The Coastal Robinson

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Abstract:

Allan Robinson made important contributions to coastal oceanography in at least two major ways. First, in 1964, he introduced continental shelf waves to the nascent coastal oceanography community, and so initiated a very profitable line of research that remained active for two decades. Second, he had the drive and vision to conceive of, and then direct, the first global synthesis of coastal oceanography.

1. Introduction:

Undoubtedly, when one thinks of Allan Robinson, one thinks first of the broad sweep of his important contributions to understanding the grand, deep, open ocean. Yet, to assume this risks losing track of some of his more impressive and lasting accomplishments. He played a seminal role when coastal physical oceanography was just starting to define itself within the scientific community, and he kept returning to coastal issues until the end of his life.

2. Continental shelf waves:

During the early 1960's, Allan Robinson visited CSIRO at Cronulla, Australia. While he was there, he was exposed to Bruce Hamon's work (1962, 1963) investigating the relations between atmospheric forcing and coastal sea level variability on "weather band" (2-10 day) time scales. Hamon ultimately showed that winds excite signals that propagate northward along the east coast of Australia at speeds of O(400 km/day). Further, this sea level variability was apparently unrelated to changes observed at an offshore island.

Allan Robinson brought the insight that this alongshore propagation could be accounted for by a topographic Rossby wave confined to the shelf-slope topography of the continental margin. Topographically trapped "2nd class" waves (meaning periods longer than the inertial and where the motions have a tendency toward geostrophic balance) had been known for some time (e.g. Lamb, 1945, section 212; Reid 1958), but they had been viewed somewhat as mathematical curiosities. Indeed, Reid did not provide any comment about the possibility of observing such waves.

Enter Allan Robinson (1964). First, he recognized that Hamon's sea level signal could potentially be associated with a trapped barotropic topographic Rossby wave because of its propagation speed and direction. Second, he reformulated the model's geometry in a way that mimics a real continental margin: a linearly sloping shelf, a cliff and then the deep ocean. This geometry includes a realistic depth range and shelf width, but is still simple enough to allow analytical solutions. More importantly, these solutions yield propagation speeds about half of those obtained by Hamon: they are the right sign and the right order of magnitude compared to the measurements (that his wave speed is about half that observed is probably due to a combination of his neglect of the ocean's density stratification, and to approximations in Hamon's analysis). Finally, Allan Robinson gave this class of waves a clear, descriptive and enduring name: continental shelf waves. The Robinson (1964) paper was less than two pages long, but it made its point clearly and convincingly. It set off a chain reaction of other studies that eventually led to a coastal-trapped wave synthesis that does a remarkably good job explaining and hindcasting alongshore current and sea level variability over the continental shelf in the weather band (e.g., Chapman, 1987).

The first phase of the chain reaction occurred within Allan Robinson's own scientific group. Lawrence Mysak, then a graduate student at Harvard, became excited about this new class of waves, and he set about creating a sequence of major model advances as part of his Ph.D. thesis. Some of the aspects of this work included dealing with the effects of deep-ocean stratification and of the strong, opposing East Australian Current (Mysak, 1967a). Further, Mysak (1967b) also used the theory to explain the spectral properties of Sydney sea level records. At this point, the utility of shelf wave theory was established, and the problem then attracted a wide range of contributions over the next two decades (e.g., see Brink, 1991, for a summary). The shelf wind-driving problem has become one of the few places in oceanography where simple, linear, analytically-expressed models compare well with observations. Interestingly, Allan Robinson never returned to the shelf wave problem, once he set it in motion.

3. Realistic Models and Ocean Applications:

During the 1970's, Allan Robinson's interests turned increasingly toward applying knowledge of ocean dynamics for practical means. Perhaps the earliest sign of this direction was the pair of papers dealing with simple but practical models of storm surges (Flierl and Robinson, 1972; Robinson et al., 1973). This work was motivated by real human problems, and it was quintessentially coastal in character.

However, the core direction of his work turned to assimilating data into ocean numerical models. This process generates a dynamically consistent estimate of the true state of the ocean, and this estimate is then valuable both for practical and scientific purposes. Allan Robinson's interest in this work became apparent by 1981 (Robinson and Haidvogel, 1981), and quickly evolved into an interest in at-sea tests of descriptive-predictive systems during the OPTOMA (Ocean

Prediction Through Observation, Modeling and Analysis) program, e.g., Robinson et al. (1984). While this work, jointly led with Chris Mooers, took place in the eddy-rich region offshore of the northern California shelf and slope, it was still influential in coastal circles because of the growing interest at that time in how coastal ocean flows interact with the ambient deep ocean, e.g., Mooers and Robinson (1984) or Davis (1985).

As the underlying Harvard Ocean Prediction System (HOPS) reached maturity, its dynamical basis became generalized so that it could eventually become useful for coastal settings. One early fruit of this development was Quinn Sloan's (1996) Ph.D. thesis, which treated the shelfbreak front south of New England. The thesis brought the model system to bear on idealized simulations, as well as on tests meant to help design observational systems. Later versions of the HOPS model system included non-physical elements such as acoustical and biological sub-models. By the turn of the century, a well-established stream of publications from the HOPS group dealt with many aspects of continental shelf variability and the interface between models and observations in this complex setting (e.g., Liang and Robinson, 2009).

Through this period of growing capabilities, Allan Robinson exhibited leadership in the overall ocean community. One particularly striking case was his chairmanship of the revolutionary OPTOMA program. Another example was his key role on the steering committee (chaired by Chris Mooers) of the Coastal Ocean Prediction Systems (COPS) effort, where his strategic vision and experienced voice helped promote the development of a practical coastal model/observation system. Although this particular effort was far ahead of its time, its vision (Eden and Mooers, 1990) is now being realized as needs-driven observing systems become operational and widespread, e.g. Weisberg et al. (2009).

Allan Robinson's role in the development of coastal modeling systems differs dramatically from his earlier role in shelf wave theory. In the latter case, he made one shining contribution, but then he personally followed his interests into other, unrelated areas. In the case of coastal modeling systems, he made an extended commitment, and worked patiently and persistently to develop the intellectual basis on which modern descriptive-predictive systems rely.

4. Community leader

During 1989, Allan Robinson worked with the Intergovernmental Oceanographic Commission (IOC) to initiate the Coastal Ocean Advanced Science and Technology Study (COASTS). Shortly afterwards, he was also able to involve the Scientific Committee for Oceanic Research (SCOR) as a second international sponsor. The ultimate objective of this effort was to improve knowledge of coastal physical oceanography on a global basis. Allan Robinson served as the chair of COASTS throughout its existence, and there is no doubt that he was the main driver in this effort. As a first major step, an international meeting of coastal ocean scientists was held in Liege, Belgium in 1994. At this meeting, experts presented summaries on processes, methodologies and on regional coastal oceanography. This meeting led to the publication of two volumes of *The Sea* (Brink and Robinson, 1998 and Robinson and Brink, 1998) meant to synthesize knowledge of coastal physical oceanography on a global basis. This project was both timely and unprecedented. While there was certainly a positive response from the ocean community for this effort, the task of creating a balanced, global synthesis took a special effort to involve scientists worldwide, and to try to develop a synthesis of uniformly high quality.

In the course of developing this physical synthesis, it became clear that many important scientific and practical issues in the coastal ocean required a deeper knowledge of all oceanographic disciplines, not just physical oceanography. In response to this need, Allan Robinson led a continued COASTS effort to carry out a corresponding global synthesis of interdisciplinary coastal ocean science. In this case, an international meeting occurred in Paris during 2001, and this meeting in turn led to an interdisciplinary synthesis (Robinson and Brink, 2005; 2006). As these books were published, he always took pains to try to assure that they were made available to scientists who might usually have a difficult time accessing such material. As if to follow on this success, a subsequent volume of *The Sea* (Bernard and Robinson, 2009) codified the present knowledge of tsunamis and their coastal impact.

The COASTS effort succeeded in creating a global synthesis, but few people would be so bold as Allan Robinson in undertaking such a project and carrying it through to completion. It required special vision and determination to carry this out. It seems unlikely that anyone will attempt a similar project any time soon.

5. Summary

During the early and middle stages of his career, Allan Robinson built his reputation on his accomplishments in the deep, open ocean. Yet, five years after his Ph.D., he made a groundbreaking contribution to coastal oceanography: his insights on continental shelf waves. Although he personally did not follow up on these insights, he encouraged his student, Lawrence Mysak to do so, and this work, in turn, led to a sustained surge of interest in this class of problem, and how it relates to wind forcing in the coastal ocean.

During the 1980's, Allan Robinson began a much more sustained commitment to coastal physical oceanography. His motivation was evidently twofold. On the one hand, coastal oceans represented a frontier where the evolving HOPS capability could be applied profitably, both for scientific and practical purposes. Second, he felt the call to make a lasting international contribution to improving knowledge of the global coastal ocean. The resulting sequence of four volumes of *The Sea* reflects strongly on his personal vision and extraordinary drive. In both cases, Allan Robinson's impact will be enduring.

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References:

Bernard, E.N., and A.R. Robinson (editors), 2009. Tsunamis. *The Sea*, volume 15, Harvard University Press, Cambridge, Massachusetts, 450 pp.

Brink, K. H., 1991. Coastal-trapped waves and wind-driven currents over the continental shelf. *Annual Review of Fluid Mechanics*, **23**, 389–412.

Brink, K.H., and A.R. Robinson (editors), 1998. The global coastal ocean Processes and Methods. *The Sea*, volume 10, J. Wiley & Sons, New York, 604pp.

Chapman, D.C., 1987. Application of wind-forced long coastal-trapped wave theory along the California coast. *J. Geophys. Res*., **92**, 1798-1816.

Davis, R.E., 1985. Drifter observations of coastal surface currents during CODE: the method and descriptive overview. *J. Geophys. Res*., **90**, 4741-4755.

Eden, H.F., and CNK Mooers, Editors., 1990. The Coastal Ocean Prediction Systems Program: Understanding and managing our coastal ocean, JOI, Washington D.C., Synopsis, 20 pp. Vol. I Strategic Summary, 115 pp., Vol. II. Overview and invited papers, 353 pp.

Flierl, G., and A.R. Robinson, 1972. Deadly Surges in the Bay of Bengal; Dynamics and Storm-Tide Tables. *Nature*, **239**(5369), 312–315.

Hamon, B.V., 1962. The spectrums of mean sea level at Sydney, Coff's Harbour and Lord Howe Island. *J. Geophys. Res*., **67**, 5147-5155.

Hamon, B.V., 1963. Correction to 'the spectrums of mean sea level at Sydney, Coff's Harbour and Lord Howe Island'. *J. Geophys. Res*., **68**, 4635.

Lamb, H., 1945. Hydrodynamics. 6th Edition, Dover Publications, New York, 738 pp.

Liang, X. San, and A.R. Robinson, 2009. Multiscale processes and nonlinear dynamics of the circulation and upwelling events off Monterey Bay. *J. Phys. Oceanogr.,* **39**(2), 290-313.

Mooers, C.N. K., and A.R. Robinson,1984. Turbulent jets and eddies in the California Current and inferred cross-shore transports. *Science*, **223**, 51-53.

Mysak, L.A., 1967a.On the theory of continental shelf waves. *J. Marine Res*., **25**, 205-227.

Mysak, L.A., 1967b. On the very low frequency spectrum of the sea level on a continental shelf. *J. Geophys. Res*., **72,** 3043-3047.

Reid, R.O., 1958. Effect of Coriolis force on edge waves (I) investigation of the normal modes. *J. Marine Res*., **16**, 109-141.

Robinson, A.R., 1964. Continental shelf waves and the response of sea level to weather systems. *J. Geophys. Res*., **69**, 367-368.

Robinson, A.R., and K. H. Brink (editors), 1998. The Global Coastal Ocean: Regional Studies and Syntheses, Volume **11**, *The Sea*. John Wiley & Sons, New York, 1062 + xvii pp.

Robinson, A.R., and K.H. Brink (editors), 2005. The Global Coastal Ocean: Multiscale Interdisciplinary Processes, Volume **13**, *The Sea.*Harvard University Press, Cambridge, Massachusetts, 1033pp.

Robinson, A.R., and K.H. Brink (editors), 2006. The global coastal ocean interdisciplinary regional studies and syntheses, Volume **14**, *The Sea*. Harvard University Press, Cambridge, Massachusetts, 1567pp.

Robinson, A.R., J.A. Carton, C.N.K. Mooers, L.J. Walstad, E.F. Carter, M.M. Rienecker, J.A. Smith, and W.G. Leslie, 1984. A Real-Time Dynamical Forecast of Ocean Synoptic/Mesoscale Eddies. *Nature*, **309**(5971), 781–783.

Robinson, A.R., and D.B. Haidvogel, 1981.– Dynamical Forecast Experiments with a Barotropic Open Ocean Model**.** *Journal of Physical Oceanography*, **10**(12), 1909–1928.

Robinson, A.R., A. Tomasin, and A. Artegiani, 1973. Flooding of Venice. *Quarterly Journal of the Royal Meteorological Society*, (London), **99**(422), 688–692.

Sloan, N.Q., 1996. Dynamics of a shelf-slope front: process studies and data-driven simulations in the Middle Atlantic Bight. Ph.D. thesis, Harvard University, Cambridge, Massachusetts, 230 pp.

Weisberg, R.H., A. Barth, A. Alvera-Azcarate, and L. Zheng, 2009. A coordinated coastal ocean observing and modeling system for the West Florida continental shelf. *Harmful Algae*, **8**, 585-597.