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Discussions

# *Interactive comment on* "On the shelf resonances of the English Channel and Irish Sea" *by* D. J. Webb

**Anonymous Referee #1**

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Motivated by large tides and some previous ideas on resonance in the area, this manuscript explores further the relation between the tides and the set of resonances. The approach is essentially the same as in Webb (2012, loc. cit., Gulf of Carpentaria) apart from some discussion of the model numerics that ensure energy conservation. Hence the interest lies with the context. Although a limited area, aspects creating interest are: the size of the tides (only a few areas globally have larger amplitudes); previous ideas about resonances; existing and potential future tidal energy schemes that need some understanding for proper impact assessment. A novel finding is of two forms of resonance contributing to the large amplitudes in the Bristol Channel and at St. Malo. [The "second" resonance with these two locations in antiphase might be sensitive to the model resolution and form of model boundary conditions, see below, and some discussion of this would be welcome]. Hence there is interest in the area



and results, and I am in favour of this approach to understanding, so favour publication in due course.

The comparison of the model with observed tides is not very good and would not be acceptable now in the operational UK storm surge model, for example. Whilst this is a weakness in the manuscript's presentation, however, it does not necessarily imply a model deficiency for investigating resonances. Comparison with observations depends on model configuration (numerics, bathymetric grid), the applied forcing and only marginally on the form of the boundary conditions where the boundary forcing is applied (assuming the forcing is accurate). Representation of resonances depends equally on model configuration but also strongly on the form of the boundary conditions and only marginally on the applied forcing. [Dependence on the bathymetric grid is illustrated by the sensitivity of Bristol Channel tides as correctly stated on page 403 lines 5-7. Regarding boundary conditions, for example in 1-D, specified elevation at the open boundary corresponds with 1/4-, 3/4-, . . wave resonances between there and the coast, whereas specified flux at the open boundary corresponds with 1/2-, 2/2-, . . wave resonances. However, no boundary condition known to me can represent the remainder of the global ocean, let alone allow passage of continental shelf waves as alluded to on page 403 lines 12-15]. I think the author understands all this, but this aspect could be better discussed. Of course the whole would be more convincing if a closer simulation of the observed tide were shown. Forcing other than Cartwright et al. (loc. cit.) used by models of the NW European shelf includes a NE Atlantic tide model of Flather (Flather and Wolf, 1991?), an Oregon State University derivation from altimetry, "FES2004" (which assimilates altimetry into a global model).

In particular, the model representation of the M2 tide has an amphidrome in the southern North Sea that is too far south; this may be attributable to proximity of the closed boundary but might not affect the response too much in the Channel and elsewhere further west. However, I suspect that the model near-amphidrome in the Channel may be a result of too much reflected wave from that closed boundary. Possibly the same

applies in the Irish Sea where the model amphidrome is real rather than marginal or virtual – is there too much reflection from the North Channel?

Much is made about energy conservation through the form of averaging for the Coriolis terms. This is not my expertise, but I have been given to understand that this is not new. E.g. NEMO has energy-conserving Coriolis terms. [I do not know if the UK surge model terms conserve energy – this is a relevant comparator]. There should at least be some reference to the literature on this point.

I am puzzled by the small response at Workington (page 404, lines 26-28 and figure 3). This seems to disagree with its large tidal amplitude in the model (and in observations). On the other hand the peak (such as it is) between 5 and 6 radians/day is in accord with previous notions that the large semi-diurnal tidal amplitudes in the NE Irish Sea relate to a 3/4-wave. Is there something about the forcings used that affects the relative responsiveness of the tide and the resonances? Or perhaps it would be useful to show an equivalent of figure 10 for Workington.

Resonance "E" (page 410 lines 5-8) is perhaps the most interesting new finding because it is not apparent from the modelled or observed M2 tide. It looks like a "cross-bay" resonance between the Bristol Channel and St. Malo. The form in figure 8 suggests that it would hardly be affected by a change of open boundary condition but it would be good if this could be confirmed. I also like the discussion in the remainder of section 6.

Detailed comments

Page 395 line 19 ". . at a particular real angular velocity, there will be nearby resonances . .". Not necessarily for any angular velocity. I think this sentence should be clarified and if possible simplified.

Section 2.1 This is more about the numerical scheme than one would expect "conventionally". Depending on the response to the issue about energy conservation (see



above), it might be reduced.

Page 404, equation (10) and line 9. $\zeta(\omega)$ or $\zeta(x)$? Page 404 line 13. Le Havre ought to appear in Tables 1, 2 and on a map.

Page 405, lines 17 onwards. It is not clear what is meant by a "loop" and especially what marks the boundary between one loop and another.

Page 409 line 18. Add "is" before "fixed". Page 409 line 21. Not exactly "zero"?

Page 412 line 6 and figure 10 caption. It looks to me as though the curves are from 11 (not 10) to 14 radians/day.

Page 414 line 7. I think this should be ". . effect on the tides . ." (on not of)

Figures 2, 4, 5, 6, 8, 9, 10. Electronically they can be looked at with any magnification, but when printed at present they are too small or lines need to be thicker and labelling larger.

Figure 8 caption line 5. "than" not "that".

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Interactive comment on Ocean Sci. Discuss., 10, 393, 2013.