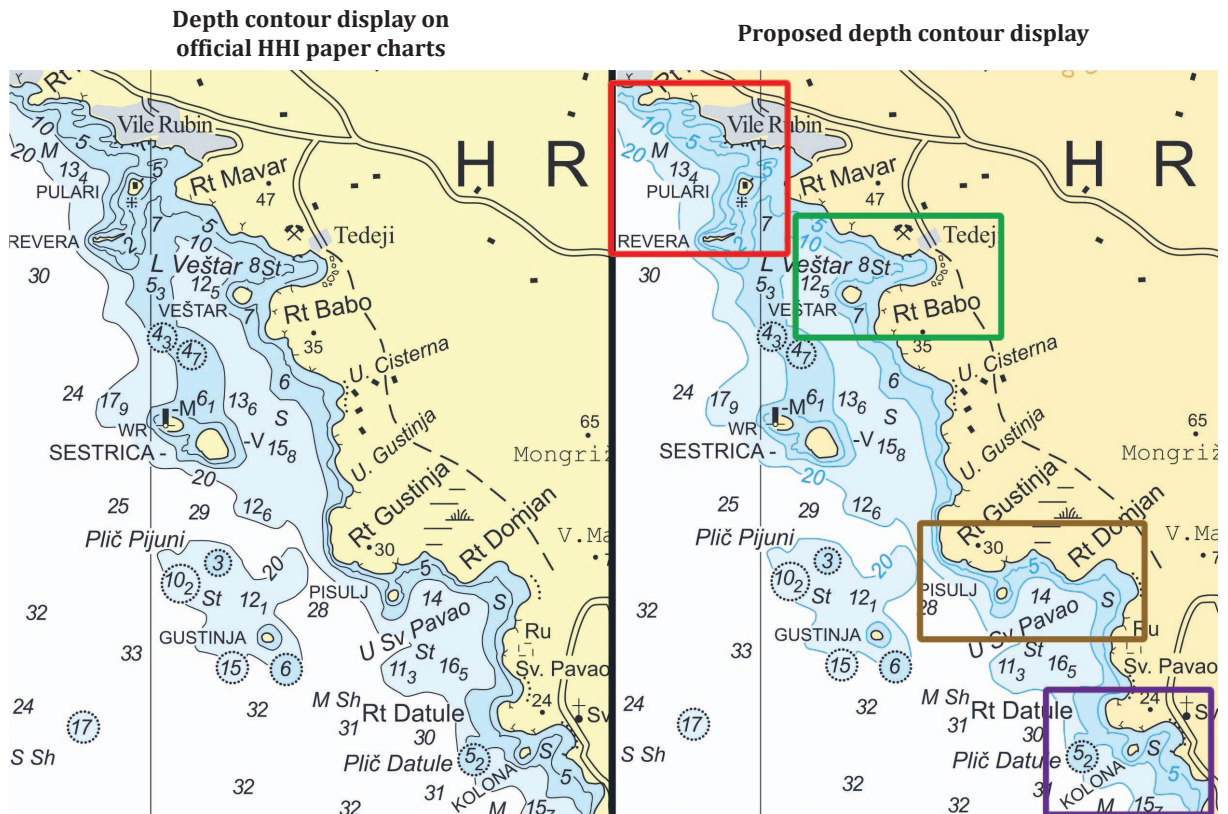
The symbol for displaying depth contours on HHI charts has changed through history and can be analysed in the editions of Symbols and Abbreviations. In the 1<sup>st</sup> edition in 1929, only the depth contours for the 2,5 and 10 m were defined. Depth contours are shown in dotted lines of varying thickness without numerical values (e.g. a, Figure 1). In the 1965 edition, more depth contours were defined, by increasing the number of depth contours their density also increased. Depth contours were shown by dashed and dotted lines, depending on the value (e.g. b, Figure 1). Next display change came in the 4<sup>th</sup> release in 1988 where depth contours were shown by continuous black lines with certain numerical values, as is used up to date, with diluted depth scale (0, 2, 5, 10, 20, 30, 50, 100, 200, etc.) (e.g. c, Figure 1). In the latest edition in 2013, as an alternative display continuous blue lines with numerical values were added (e.g. d, Figure 1).

#### 3.2. Proposed depth contour display

Is there a need to change the already entrenched depth contour display? The symbols on charts need to be easily and quickly visible. When in 1988 the depth contour display changed, the result was an advanced display which has elevated the quality of nautical charts as navigational aids. By comparing the depth contour display used today on the HHI paper charts in some selected areas and the newly proposed depth contour display in the same areas (e.g. d, Figure 1), the improvement that the new display brings in presenting other navigational symbols while fully retaining its basic function of defining the configuration of the seabed will be shown. An official paper HHI chart from the 100 series (scale 100 000) has been used in the



**Fig. 1** Historical Development of the Depth Contour Symbol in the HHI Symbols and Abbreviations Publication [4], [7], [6], [8]



**Fig. 2** Comparative Review of the Depth Contour Display, Analysed Area – Southern Part (South of the Rovinj Harbour) of the HHI Paper Chart 100-15 (Grado-Rovinj)[5]

analysis, 100-15 (Grado – Rovinj). A new version in which the depth contours are shown in the newly proposed display (blue colour) has been created.

In Figure 2, we can see a selected area on the chart with a large number of depth contours where objects on the right clip surrounded with blue depth contours are more highlighted. There are some examples that are visible on this small part of the chart:

1. islets Pulari, Revera – red box, Kolona – violet box, Pisulj – brown box,
2. depth values near depth contours (values 7 and 13.4 – red box, values 7 and 8 – green box),
3. nature of the seabed symbols between depth contours (S – violet box, M – red box, S – brown box)

In the next example (Figure 3), we can also notice many objects with enhanced visibility resulting in improved navigation features of the chart. The impact of blue depth contours has become obvious in this selected area where, because of the content density, many important navigational symbols overlap with depth contours. Some selected objects with upgraded readability in this area are:

1. text near depth contours (Fržital, Plič Janjci and V Školj – orange box, Tuf and Lakal – green box),
2. depth values near depth contours (values 1 and 16.7 – red box, value 13 – orange box, value 13.9 – violet box),
3. obstructions (value 3.8 – orange box, value 4.2 – violet box, value 6.4 – green box),
4. lights, buoys and beacons (beacon at Plič Janjci – orange box, buoy at Plič Velika and light at Plič Mramori – brown box, buoy at Plič Lim – violet box),
5. symbol for sector limits of a light above Grgetov rt displayed in a straight dashed black line (4 lines) – orange box.

#### 4. Sector lights

Sector lights belong to the navigational aids and services group of symbols. Aids to navigation are a visual, acoustical, or radio device, external to a ship, designed to assist in determining a safe course or a vessel's position, or to warn of dangers and/or obstructions. Aids to navigation

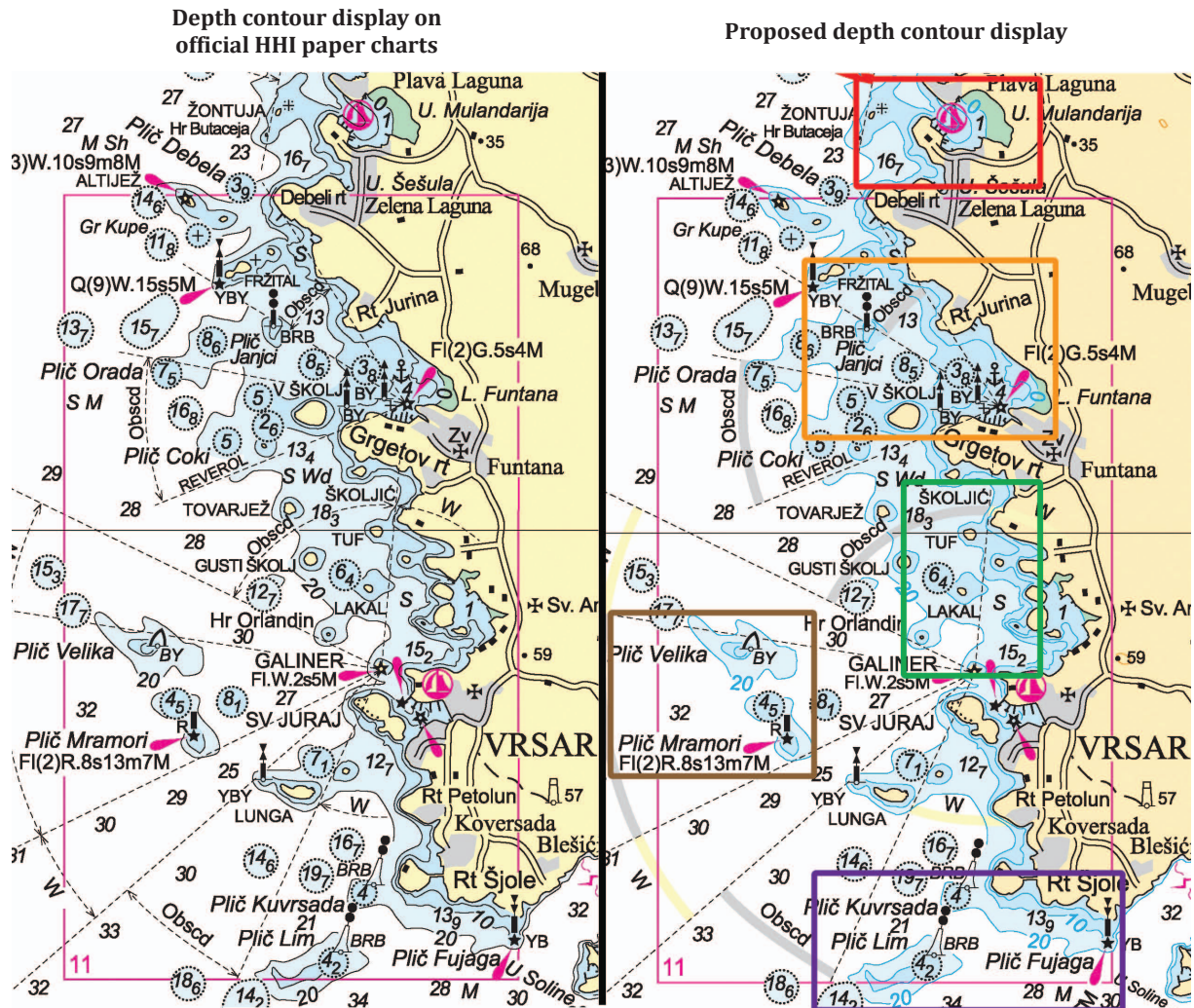


Fig. 3 Comparative Review of the Depth Contour Display, Analysed Area – the Vrsar Harbour and the Northern Part on the HHI Paper Chart 100-15 (Grado-Rovinj)[5]

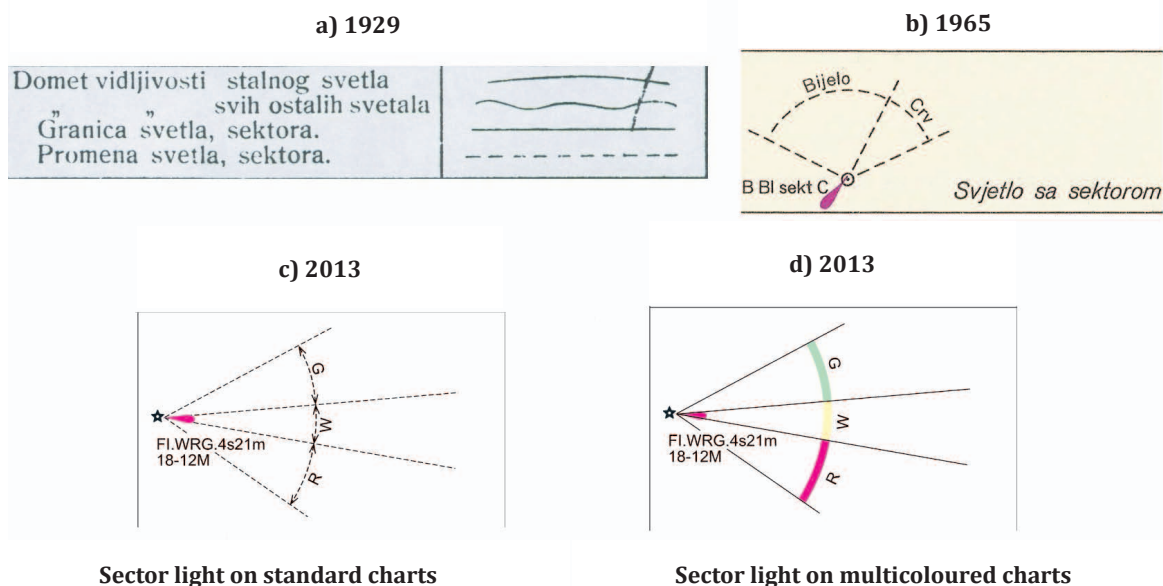


Fig. 4 Historical Development of a Sector Light Symbol in the HHI Symbols and Abbreviations Publication [4], [6], [8]

usually include buoys, beacons, fog signals, lights, radio beacons, leading marks, radio position fixing systems and GNSS which are chart-related and assist safe navigation [10].

An all-round (or Omni-directional) light is one that presents the same character over the whole horizon of interest to marine navigation. If a light is not visible on some bearings, or changes its character as the bearing changes, this must be shown, usually by inserting sector limits and arcs on at least the largest scale charts. Sector limit is used to denote the line or bearing of a light where the character changes or the light is obscured. Sector arc is used to denote the curved line against which the character of the light in that sector is inserted. There are many different types of light visible on certain bearings only or different types of sector lights: where a light is deliberately restricted from a sector, where a light is intensified in a sector, all-round lights partially obscured by obstructions etc. [11].

#### 4.1. Development of the sector light display

In the 1<sup>st</sup> Symbols and Abbreviations edition in 1929, sector lights did not have a symbol defined, but a separate symbol for a sector limit was defined (continuous line) and a symbol for a border between different sectors (dashed line) (e.g. a, Figure 4). In the 1965 edition, a symbol for a light with a sector was defined where all the sector boundaries were shown as dashed lines. At the arcs, there is a textual description of the colour of each sector that may be in the form of abbreviation (e.g. b, Figure 4). The same symbol has remained until today, only in the fifth edition (2002), a second display option for multi-coloured charts was added, on which the sector arc was shown by 1 mm thick coloured dash instead of a continuous line (e.g. d, Figure 4).

#### 4.2. Proposed sector light display

Sector light display with a coloured sector arc is used in electronic versions of charts (ENC) and paper charts in some countries (e.g. UK). Sector lights, unlike depth contours which maintained their visibility but increased the visibility of objects in their vicinity by changing colour, are adding colour to the sector arc to increase its visibility. Given that they are among the most important navigational symbols, sector lights must be quickly visible on navigational charts and, in situations of dense content, easily readable. By comparing the sector light display used today in some selected areas and the newly proposed sector light display (e.g. d, Figure 4) in the same areas, we will show that the newly proposed display has achieved the desired effects. Two official HHI paper charts scale of 1:100 000, 100-15 (Grado – Rovinj) and 100-19 (Silba – Pag) have been used in the analysis.

In figure 5, we can see a selected navigational area with four sectors lights. Although the sector of the light at the top part of the clip (at Rt Zali) has a satisfactory visibility in the left clip, the sector light on the right (in U Prizna) does not. Limits of the sector in this light are obscured by dense content (mostly textual) (blue arrow) and are more visible, represented by the thicker red line on the right clip. At the bottom of the area, there is a situation where sectors from two different lights are overlapping (U Žigljen). In this case, in the left example, it is much harder to spot the exact area of overlap (brown arrow), while, in the right clip, red line plainly clarifies the overlap area. The sector limit is also hard to notice when crossing the land, in the example the line is crossing the road symbol (orange arrow).

In the next example (figure 6), we have selected a large area with 3 sector lights. While sector limits are vis-

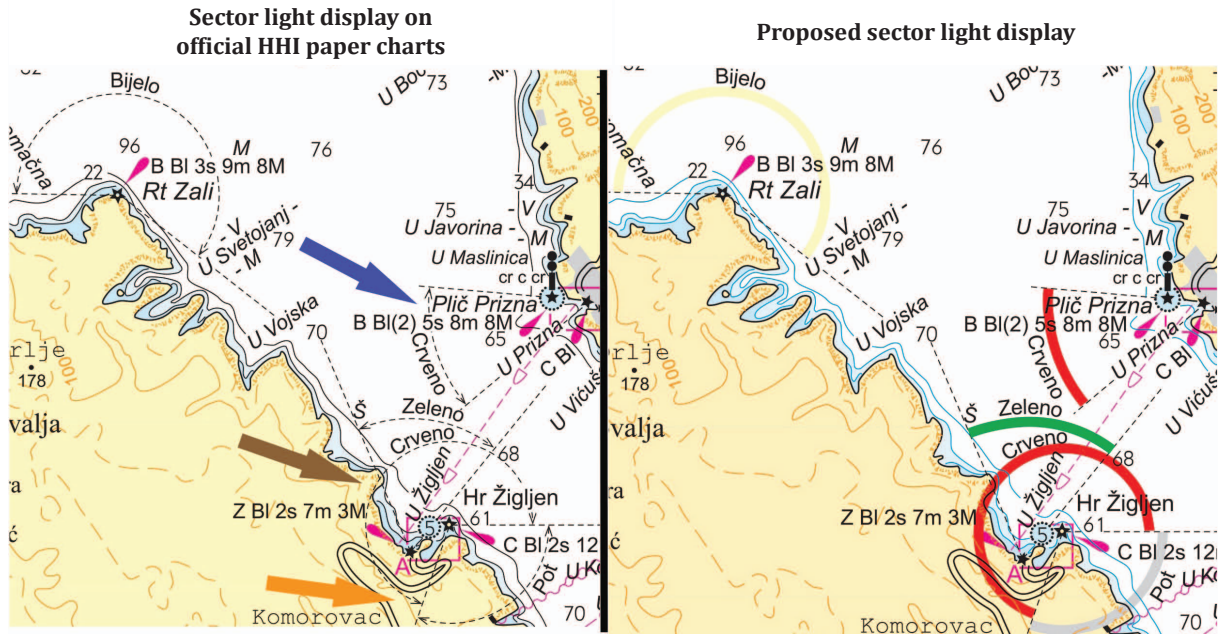


Fig. 5 Comparative Review of the Sector Light Display, Analysed Area – North-eastern Part (between the Paški Channel and the Velebitski Channel) of the HHI Paper Chart 100-19 (Silba - Pag)[2]

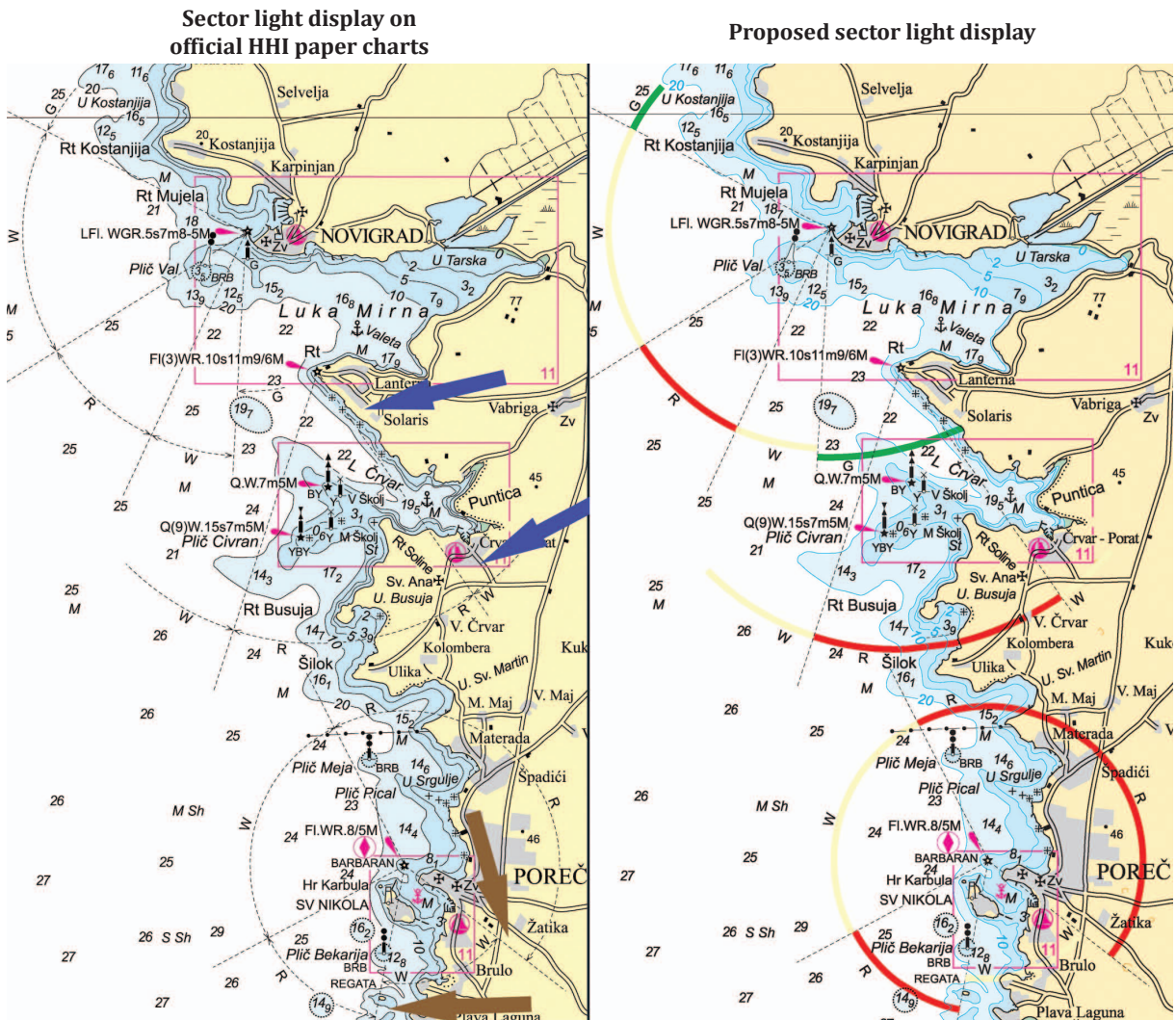


Fig. 6 Comparative Review of the Sector Light Display, Analysed Area – Central Part (between the harbours of Poreč and Novigrad) of the HHI Paper Chart 100-15 (Grado-Rovinj)[5]

ible on both clips in the deeper part of the sea (shown in white) inside the warning depth contour (blue colour) and on land some limits are harder to spot on the left example with standard presentation of the sectors. Sector limits of the middle light (Rt) are crossing over depth contours and (especially the limit on the right that crosses over the land – blue arrows) are noticeable much more quickly when the colours are used because the thin black dashed line gets lost crossing other black symbols (or grey like urban areas). The third sector light in the selected area (Poreč), much like the second one, has sectors crossing over the land and dens area of other symbols and objects, so again (especially two southern limits showing the end of red sectors – brown arrows) has gained quality visual attributes that enable them to be a better navigational aid and indicate to mariners all the needed information quickly and clearly.

## 5. Conclusion

This represented depth contour and sector lights display using colours visually fragments the chart, increases the readability of its content and generally improves the display quality of nautical charts as one of the primary means of navigation. In a comparative review of depth contours and sector lights display, a qualitative step forward in improving the presentation with the aim of reaching a better readability to facilitate safe navigation is visible. The **Hydrographic Institute of the Republic of Croatia** is currently in the process of analysing the possibilities and in pursuit of printing on plotter multicolour nautical charts. Currently, the majority of the charts are still multiplied by the offset printing and the ability to display symbols of sector lights presented in a way in this paper is difficult. This paper presents only some selected examples based on the analysis of only two charts. Although there is an obvious advantage of the new display of these symbols, before the change could be made on the official HHI charts, an additional analysis from the user's perspective (Nautical department) on a larger number of charts is required. It is obvious that when the plotter printing multiplication

system is standardized in the HHI, due to the obligation of issuing charts of the highest possible quality, multicolour nautical charts should seriously be considered.

## References

- [1] Bičanić, Z., Solarić, R., Kasum, J. (2003): Prikazivanje reljefa morskog dna na pomorskim navigacijskim kartama, Naše more, Vol. 50 Br. 1-2, Lipanj 2003., Sveučilište u Dubrovniku, str. 6-12.
- [2] HHI (2007): Obalna karta, 100 – 19 (Silba – Pag), mjerilo 1:100 000, Nova naklada, ožujak 2007., Hrvatski hidrografski institut, Split.
- [3] HHI (2013a): Katalog pomorskih karata i nautičkih publikacija, Hrvatski hidrografski institut, Split.
- [4] HHI (2013b): Znakovi i kratice na hrvatskim pomorskim kartama, šesto izdanje, ožujak 2013., Hrvatski hidrografski institut, Split.
- [5] HHI (2013c): Obalna karta, 100 – 15 (Grado – Rovinj), mjerilo 1:100 000, Novo izdanje srpanj 2013., Hrvatski hidrografski institut, Split.
- [6] HIJRM (1965): Znaci i skraćenice na pomorskim kartama, 2. izdanje, 1988., Hidrografski institut jugoslavenske ratne mornarice, Split.
- [7] HIJRM (1988): Znaci i skraćenice na jugoslavenskim pomorskim kartama, 4. izdanje, 1988., Hidrografski institut jugoslavenske ratne mornarice, Split.
- [8] HUKSHS (1929): Ključ za kratice i znakove na pomorskim kartama (samo za karte austrijskog izdanja), 1929, Hidrografski ured Mornarice Kraljevine Srba, Hrvata i Slovenaca, Dubrovnik.
- [9] IHO (1994): Special Publication No.32, Hydrographic dictionary, Fifth Edition, Part 1, Volume 1, International Hydrographic Bureau, Monaco.
- [10] IHO (2007): Special Publication No.32, Appendix 1, Hydrographic dictionary Glossary of ECDIS Related Terms, Volume 1, September 2007, International Hydrographic Bureau, Monaco.
- [11] IHO (2013): Special Publication No. 4, Regulations of the IHO for International (INT) charts and chart specifications of the IHO, Edition 4. 4. 0., September 2013, International Hydrographic Bureau, Monaco.
- [12] [http://www.iho.int/iho\\_pubs/IHO\\_Download.htm](http://www.iho.int/iho_pubs/IHO_Download.htm)