

# PRELIMINARY STUDIES ON THE EFFECTS OF HEAT PUMP DISCHARGES ON SHALLOW BENTHIC LITTORAL COMMUNITIES IN MONACO

F. Bartolini<sup>1\*</sup>, F. Gianni<sup>1</sup>, C. Lafargue<sup>1</sup>, J. Cottalorda<sup>1</sup>, P. Francour<sup>1</sup>, T. Thibaut<sup>1</sup> and L. Mangialajo<sup>1</sup>  
<sup>1</sup> ECOMERS University of Nice - fabrizio.bartolini@unice.fr

## Abstract

Among renewable energies, seawater heat pumps (HP) represent useful technology which uses oceans thermal energy needed for air conditioning and heating systems. However, the outflow of these systems consist of thermally altered brackish or seawater which is discharged directly into the sea, thus potentially impacting local benthic communities.

We measured the effects of HP discharge along spatial gradients east- and westward of an outflow in the Ligurian Sea, assessing the composition of upper sublittoral benthic assemblages. The combined effect of temperature and salinity alteration did not seem to affect the structure of macrolaglal assemblages, while *C. compressa* was absent close the outflow.

These preliminary results showed a limited effect of HP in artificial zones characterized by tolerant species-dominated assemblages.

**Keywords:** *Thermal pollution, North-Western Mediterranean*

Heat pumps (HP) represent relatively new technology based on a renewable source of energy, namely ocean's heat, and have potential for future energy supply in coastal developed areas. HP are thermodynamic plants which, based on the differences of surface and deep seawater temperature, extract the energy necessary for domestic cooling or warming [1]. However HP outflow consist of thermally altered brackish or seawater discharges, which could impact the local meso- and sublittoral benthic communities.

Thermal pollution has mainly been studied at the outflows of nuclear or thermal power plants in the past, showing alteration of seaweeds communities and pattern of invertebrate recruitments ([2], [3]).

The project OPTIMA-PAC (OPTimisation des performances énergétiques et MAîtrise des impacts sur le milieu marin des PAC eau de mer : vers une nouvelle filière industrielle compétitive), aimed at evaluating the impacts of such discharge is being carried out in the North-Western Mediterranean along the coast of the Principality of Monaco, where HP are utilized since more than 30 years.

In an early stage of the project, the impact of a brackish HP outflow was studied in Summer 2012. Temperature dataloggers were placed at the discharge point and 5, 10 20 40 and 60/80 m east- and westward, respectively, to quantify the entity of thermal disturbance due to the HP on such spatial gradient. Salinity measurements along the gradient were carried out as well. Photographic sampling quadrates were carried out at each station to analyse possible differences in benthic communities' structure and composition and the distribution of the mesolittoral brown alga *Cystoseira compressa* was mapped along the two spatial gradients.

The largest thermal effects were recorded mainly within the first 5-10 m apart from the outflow. The main effect seems to be a widening of the daily temperature range compared to extreme positions (Fig.1). Salinity alteration followed a similar spatial pattern to temperature, with a minimum average value of 29‰ at the outflow.

A preliminary analysis of the benthic assemblages, strongly dominated by coralline and turfs of filamentous algae, revealed significant differences among stations in the gradient, however without any clear relation with the distance to the discharge point. Other environmental factors are potentially affecting the structure of artificial reefs assemblages more that the combined effect of temperature and salinity alteration recorded. The strong anthropization of the study area, characterized by algal communities dominated by relatively tolerant species, could account for the lack of a clear effect of HP discharge on assemblages structure. On the contrary, *C. compressa* patches were distributed only starting from 27 and 40 m from the outflow, westward and eastward respectively.

These preliminary results suggest that the effects of HP rejects may be limited in highly impacted artificial zones, but the response of benthic communities may be very different on natural substratum, where sensitive species (i.e. *Cystoseira* species) are thriving. Future investigations should consider biological indicators potentially more sensitive to the observed alteration of the environmental parameters, like early life stages, reproduction and physiological traits of benthic organisms.

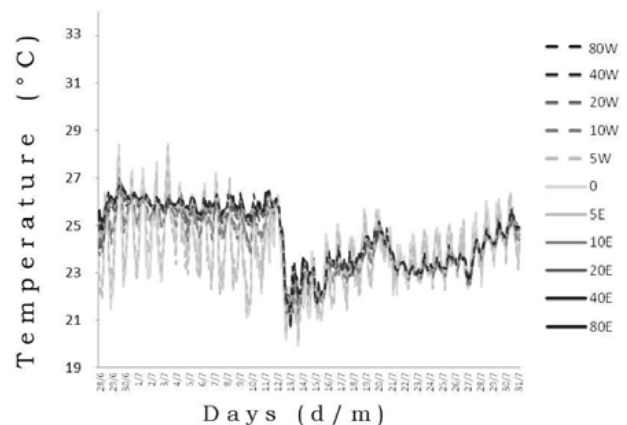


Fig. 1. Recorded temperature from 28/06 to 01/08/2012 along spatial gradients (0-80, E-W) from the HP discharge.

## Acknowledgements

The present work was funded by the project Otpima-PAC, supported by the PACA marine competitiveness cluster and selected by DGCIS under the 11th FUI (Fonds unique Interministériel) call for proposal. Authors wish to thank the other partners of the project for the constructive discussions during the meetings and in particular the Environment Direction and the Maritime Affairs of Monaco Principality that supported the field activities.

## References

- 1 - Pelc R., Fujita R.M., 2002. Renewable energy from the ocean. *Mar. Policy*, 26: 471– 479.
- 2 - Chou Y., Lin T., Chen A.C. and Liu L., 2004. Effects of nuclear power plant thermal effluent on marine sessile invertebrate communities in Southern Taiwan. *J. Mar. Sci. Technol.*, 12: 448-452.
- 3 - Keser M., Swenarton J.T. and Foertch J.F., 2005. Effects of thermal input and climate change on growth of *Ascophyllum nodosum* (Fucales, Phaeophyceae) in eastern Long Island Sound (USA). *J. Sea Res.*, 54: 211 – 220.

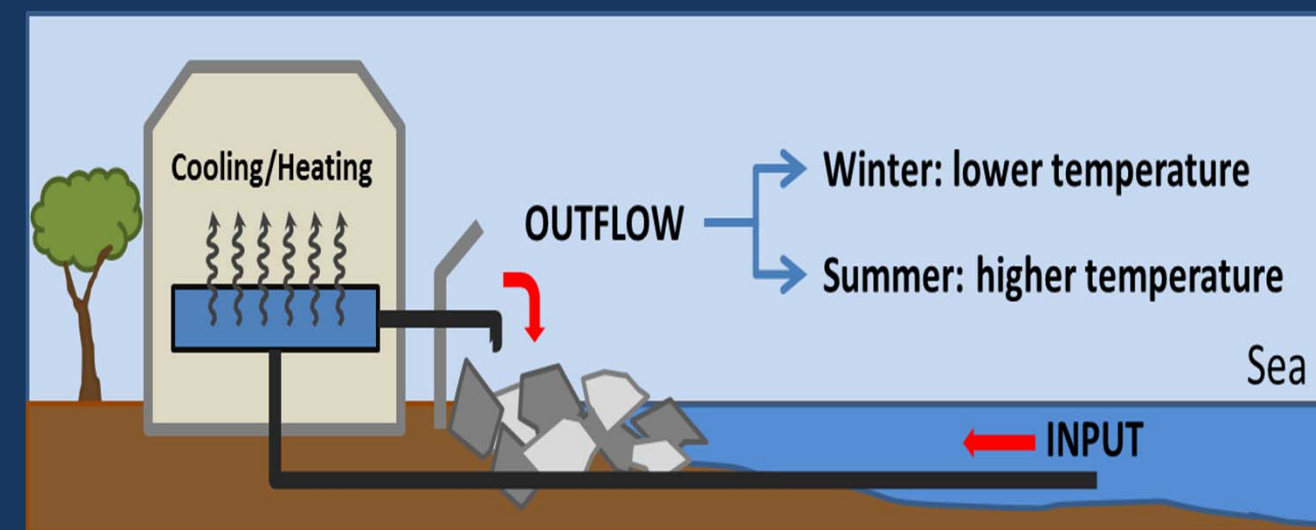


# Preliminary studies on the effects of heat pump discharges on shallow benthic littoral communities in Monaco

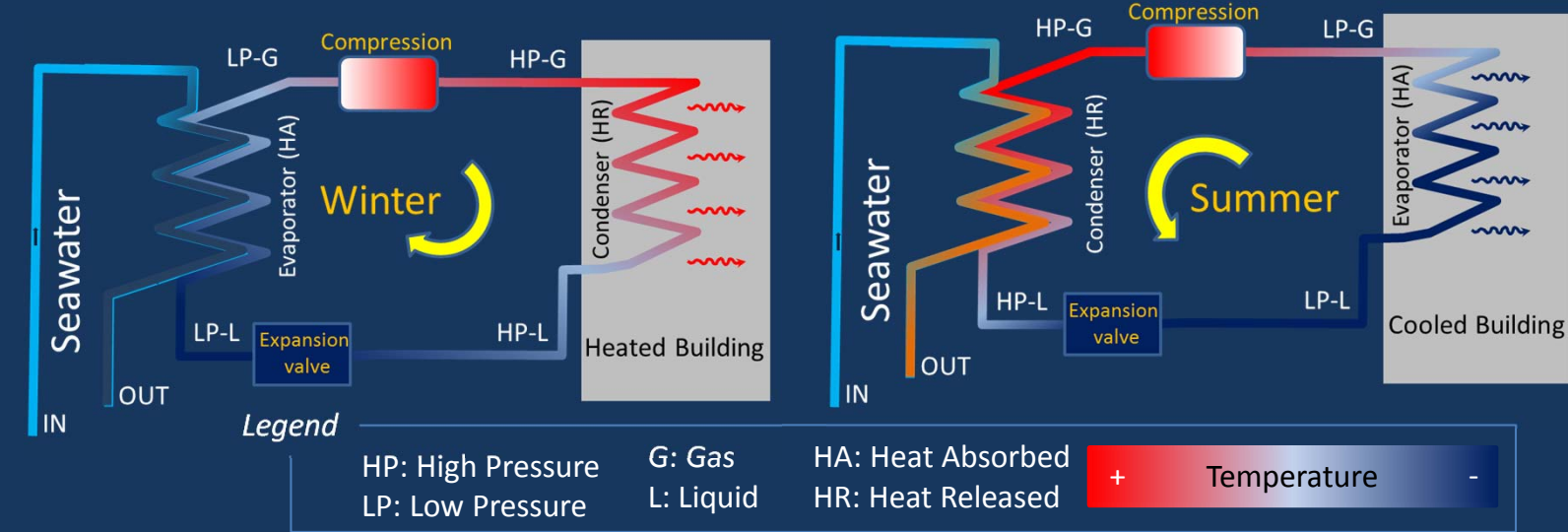
Fabrizio Bartolini\*, F. Gianni, C. Lafargue, JM. Cottalorda, P. Francour, T. Thibaut, L. Mangialajo

## Seawater heat-pumps (SHP)

- Thermodynamic systems used for cooling/heating buildings
- Use of seawater for energy exchange → Outflows with certain  $\Delta T$
- Reduction of emissions by over 60%



- Monaco: more than 30 years of SHPs
- Within OPTIMA-PAC project (FUI, Fr)



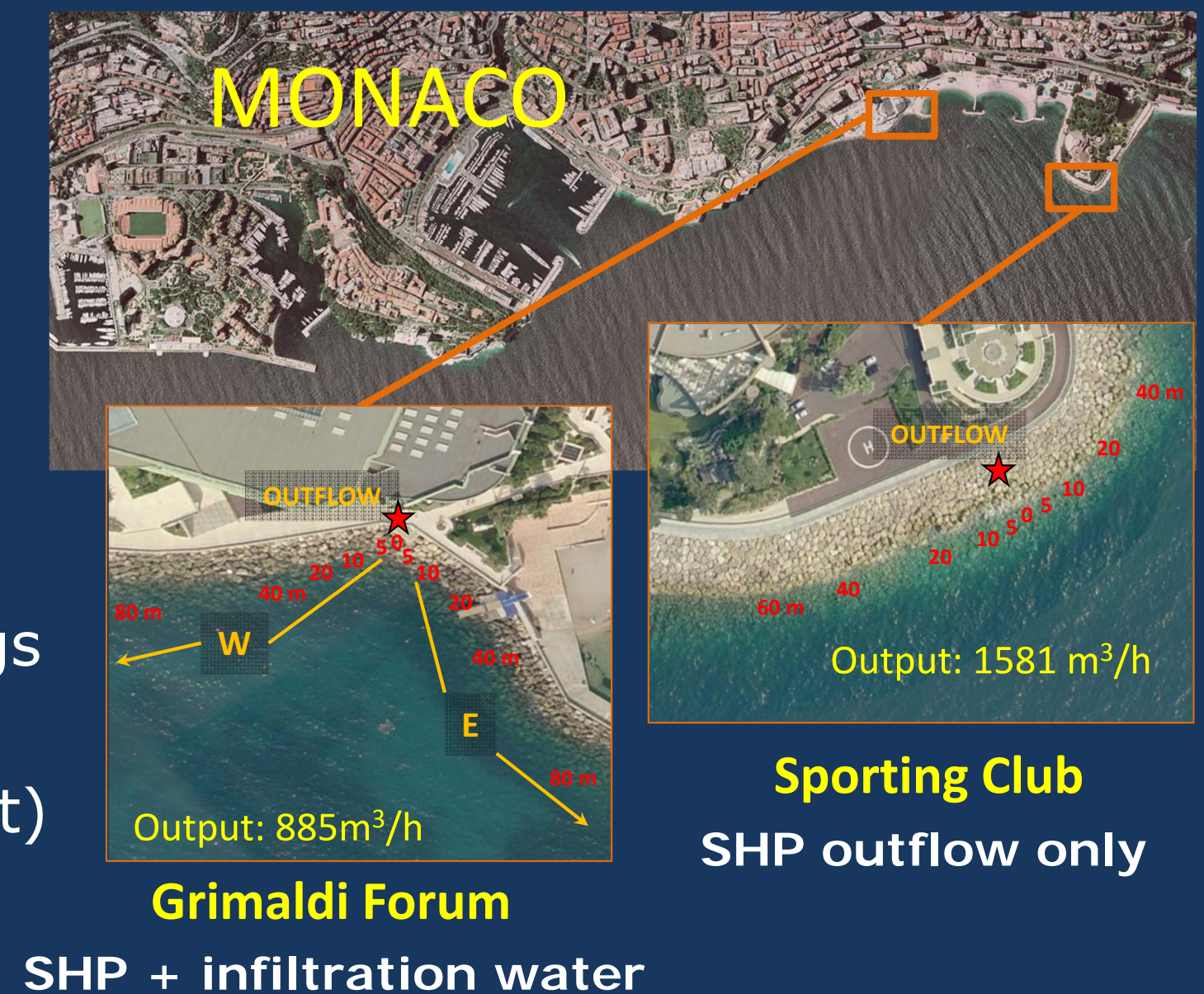
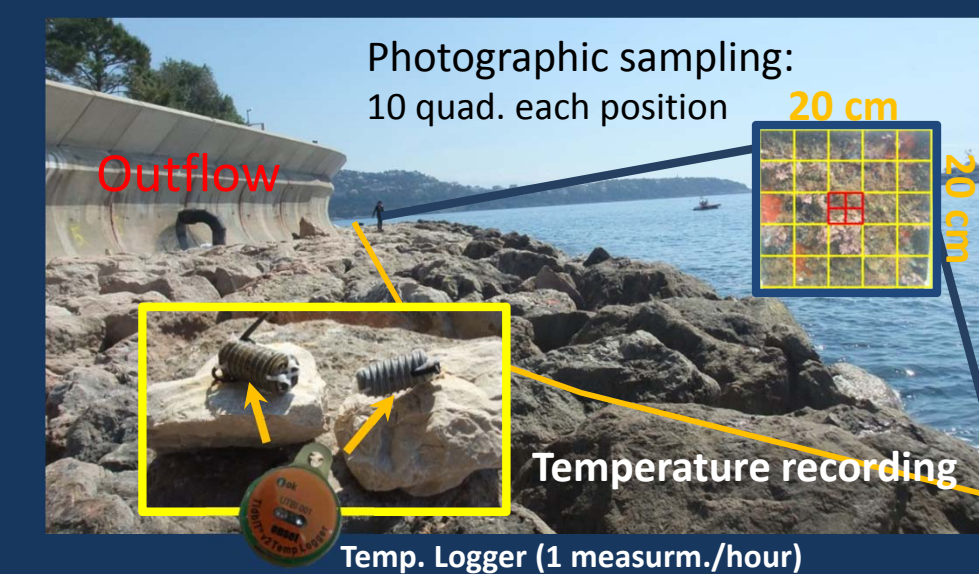
## Impact of HPs outflow on benthic communities

## Study sites and methods

Effect along east-westward spatial gradients at two SHPs

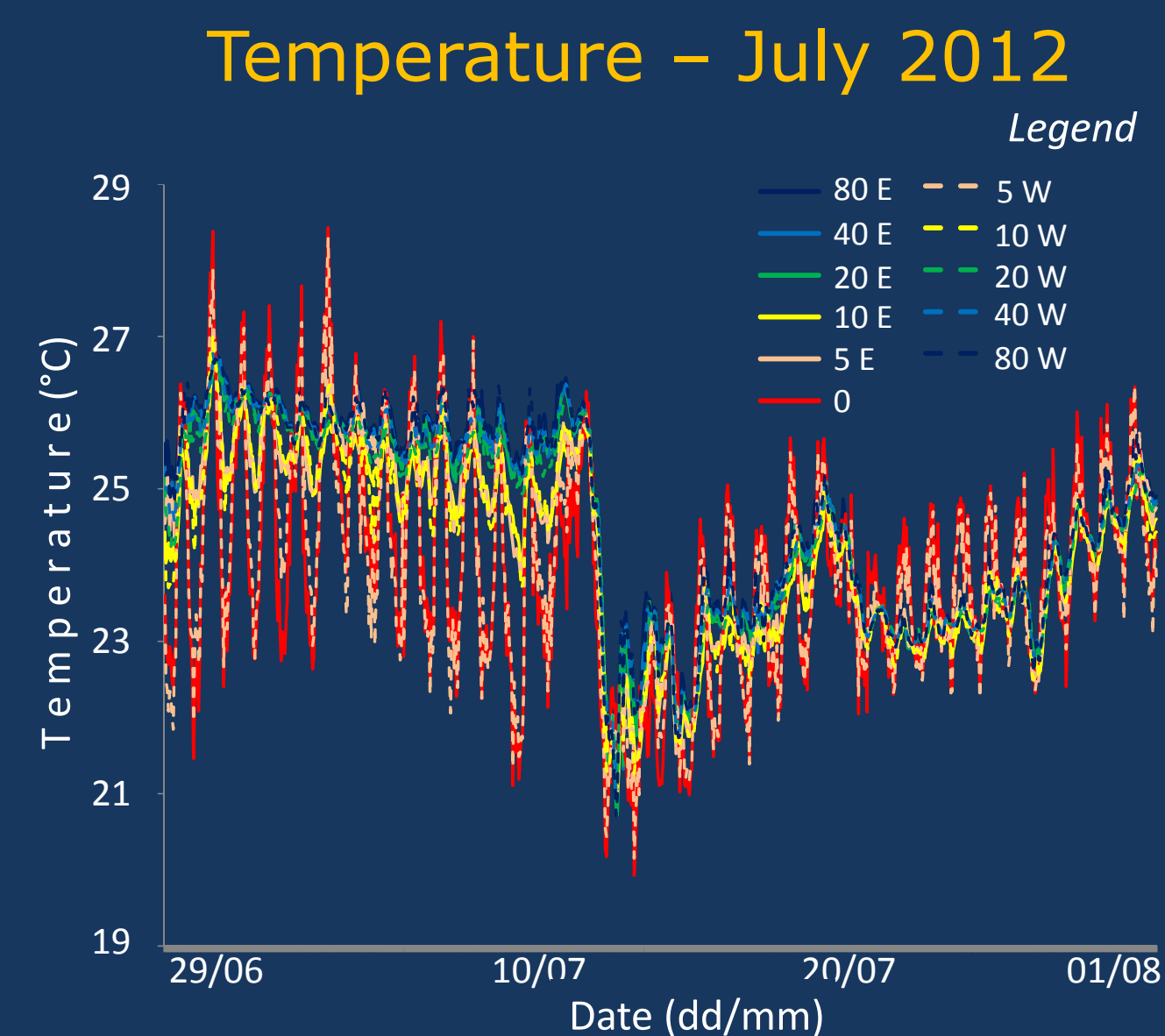
Artificial substrata with articulated corallines and turf as dominating taxa

- Temperature and salinity measurements
- Algal assemblages photographic samplings
- *Cystosiera compressa* distribution (if present)



## Preliminary results

- Lower salinity within 10m around the outflow (ANOVA, not presented)
- Larger temperature fluctuations in the 5-10 m around the outflow (ANOVA, not presented)



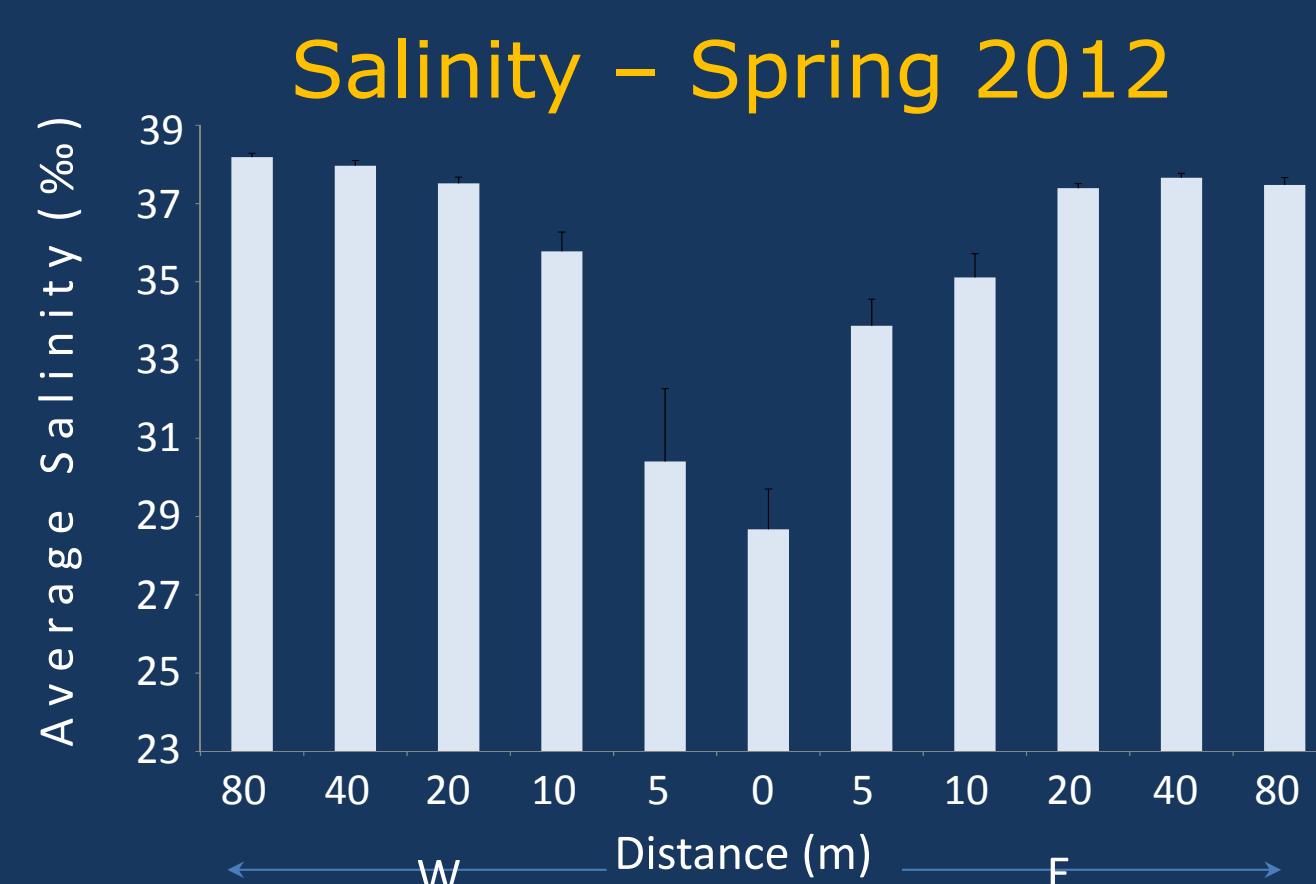
## *C. compressa* distribution



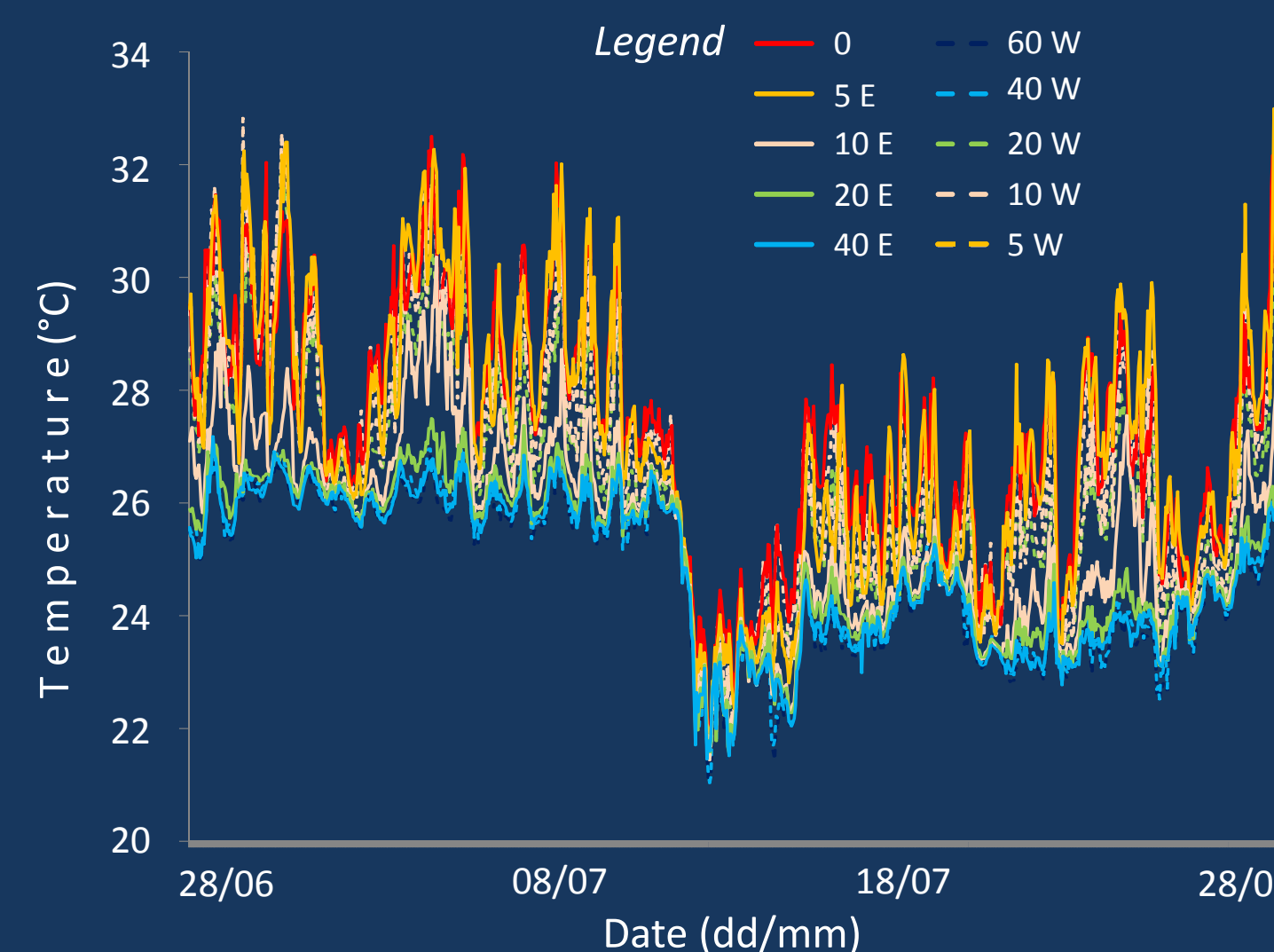
- *C. compressa* absent around the outflow

→ salinity, temperature or interaction?

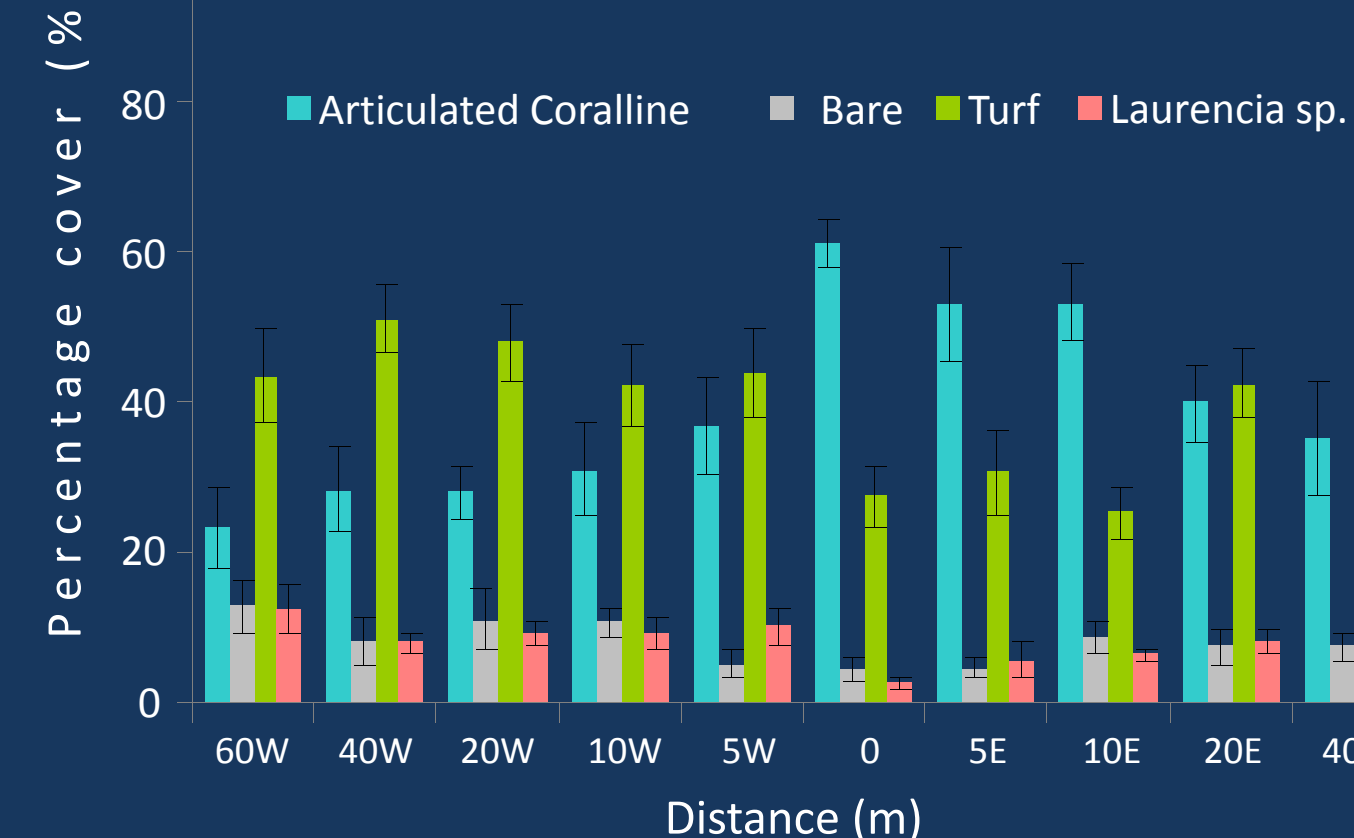
- No effect on algal assemblages (PERMANOVA, PCO not presented)



## Temperature - July 2013



## Algal assembl. - Nov. 2012



- No salinity alteration (ANOVA, not presented)
- Important  $\Delta T$  in July-August (up to 8 °C) within 10-20 m from the outflow (ANOVA, not presented)
- Effects on algal assemblages only after summer (PERMANOVA; 0 ≠ all other stations except 5E, 10E)

## Remarks and future directions

- Limited effects on little structured algal communities

## GENERAL PATTERN?

- Effect of SHPs function of its output magnitude
- Higher impact on natural/pristine areas?

## In progress...

- Analysis of algal assemblages summer 2013
- Physiological response:
  - Mussel HSP
  - Limpets fecundity

**Aknowledgments** We wish to thank Monaco's Buereau of Environment for providing logistic support during field activity. Ciriani Marie-Lyne for helping in data analysis.

\* fabrizio.bartolini@unice.fr

