Workshop on the protection of groundwater as a source of drinking water in karst areas
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Improvement of water supply on inhabited Croatian islands

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Croatia and its islands

Main geographical features

- The climate is typically Mediterranean
- Soil zones are very rarely remarkable
- Cultivation of olives, grapes, cereals, vegetables, figs and almond is dominant
- The industry is characteristic only for bigger and densly inhabited islands
- Some parts of islands try to affirm the advantages of the preserved natural phenomena (eg National park Kornati, Mljet, Brijuni, Nature Park Telaščica)

Islands water resources

- Almost all islands are formed of carbonate
- In general there is **no superficial running water**
- Among **a few freshwater lakes** most significant is Vransko jezero on the island Cres
  - Some brackish lakes are present, too
- The permanent **springs** with higher capacity are located at a few bigger islands (often brackish)

The aim of this study

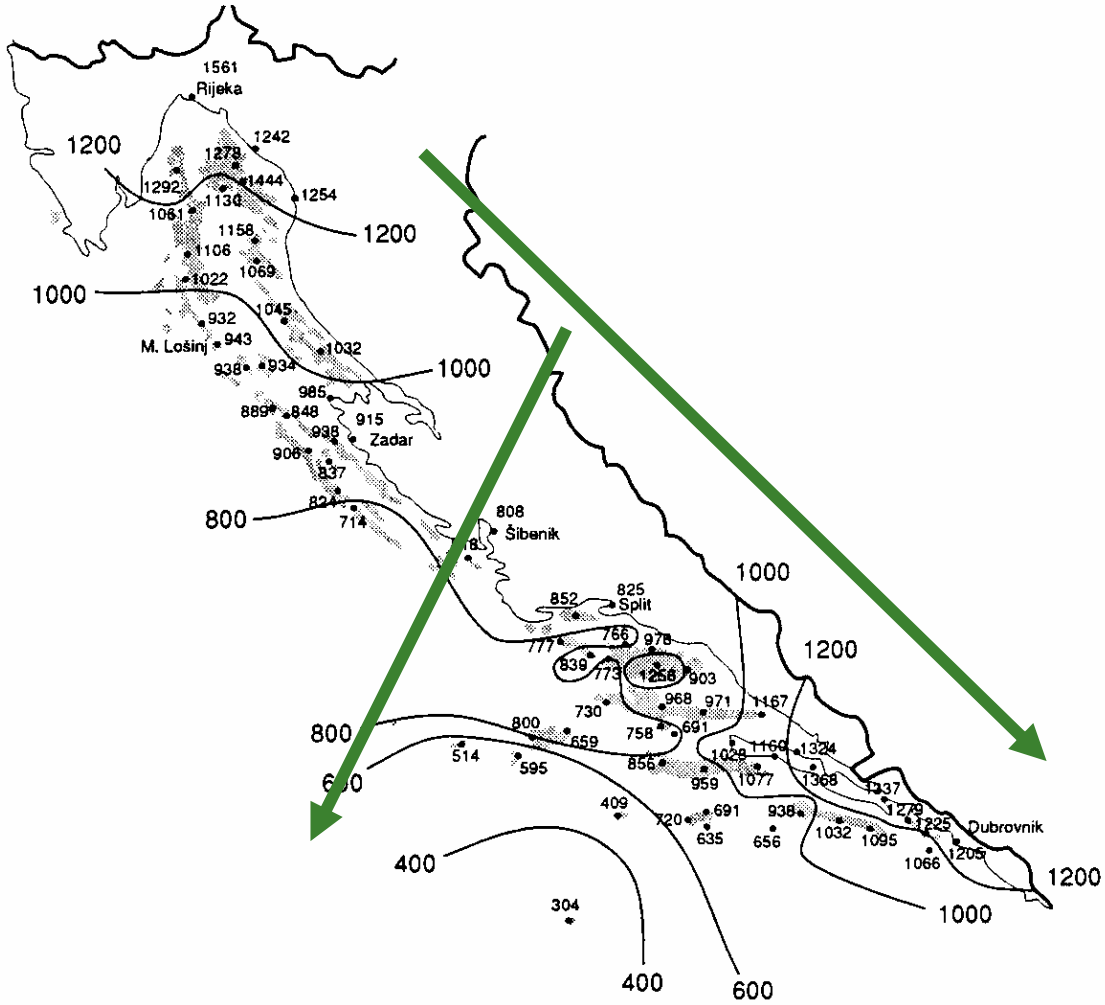
- Islands are of crucial importance for Croatia due to depopulation trend and their tourist attraction
- One of the most limiting factor in their development is undeveloped water supply system

- The aim of this study was to scan prevalent conditions and to propose optimal solution for water supply on each inhabited island

- Rounds of all inhabited islands were made between summer 1999 and summer 2000

Water level depends on precipitation

- mean annual precipation from 400 – 1200 mm
- decreasing from north to south
- from land to open sea



Slika 1. Srednje godišnje količine oborine 1961.-1990.

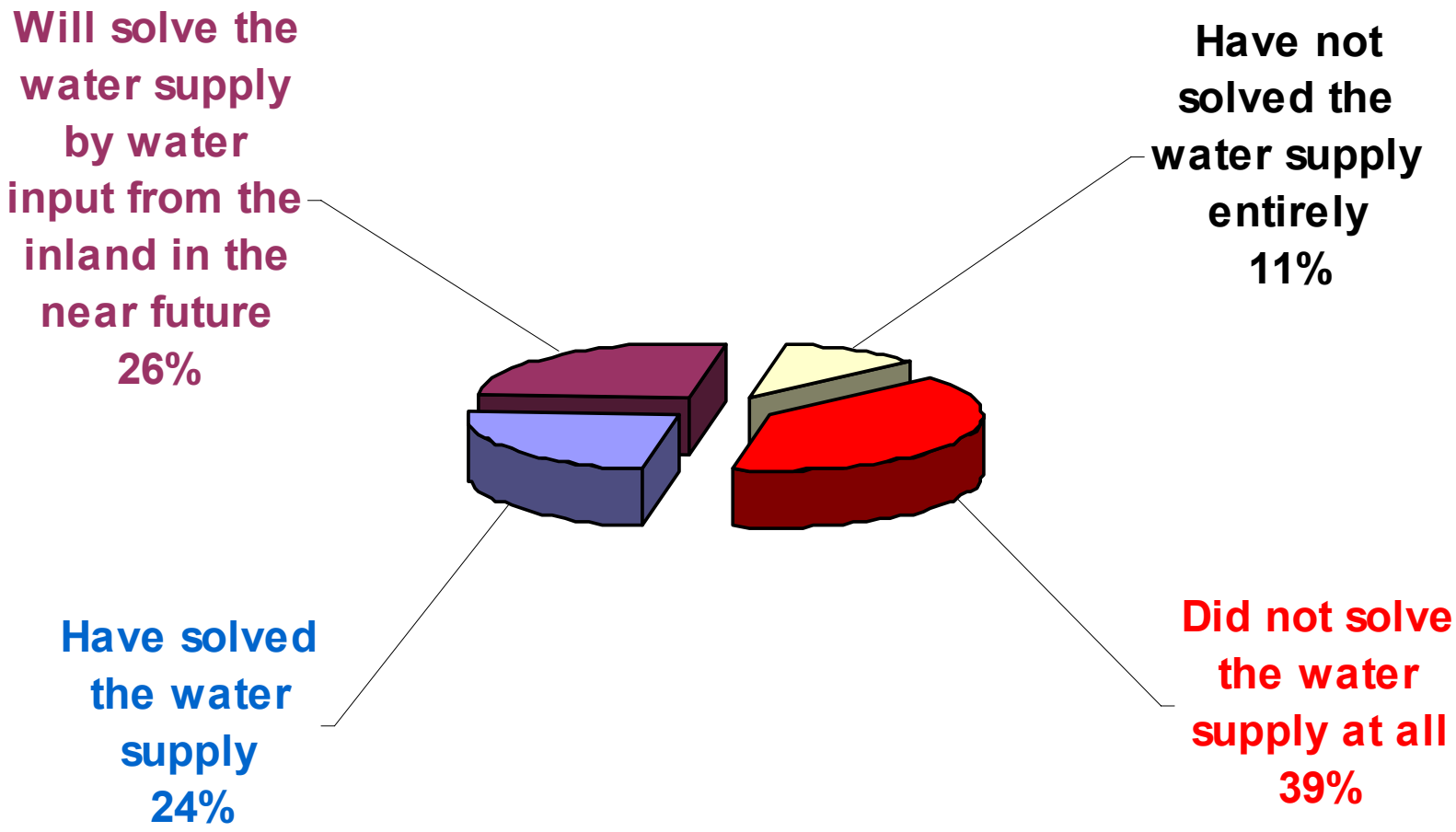
Present islands water supply

- Among all inhabited islands only 9 use their own resources
- Other islands have solved water supply in different ways:
  - through water input from the inland
  - by a water carrier
  - rainwater harvesting
  - from private boreholes and wells

Present islands water supply

- A brackish water desalination plant was put into operation:
  - on the island Lastovo in 1997
  - three plants on Mljet in 1999
  - one on Dugi otok in 2005

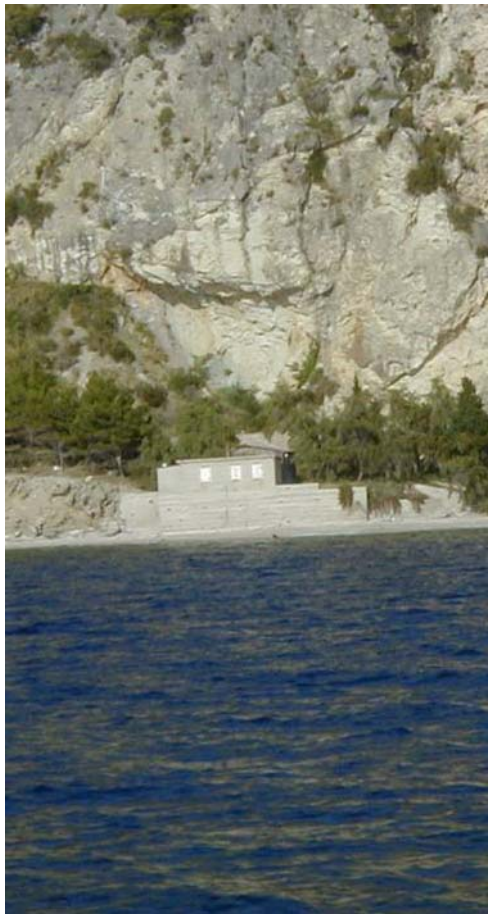
Present islands water supply



Water quality

- 119 water samples were taken by random from:
  - the existing groundwater well fields (14)
  - the wells and boreholes (66)
  - the springs (21)
  - the lakes (16)
  - the pits (2)
- The chemical analyses were performed (TDS, TOC and salinity are taken into account in this study)

Water quality



- On the islands which ***have not solved the water supply entirely*** and which ***did not solve the water supply at all*** water quality is often not satisfying
- 66 % samples have TDS higher than 1000 mg/L
- Even if TDS does not affect human health, it is not recommended in amounts higher than 1000 mg/L

Desalination plants

1. Permanent (>15 l/s)

sea- 576 m^3 brackish- 1323 m^3

2. PERMANENT FOR A SPECIFIED TIME (<15 l/s)

-brackish water – to 1300 m^3 or to 15 l/s

- sea – to 600 m^3 or to 6,6 l/s

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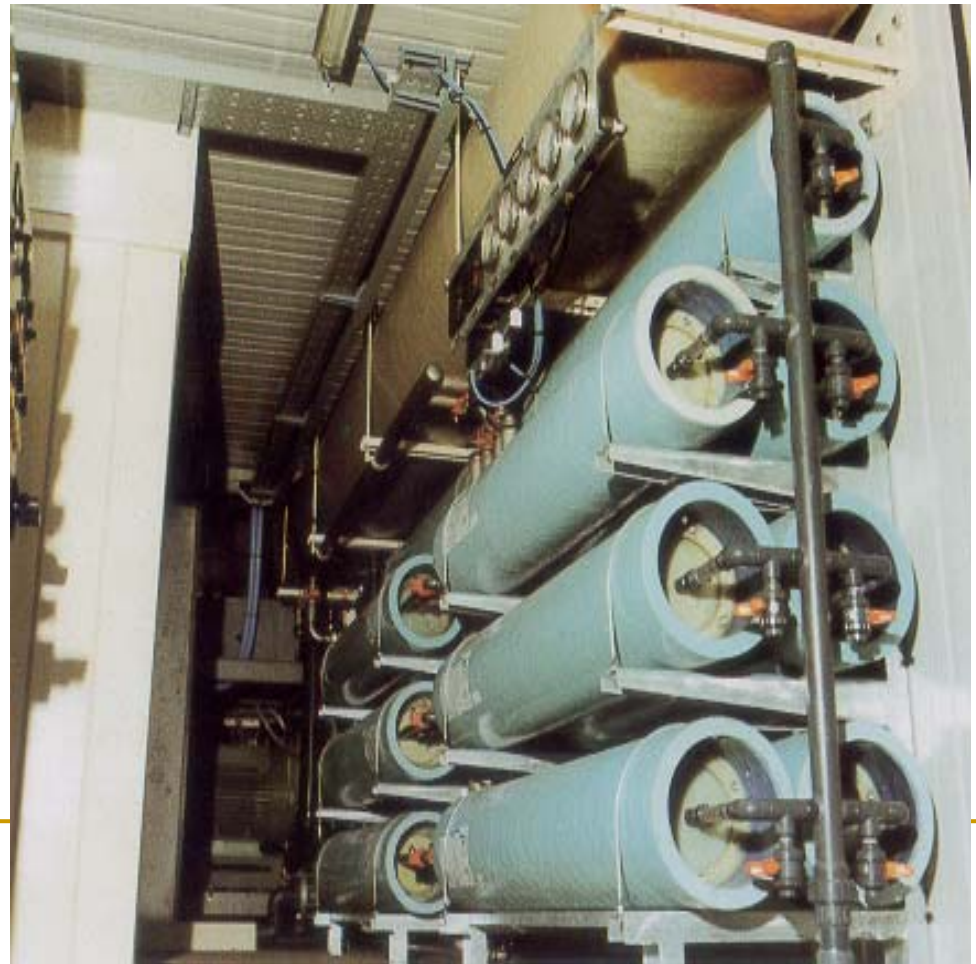
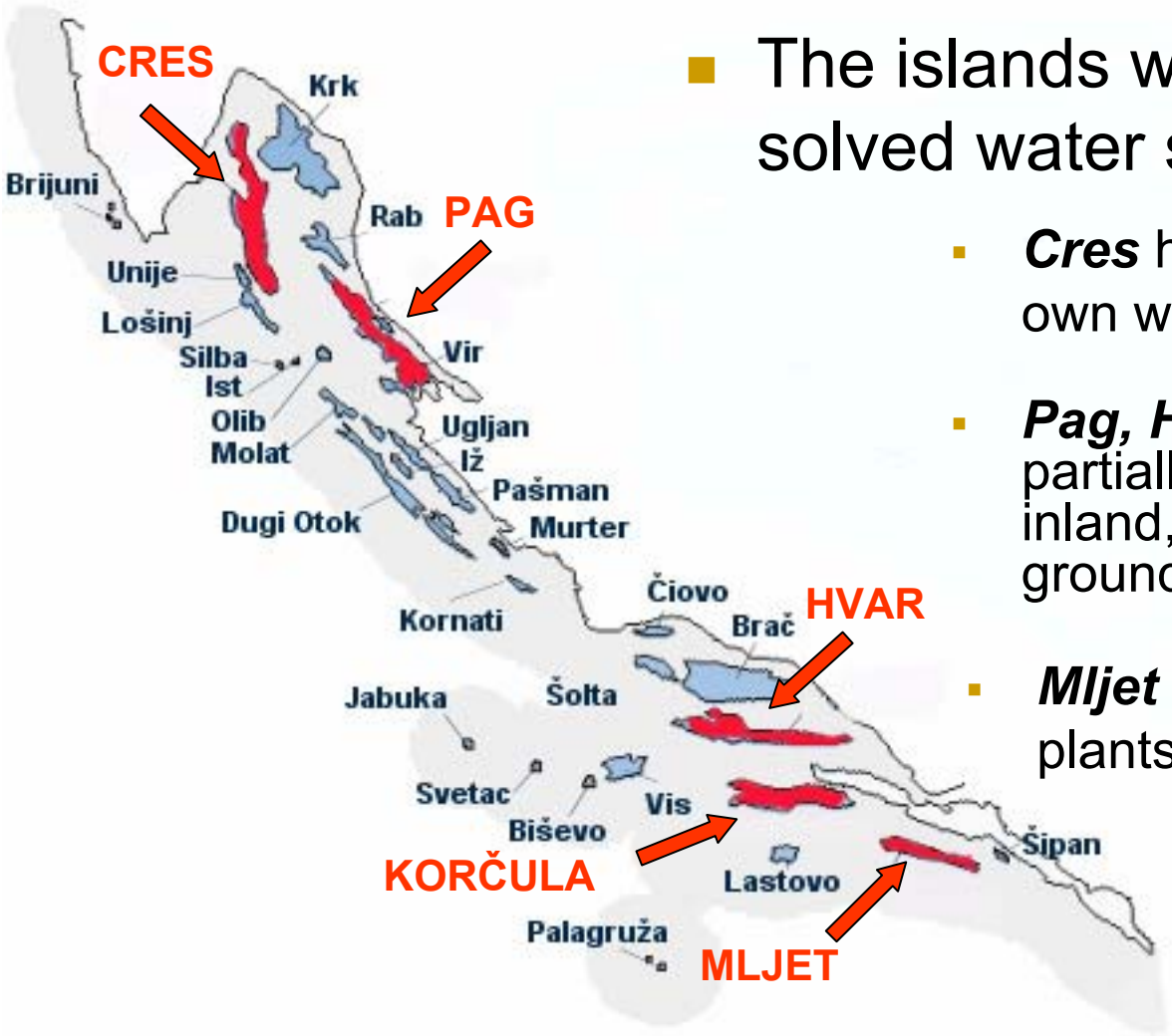


3. PERMANENT MOBILE PLANTS
(all remaining)

Suggestions for water supply improvement

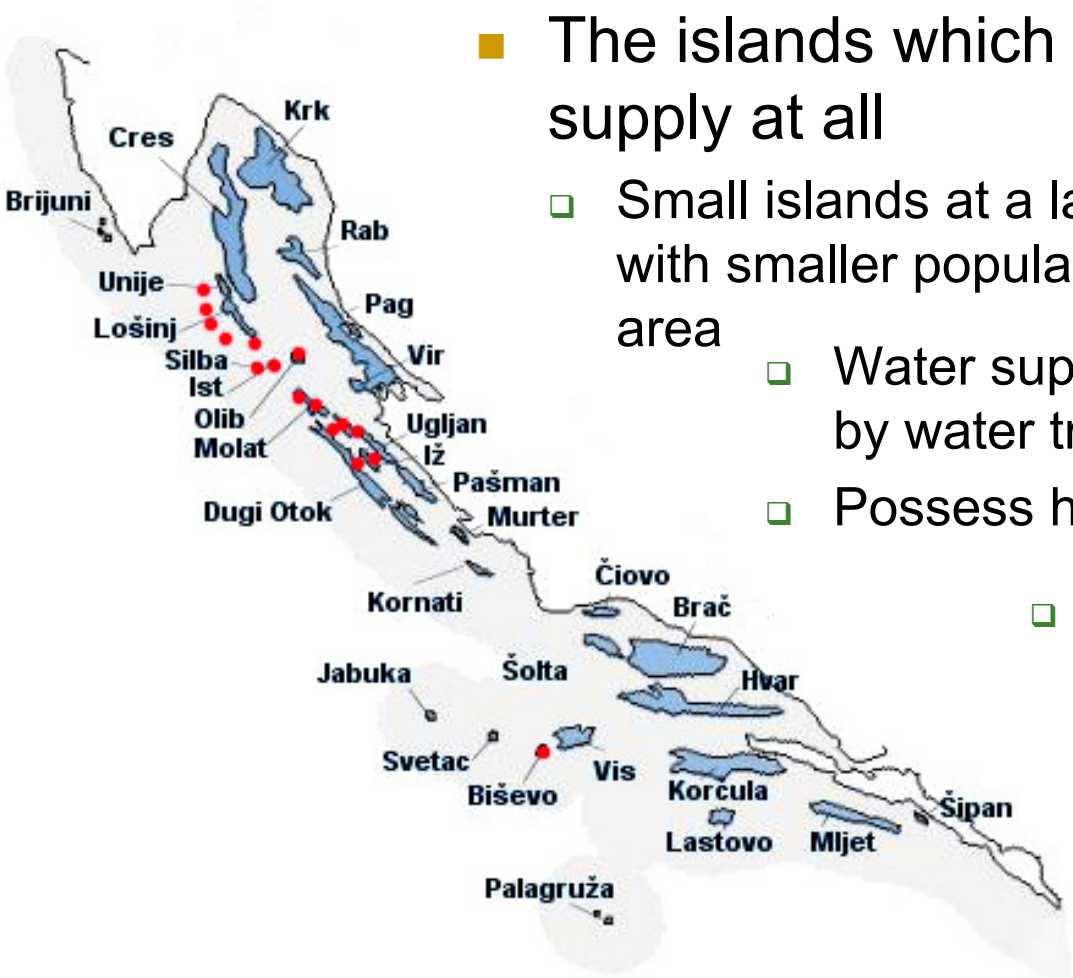


- The islands which have not solved water supply entirely
  - ***Cres*** has huge amounts of its own water (Vrana lake)
  - ***Pag, Hvar*** and ***Korčula*** are partially connected to the inland, there are the local groundwater well fields
  - ***Mljet*** has three desalination plants
- Still they have problem with water supply

Suggestions for water supply improvement

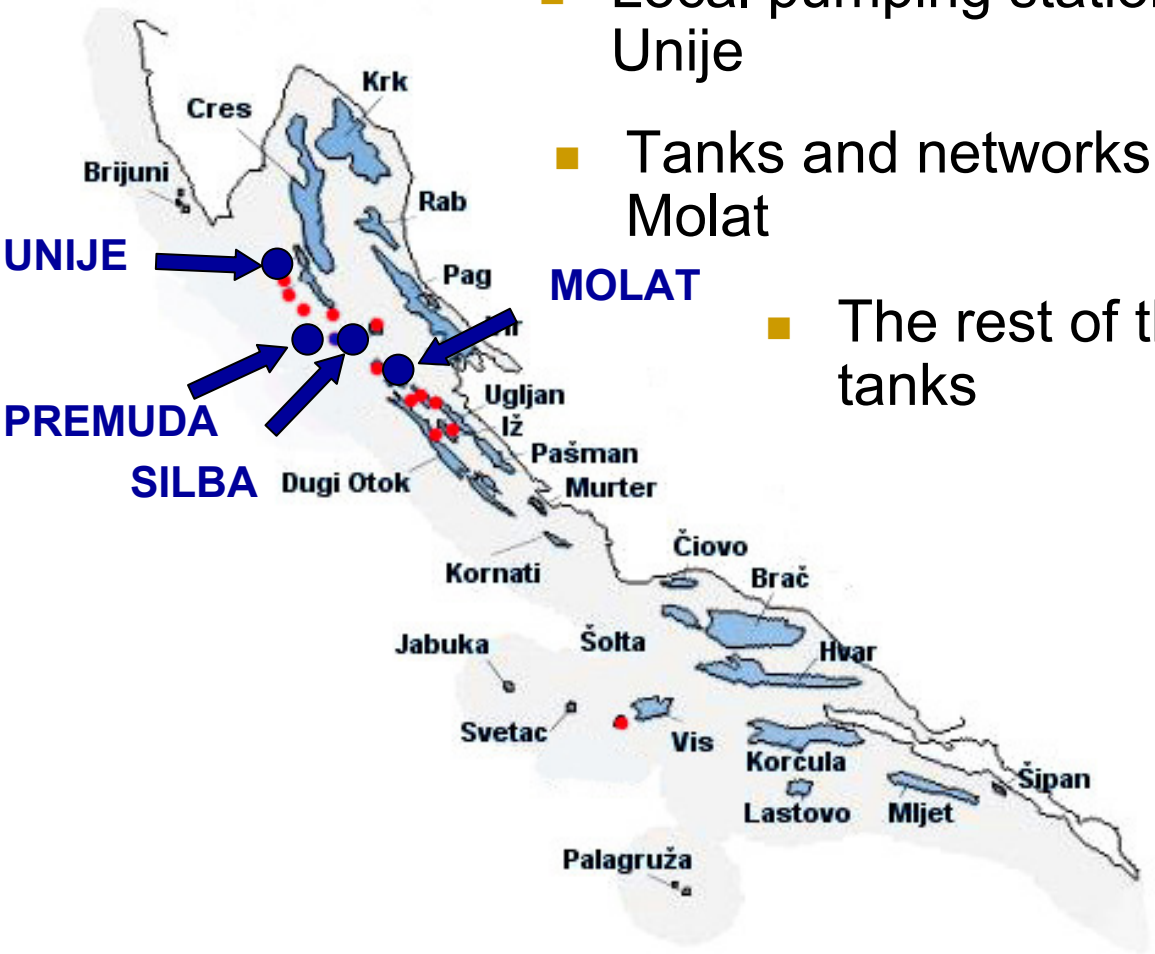
- The islands which have not solved water supply entirely
  - CRES
    - Although Cres has huge amounts of its own water it is not justified economically to install the water supply system onto each outlying and poorly inhabited community, **rain harvesting** and **supplying water in a tank** are better solutions
  - PAG, HVAR, KORČULA AND MLJET
    - Posses huge amounts of brackish waters
    - Could solve their problems by **installing desalination plants** on the existing groundwater well fields or boreholes

Suggestions for water supply improvement



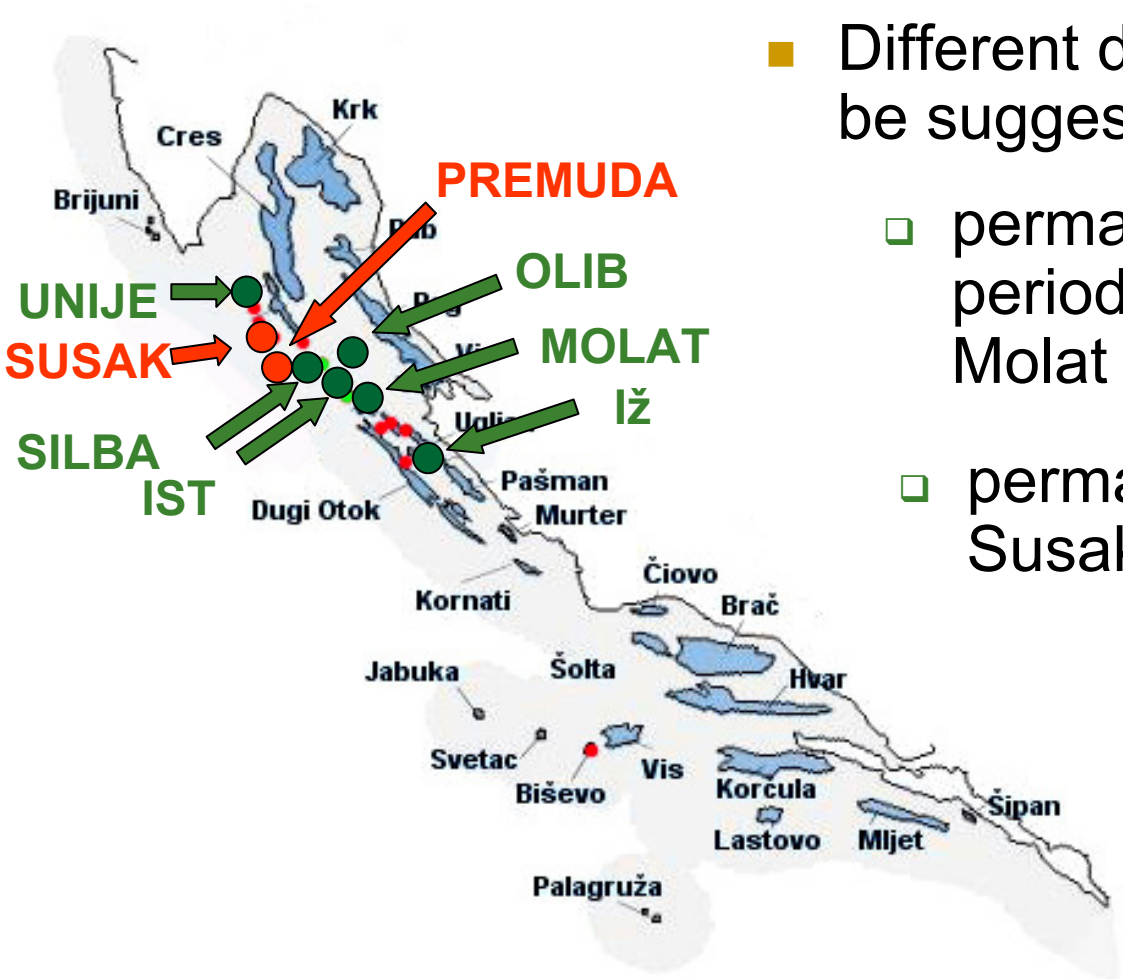
- The islands which have not solved water supply at all
  - Small islands at a large distance from the inland with smaller population concentrated in a small area
    - Water supply has been preformed mainly by water transport using water carriers
    - Possess huge brackish water quantities
      - It would not be economically justified to bring water from the inland

Suggestions for water supply improvement



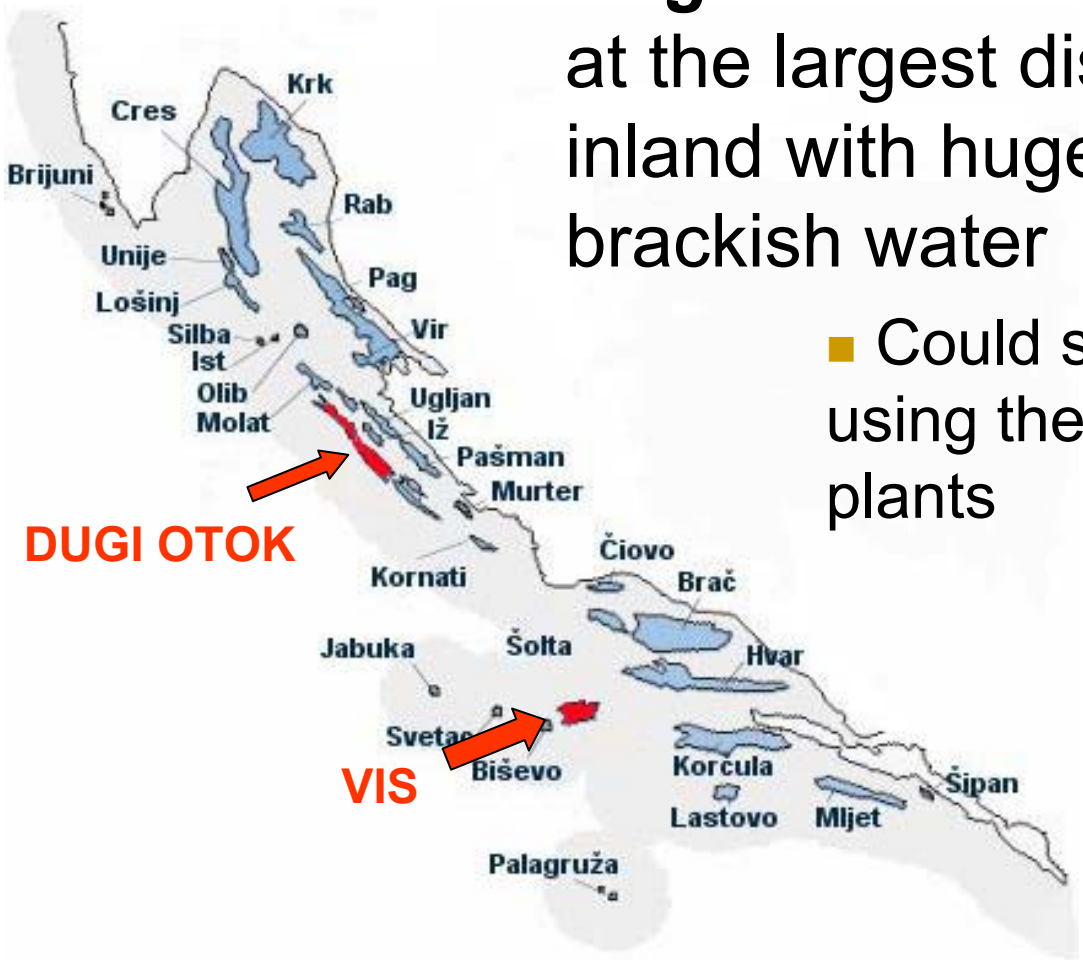
- Local pumping station, tank and a network on Unije
- Tanks and networks on Silba, Premuda and Molat
- The rest of the small islands have tanks
- The optimum would be to install a desalination plant and to deposit that water in the already existing reservoirs

Suggestions for water supply improvement



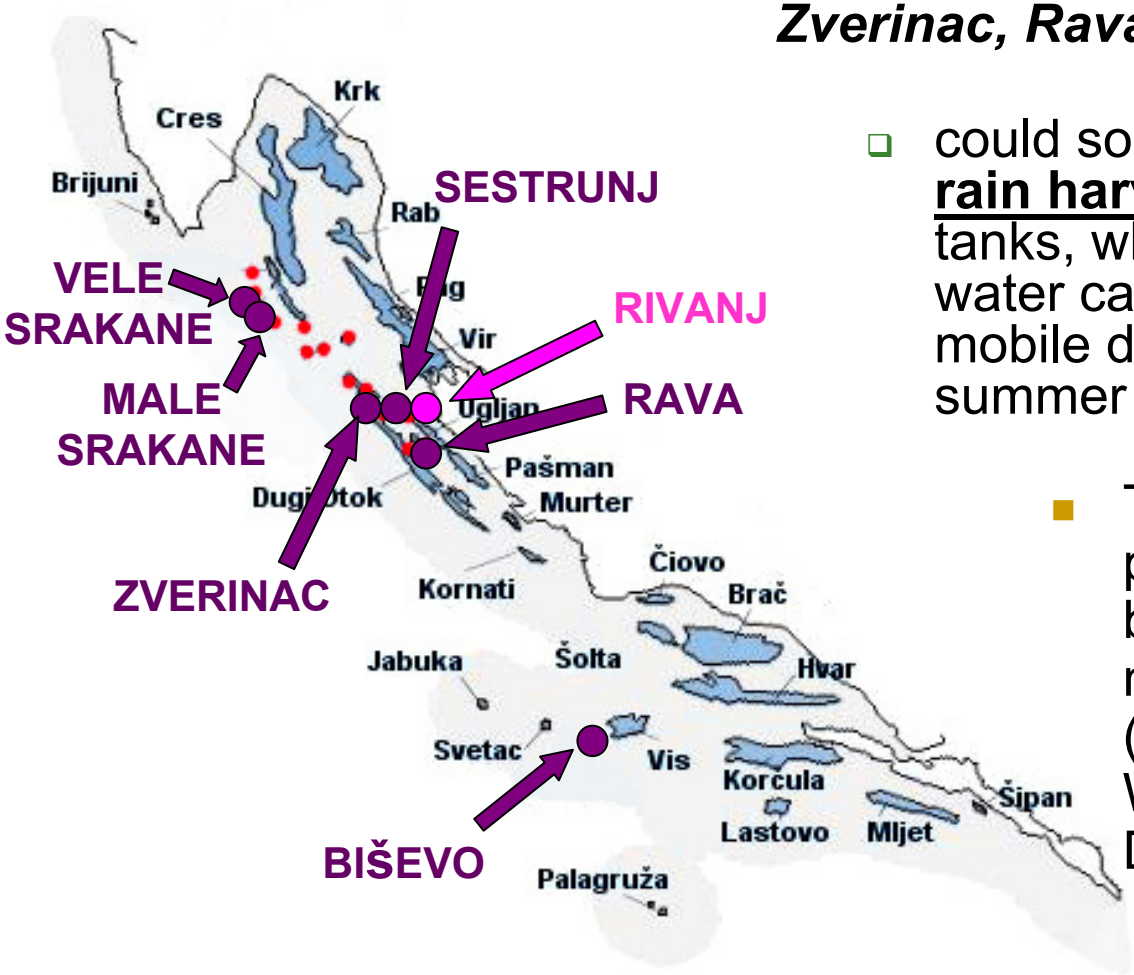
- Different desalination plant could be suggested:
  - permanent for a specified time period: Unije, Silba, Olib, Ist, Molat and Iž
  - permanently mobile plants: Susak and Premuda

Suggestions for water supply improvement



- ***Dugi otok*** and ***Vis*** are big islands at the largest distance from the inland with huge quantities of brackish water
  - Could solve its water supply using the local desalination plants
    - Dugi otok - permanent for a specified time period
    - Vis - a central permanent desalination plant based on the groundwater well field *Korita*

Suggestions for water supply improvement



- **Male Srakane, Vele Srakane, *Sestrunj, Zverinac, Rava*** and **Biševo**
  - could solve the water supply by **<u>rain harvesting</u>** using their own tanks, which could be filled by a water carrier or by a permanently mobile desalination plants during summer
    - The island ***Rivanj*** - a permanent solution would be a connection with a nearby island Ugljan (connected to the Regional Water Company North Dalmatia)

Conclusion

- The bigger islands have quite satisfying water supply
  - the population density and habitation pattern influence the extent to which consumers are supplied by piping networks

- The islands at a larger distance from the inland are usually supplied by water transport from the inland or with water from their own tanks, boreholes or wells
  - water quality is often not satisfying

Conclusion

- **The water input from the inland** is the right solution for bigger islands and those closer to the inland (Rivanj – connection over Ugljan)
- **Rain harvesting** and its retention in the underground or on the surface could be a solution for: Male Srakane, Vele Srakane, Sestrunj, Zverinac, Rava and Biševo
- **Desalination** could solve the problem especially for the islands at a large distance from the inland:
  - permanent desalination plants (Vis and Korčula)
  - permanent for a specified time period (Pag, Dugi otok, Hvar, Mljet, Unije, Silba, Olib, Ist, Molat and Iž)
  - permanently mobile plants (Susak and Premuda)

Perspective

- The existing resources of fresh- and brackish water must be protected
- Additional hydrogeological research of quantity and yields must be carried out
- Special attention must be paid to the waste management
  - since most of the islands do not treat domestic effluents


Thank you!