The tidal bore of the Garonne River, France

By

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A tidal bore is a series of waves propagating upstream as the tidal flow turns to rising. It forms during spring tide conditions when the tidal range exceeds 4 m to 6 m and the flood tide is confined to a narrow funneled estuary. In France alone, several tidal bores are observed (Figure 1). One most famous tidal bore on Earth was the *mascaret* of the Seine River (Malandain 1988). The Seine River tidal bore had had a sinister reputation: Its height could reach up to 7.3 m and the bore front travelled at a celerity of about up to 10 m/s (Bazin 1865, Tricker 1965). In the Baie du Mont Saint Michel, several tidal bore processes are experienced in creeks and rivers (Tessier and Terwindt 1994, Chanson 2004, 2008). The largest bores are observed in the Couesnon, Sélune and Sée Rivers. In Brittany (*Bretagne*); smaller tidal bores are also observed in the Baie de la Frênaye, in the Baie de l'Arguenon and at Saint Briac sur Mer (Chanson 2008).

In the southwest of France, the large tidal bores are observed in the Gironde estuary, and the Dordogne and Garonne Rivers. In the Gironde Estuary, a tidal bore develops during spring tides and continues upstream into the Dordogne and Garonne Rivers (Figure 1). Small tidal bores are also observed in their tributaries: e.g. l'Isle River at Libourne. Surfers and kayakers regularly surf the Dordogne and Garonne River tidal bores (Figure 3-5), and this has been the topic of several television documentaries.

The Gironde estuary flows northwest between Bec d'Ambès (confluence of the Garonne and Dordogne Rivers) and the Pointe de Grave for about 72 km and it is navigable for oceangoing vessels up to Bordeaux, despite sandbanks and strong tides. Its funnel shape and bathymetry amplifies the tidal range. For example, when the tidal range is 4.24 m at Pointe de Grave, at the mouth of Gironde, the tidal range at Bordeaux is 5.56 m.[1] The Garonne River itself is 575 km long excluding the Gironde Estuary, and is affected by the tides from the confluence with the Dordogne River at Bec d'Ambès up to Castets. Its catchment area is 56,000 km^2 with its spring in the Spanish central Pyrenees.

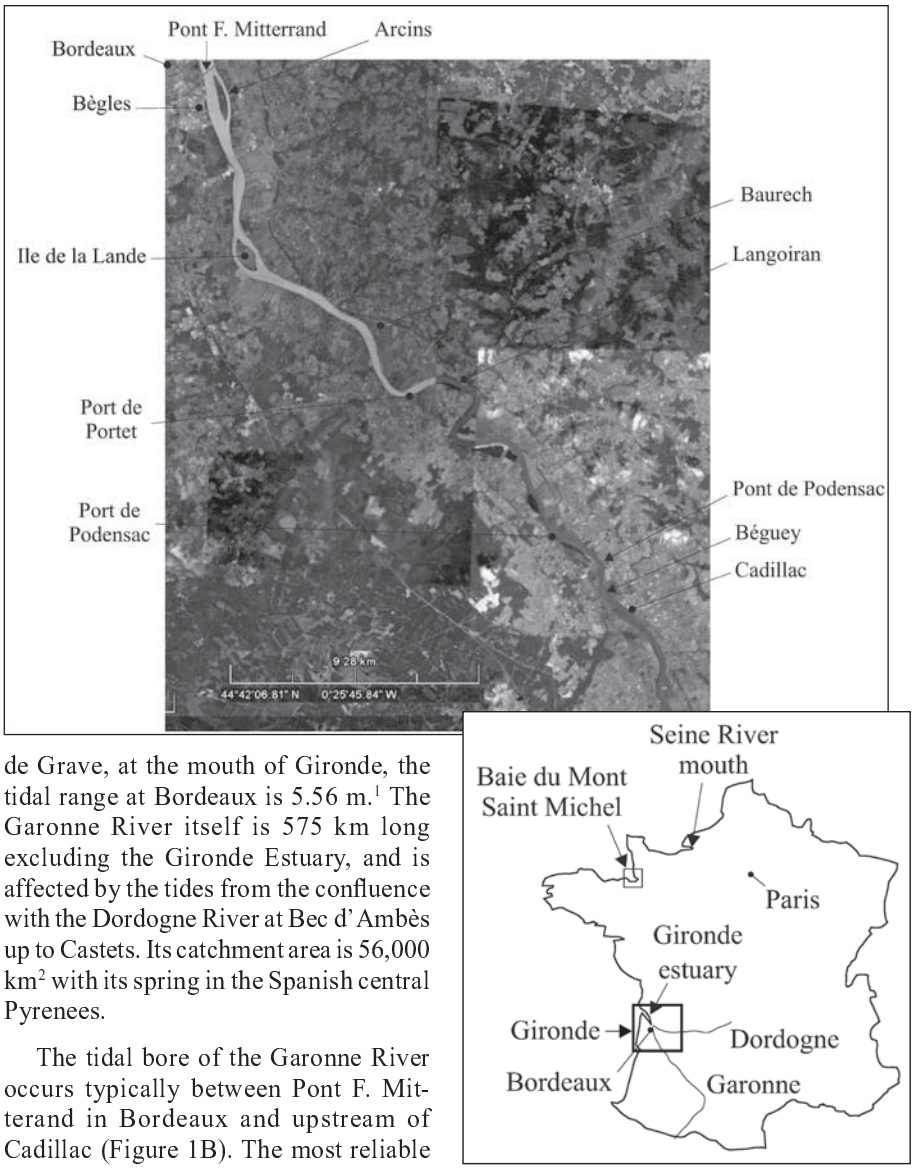

Figure 1. Map of France and aerial photograph of the Garonne River estuarine zone. Above: Map of France and tidal-bore affected estuaries. Top: Aerial photograph of the Garonne River between Bordeaux and Cadillac (Google Earth™ on 29 September 2008)

The tidal bore of the Garonne River occurs typically between Pont F. Mitterand in Bordeaux and upstream of Cadillac (Figure 1B). The most reliable viewing locations are at Langoiran and Pont de Podensac, although the latter is possibly the best. The author followed, on the water, the tidal bore of the Garonne River for over 40 km on 28 September 2008 between Bègles and Cadillac (Figure 3B and 5). He also surfed the Garonne River in kayak at Baurech on 3 Septem-

1) Predicted tidal ranges on 1 October 2008.

Figure 2 (above). Garonne River tidal bore at Arcins near Latresne on 4 September 2008 at 19:20. Undular bore propagation from right to left; note wave breaking next to the banks in the foreground and background

Figure 3. Garonne River tidal bore at Baurech. Below: On 3 September 2008 (photograph by Michel Deyrich with permission); looking downstream at the incoming tidal bore, Hubert Chanson was on the second kayak from the left. Right: On 28 September 2008 at 16:50, looking upstream from behind the bore front while riding a dinghy.

Figure 4. Garonne River tidal bore at Pont de Podensac. Above: On 21 July 2008 at 20:00. Note the breaking bore next to the left bank while the bore front vanished in the deeper middle section of the river. Right: On 27 September 2008 at 16:50. The bore front extended across the entire river width.

ber 2008 (Figure 3A). Both experiences were memorable.

Importantly these highlighted the rapid evolution of the tidal bore shape and appearance in response to the estuarine bathymetry. In regions of deeper water, the bore may disappear, while it may strengthen in regions of shallow waters and sand banks. The bore may vanish for several kilometres, and then re-appear as an undular bore. In very shallow regions, the bore may even break, implying that the bore Froude number exceeds 1.5 to 1.8 (Koch and Chanson 2008, Chanson 2009). Further, in a given river section, the tidal bore may have a breaking bore appearance next to the bank in shallow waters, and have an undular shape in a deeper section of the river channel (Figure 2 and 4A). The bore characteristics are functions of the tidal range, channel bathymetry and freshwater conditions. Stronger bores are typically experience during low-water periods. For example, let us compare Figures 4A and 4B taken two months apart. In Figure 4B (September 2008), the water level was nearly 1 m lower than in July 2009 and the bore was stronger.

Figure 5. Garonne River tidal bore upstream of Cadillac on 28 September 2008 at 17:50. Note the breaking bore front.

Figures 2 to 5 shows some recent photographs of the Garonne River tidal bore. These were taken at various locations listed in Figure 1B, from the most downstream (Figure 2) to the most upstream (Figure 5). Figure 3 illustrates the tidal bore at Baurech seen from different places: Figure 3A was taken from the left bank looking downstream at the incoming bore front, while Figure 3B was taken from a dinghy riding on the whelps behind the bore front. Figure 4 was shot from Pont de Podensac, looking downstream. Figure 5 illustrates the breaking bore in a region of shallow bathymetry upstream of Cadillac.

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REFERENCES

Bazin, H., 1865. "Recherches Expérimentales sur la Propagation des Ondes." ('Experimental Research on Wave Propagation.') *Mémoires présentés par divers savants à l'Académie des Sciences*, Paris, France, 19, 495-644 (in French).

Chanson, H., 2004. "Coastal Observations: The Tidal Bore of the Sélune River, Mont Saint Michel Bay, France." *Shore & Beach*, 72(4), 14-16.

Chanson, H., 2008. "Photographic Observations of Tidal Bores (Mascarets) in France." *Hydraulic Model Report No. CH71/08*, Div. of Civil Engineering, The University of Queensland, Brisbane, Australia, 104 pages, one movie and two audio files (ISBN 9781864999303).

Chanson, H., 2009. "Current Knowledge In Hydraulic Jumps And Related Phenomena. A Survey of Experimental Results." *European Journal of Mechanics B/Fluids*, 28(2), 191-210 (DOI: 10.1016/j.euromechflu.2008.06.004).

Koch, C., and H. Chanson 2008. "Turbulent Mixing beneath an Undular Bore Front." *J. Coastal Res.*, 24(4), 999-1007 (DOI: 10.2112/06-0688.1).

Malandain, J.J,. 1988. "La Seine au Temps du Mascaret." ("The Seine River at the Time of the Mascaret.") *Le Chasse-Marée*, 34, 30-45 (in French).

Tessier, B., and J.H.J. Terwindt 1994. "An Example of Soft-Sediment Deformations in an intertidal Environment -- The Effect of a Tidal Bore." *Comptes-Rendus de l'Académie des Sciences*, Série II, 319(2), Part 2, 217-233 (in French).

Tricker, R.A.R., 1965. "Bores, Breakers, Waves and Wakes." American Elsevier Publ. Co., New York, USA.

Audiovisual references

Chanson, H., 2005. "Tidal Bore of the Dordogne River (France) on 27 September 2000." *Flowvis: the Art of Fluid Dynamics*, Australian Institute of Physics' (AIP) "Physics for the Nation" Congress, Australian National University (ANU), School of Art, Canberra, Australia, 31 January to 4 February 2005.

Also *Flowvis: the Art of Fluid Dynamics*, South Australian Museum, Adelaide, 8-25 April 2005.

Also *Flowvis Exhibition*, Multimedia art gallery, Frankston, Victoria, 6-20 November 2005. {http://artscentre.frankston.vic.gov.au/Venues/Cube_37/index.aspx}

"Les Fils de la Lune" 2005 by Michel Lespinasse, *Grand Angle production*, France, 50 minutes. The documentary "Les Fils de la Lune" ("Children of the Moon") was shown in Thalassa on Channels FR3 and TV5 in November 2005 (over 120 million subscribers worldwide), and on SBS (Australia) on 14 March 2009.

NHK Japan Broadcasting Corp (1989). "Pororoca: the Backward Flow of the Amazon." Videocassette VHS colour, NHK, Japan, 29 minutes.

"Rendez Vous avec le Dragon" (2008) by Michel Lespinasse, Thalassa on Channel France 3, 7 March. 2008.

"La Tribu du Mascaret" (2004) by Michel Lespinasse, *Grand Angle production*, France, 30 minutes. Thalassa on Channel France 3, 9-10 Dec. 2004.

"Surfing the Dordogne," SBS, Australia, 7 October 2006.

Internet references

IAHR Library {http://www.iahrmedialibrary.net}

+ "Tidal bore of the Dordogne River, France on 27 September 2000" (2000) by Hubert Chanson, IAHR Media Library, video file (1:10).
+ "Tidal bore of the Sélune River, Baie du Mont Saint Michel, France on 7 April 2004 (1)" (2004) by Hubert Chanson, IAHR Media Library, video file (0:38).
+ "Tidal bore of the Sélune River, Baie du Mont Saint Michel, France on 7 April 2004 (2)" (2004) by Hubert Chanson, IAHR Media Library, video file (1:09).
+ "Tidal bore of the Sélune River, Baie du Mont Saint Michel, France on 7 April 2004 (3)" (2004) by Hubert Chanson, IAHR Media Library, video file (1:09).

The tidal bore of the Seine river (*mascaret*) {http://www.uq.edu.au/~e2hchans/mascaret.html}

Tidal bores, *mascaret*, pororoca. Myths, fables and reality {http://www.uq.edu.au/~e2hchans/tid_bore.html}

Free-surface undulations in open channels: undular jups, undular surges, standing waves {http://www.uq.edu.au/~e2hchans/undular.html}

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