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[Supplementary material]

A great wave: the Storegga tsunami and the end of Doggerland?

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Table S1 presents details of all Storegga deposits shown in Figure 1. This includes those from around the North Sea basin and southern Norwegian Sea; more extensive reviews can be found in Long (2018) and Bondevik (2019). A number of sites have not been included, either because they are beyond the limits of the map, or do not border on the North Sea or southern Norwegian Sea, including sites from Greenland (Wagner *et al.* 2007), the Faroe Islands (Grauert *et al.* 2001), northern Norway (Romundset & Bondevik 2011; Rasmussen *et al.* 2018) and the east coast of Denmark (Noe Nygaard *et al.* 2005). Furthermore, a number of places where Storegga has been attested comprise multiple discrete sampling points, e.g. Bjugn in Northern Norway (Bondevik *et al.* 1997: fig. 6), or Nordfjord (Vasskog *et al.* 2013). Finally, still other sites, e.g. Hålandsvannet and Braastadvann in Norway, have been excluded on the grounds that although Storegga deposits have been suggested (Prøsch-Danielsen 2006), the dating of these sites is unclear, and the deposits are noted as being unlike other documented Storegga facies—the ‘so-called’ Storegga deposit at the Stavanger Sola Airport is included here due to its possible association with archaeological materials, although the veracity of this site, along with Lego (I & II), remains unconfirmed (Prøsch-Danielsen 2006; Bang-Andersen 1995).

Table S1. Tsunami deposits shown in Figure 1. The relationship column refers to sites where tsunami deposits have been found at or near Mesolithic sites (C/U: Confirmed Underlying; C/O: Confirmed Overlying; C/A: Confirmed Association; U/A: Unconfirmed Association).

Site	Longitude*	Latitude*	Relationship	References
<i>Denmark</i>				
Rømø	8.5332	55.1566		(Fruergaard <i>et al.</i> 2015; Bondevik 2019)
Skagen Odde	10.416	57.665		(Noe Nygaard 2005)
<i>Norway</i>				
Austrheim	4.926	60.757		(Bondevik <i>et al.</i> 1997a; Bondevik 2019)
Bergsøy / Leinøy	5.655	62.322		(Svendsen 1985; Svendsen & Mangerud 1990; Bondevik <i>et al.</i> 1997a; Bondevik 2019)
Bjugn	9.837	63.822		(Bondevik <i>et al.</i> 1997a; Bondevik 2019)
Bømlo	5.173	59.691		(Bondevik <i>et al.</i> 1997a; Bondevik 2019)
Dysvikja	6.411	62.690	C/U	(Bondevik 2019)
Florø	5.031	61.596		(Aksdal 1986; Bondevik <i>et al.</i> 1997a; Bondevik 2019)
Harøy	6.464	62.763		(Bondevik 2003a; 2019)
Hommelstø	12.574	65.384		(Bondevik 2003b, 2019; Bondevik <i>et al.</i> 2012; Rydgren & Bondevik 2015;)
Kotedalen	4.916	60.739	U/A	(Warren 1995; 1994; S. Bondevik <i>pers. comm.</i>)
Lego	5.614	58.795	U/A	(Bang-Andersen 1995; Estèvez 2008)
Longva	6.276	62.662	C/O	(Bondevik <i>et al.</i> 2019)
Nordfjord	6.946	61.938		(Vasskog <i>et al.</i> 2013; Bondevik 2019)
Stavanger Sola	5.634	58.886	U/A	(Prøsch-Danielsen 2006)
Sula	6.247	62.431		(Bondevik <i>et al.</i> 1997a; Bondevik 2019)
<i>Britain</i>				
Barnyards	-4.4610	57.4621		(Haggart 1982; Long 2018)
Bellevue	-4.4417	57.4997		(Firth 1984; Long 2018)

Broomhouse Farm	-1.9411	55.7003		(Horton <i>et al.</i> 1999; Shennan <i>et al.</i> 2000; Long 2018)
Broughty Ferry	-2.8539	56.4710	U/A	(Hutcheson 1886; Lacaille 1954; Smith <i>et al.</i> 2004; Long 2018)
Burragarth	-0.9499	60.7138		(Smith 1993; Smith <i>et al.</i> 2004; Long 2018)
Castle St. Inverness	-4.2217	57.4786	C/U	(Wordsworth 1985; Dawson <i>et al.</i> 1990; Long 2018)
Cocklemill Burn	-2.8672	56.1977		(Tooley & Smith 2005; Long 2018)
Craigie	-2.8833	56.4070		(Haggart 1978; Long 2018)
Creich	-4.2777	57.8685		(Smith <i>et al.</i> 1992; Long 2018)
Dounie	-4.1971	57.8456		(Smith <i>et al.</i> 1992; Long 2018)
Dryleas	-2.4806	56.7363		(Smith & Cullingford 1985; Long 2018)
Dubton	-2.4904	56.7326		(Smith & Cullingford 1985; Long 2018)
Fullerton	-2.5307	56.6947		(Smith <i>et al.</i> 1980; Long 2018)
Garth Loch	-1.1504	60.2663		(Bondevik <i>et al.</i> 2005; Long 2018)
Garth's Voe	-1.2565	60.4492		(Long 2018)
Goodie Water	-4.2168	56.1764		(Holloway 2002; Long 2018)
Hedderwick	-2.5773	55.9999		(Long 2018)
Howick	-1.5917	55.4406	C/A	(Boomer <i>et al.</i> 2007; Long 2018)
Loch Eriboll	-4.7433	58.4485		(Long <i>et al.</i> 2016; Long 2018)
Loch of Benston	-1.1595	60.2645		(Bondevik <i>et al.</i> 2005; Long 2018)
Loch of Flugarth	-1.3399	60.5972		(Bondevik <i>et al.</i> 2002; Long 2018)
Lochhouses	-2.6162	56.0303		(Newey 1965; Smith <i>et al.</i> 1991; Long 2018)
Low Hauxley	-1.5542	55.4406	C/A	(Waddington 2014; Long 2018)
Maggie Kettle's Loch	-1.3326	60.4631		(Bondevik <i>et al.</i> 2002; 2003 Long 2018)
Maryton	-2.5177	56.7002		(Smith <i>et al.</i> 1980; Long 2018)
Mid Yell	-1.0849	60.6056		(Costa <i>et al.</i> 2015; Long 2018)
Moniack	-4.4308	57.4621		(Haggart 1982; Smith <i>et al.</i> 1985; Long 2018)
Munlochy Bay	-4.2609	57.5462		(Firth 1984; Long 2018)

Northton	-7.0596	57.7975	C/A	(Jordan <i>et al.</i> 2010; Gregory <i>et al.</i> 2005; Long 2018)
Norwick	-0.8035	60.8051		(Smith 1993; Smith <i>et al.</i> 2004; Long 2018)
Old Montrose	-2.5438	56.6992		(Smith & Cullingford 1985; Long 2018)
Otter Loch	-1.3168	60.4369		(Bondevik <i>et al.</i> 2002; Long 2018)
Over Easter Offerance	-4.2902	56.1373		(Sissons & Smith 1965; Long 2018)
Puggieston	-2.4937	56.7335		(Smith & Cullingford 1985; Long 2018)
Scatsta Voe	-1.2805	60.4367		(Birmie 1981; Smith 1993; Smith <i>et al.</i> 2004; Long 2018)
Silver Moss	-2.8847	56.4007		(Chisholm 1971; Long 2018)
Smithy House	-4.0100	57.9656		(Smith <i>et al.</i> 1992; Long 2018)
Snarravoe	-0.9579	60.6923		(Bondevik <i>et al.</i> 2005; Long 2018)
St Michael's Wood	-2.8864	56.4043		(Haggart 1978; Long 2018)
Strath Halladale	-3.9069	58.5377		(Dawson & Smith 1997; Dawson & Smith 2000; Long 2018)
Talisker Bay	-6.4574	57.2850		(Selby & Smith 2015; Long 2018)
Tarty Burn	-2.0299	57.3346		(Smith <i>et al.</i> 1999; Long 2018)
The Houb, Sullom Voe	-1.3364	60.4550		(Bondevik <i>et al.</i> 2002, 2003, 2005; Long 2018)
Tomich	-4.4611	57.4912		(Firth 1984; Long 2018)
Water of Philorth	-1.9765	57.6670		(Smith <i>et al.</i> 1982, 2004; Long 2018)
Waterside	-1.9884	57.3310		(Smith <i>et al.</i> 1983; Long 2018)
Whalefirth	-1.1193	60.6048		(Casalho <i>et al.</i> 2016; Long 2018)
Wick River	-3.1276	58.4535		(Dawson & Smith 1997; Long 2018)

* Coordinates for sites from the UK are sourced from Long (2018), and for Rømø, from Fruergaard *et al.* (2015). All other coordinates are approximations based on location maps published in corresponding references.


Unit Number	Core
1A-1	
1A-2	
1A-3	
1A-4	
1A-5	
1A-6	
1A-7	

Figure S1. Core section for ELF001A. Accompanying core log details (unit depth and lithological description) presented in Table S2 (image courtesy of M. Bates).

Table S2. Core-Log for ELF001A (see Figure S1) showing 7 units spanning a depth of 3.50m (core terminus). Units 1A-5 and 1A-6 constitute the posited Storegga tsunami event, with a weighted combination optically stimulated luminescence (OSL) depositional age for Units 1A-5 and 1A-6: 8.14 ± 0.29 ka (lithological description courtesy of M. Bates; OSL dating courtesy of T. Kinnaird; For technical details and protocols, see Gaffney *et al.* (2020: supplementary material)).

Unit number	Depth below ground surface (m)	Lithological description
1A-1	0.00–0.21	Yellow shell gravel with whole and fragmented shell. Small sub-rounded to sub-angular gravel clasts (<10mm). Structureless and loose/unconsolidated. <i>(Sharp Contact)</i>
1A-2	0.21–0.67	Pale greyish yellow medium sand. Structureless. Occasional small (2–4mm) shell fragments. Some black flecks below 0.46m. <i>(Abrupt Contact)</i>
1A-3	0.67–0.90	Greyish yellow medium sand with common shell fragments. Some possibly articulated Mytilus shells. Some burrowing evident, possibly very crudely bedded. Loose and unconsolidated. Some small stones. <i>(Abrupt Contact)</i>
1A-4	0.90–1.09	Mid to dark grey, very well laminated fine sands and silts. Predominantly sub-horizontal laminations of 2–4mm thick. Occasional dipping laminations of sand. Occasional shell fragments. Moderately cohesive.

		<i>(Abrupt Contact)</i>
1A-5	1.09–1.19	Dark grey silty fine sand with common shell fragments. Shells are <4mm commonly but with occasional fragments >30mm. Shells are broken and sharp/fresh. Possibly some crude bedding. Moderately firm and compact. <i>(Diffuse Contact)</i>
1A-6	1.19–1.51	Grey medium sand with very common shells fragments including whole shells and freshly broken shell fragments. Small stones throughout unit. Loose, unconsolidated and structureless. OSL depositional age for Units 1A-5 and 1A-6: 8.14±0.29ka <i>(Sharp Contact)</i>
1A-7	1.51–3.50	Mid to dark grey finely laminated silts and fine sands. Sub-horizontal laminations from 2–3mm thick to 10mm thick. Occasional brown organic fragments. Moderately firm and compact. Occasional sand beds 20mm thick. Possibly becoming more silty with depth. <i>(Base)</i>

References

- AKSDAL, S. 1986. Holocene vegetasjonsutvikling og havnivåendringer i Florø, Sogn og Fjordane. Unpublished PhD dissertation, University of Bergen.
- BANG-ANDERSEN, S. 1995. Mesolithic man and the rising sea spotlighted by three tapes-transgressed sites in SW Norway, in A. Fischer (ed.) *Man & sea in the Mesolithic: coastal*

- settlement above and below present sea-level* (Oxbow Monograph 52): 113–21. Oxford: Oxbow.
- BIRNIE, J.F. 1981. Environmental changes in Shetland since the end of the last glaciation. Unpublished PhD dissertation, University of Aberdeen.
- BONDEVIK, S. 2003a. Storegga tsunami sand in peat below the Tapes beach ridge at Harøy, western Norway, and its possible relation to an early Stone Age settlement. *Boreas* 32: 476–83. <https://doi.org/10.1080/03009480310003379>
- 2003b. *Records of paleo-tsunamis around the Norwegian Seas*. Tromsø: University of Tromsø.
- 2019. Tsunami from the Storegga landslide, in R.A. Meyers (ed.) *Encyclopedia of complexity and systems science*: 1–33. Berlin: Springer.
- BONDEVIK S., J.I. SVENDSEN, G. JOHNSEN, J. MANGERUD & P.E. KALAND. 1997a. The Storegga tsunami along the Norwegian coast, its age and runup. *Boreas* 26: 29–53. <https://doi.org/10.1111/j.1502-3885.1997.tb00649.x>
- BONDEVIK, S. 2002. Records of palaeotsunamis around the Norwegian Seas. University of Tromsø: Norsk Hydro Contract: NHT-B4407822-00, 124p.
- BONDEVIK, S., J. MANGERUD, S. DAWSON, A. DAWSON & Ø. LOHNE. 2005. Evidence for three North Sea tsunamis at the Shetland Islands between 8000 and 1500 years ago. *Quaternary Science Reviews* 24: 1757–75. <https://doi.org/10.1016/j.quascirev.2004.10.018>
- BONDEVIK, S., S.K. STORMO & G. SKJERDAL. 2012. Green mosses date the Storegga tsunami to the chilliest decades of the 8.2 ka cold event. *Quaternary Science Reviews* 45: 1–6. <https://doi.org/10.1016/j.quascirev.2012.04.020>
- BONDEVIK, S., T. KLUNGSETH LØDØEN, C. TØSSEBRO, H. ÅRSKOG, LOE HJELLE & I.K. MEHL. 2019. Between winter storm surges: human occupation on a growing Mid-Holocene transgression maximum (Tapes) beach ridge at Longva, Western Norway. *Quaternary Science Reviews* 215: 116–31. <https://doi.org/10.1016/j.quascirev.2019.05.006>
- BOOMER, I., C. WADDINGTON, T. STEVENSON & D. HAMILTON. 2007. Holocene coastal change and geo-archaeology at Howick, Northumberland, UK. *The Holocene* 17: 89–104. <https://doi.org/10.1177/0959683607073281>
- CASCALHO, J., P. COSTA, S. DAWSON, F. MILNE & A. ROCHA. 2016. Heavy mineral assemblages of the Storegga tsunami deposit. *Sedimentary Geology* 334: 21–33. <https://doi.org/10.1016/j.sedgeo.2016.01.007>
- CHISHOLM, J.I. 1971. The stratigraphy of the post-glacial marine transgression of NE Fife. *Bulletin of the Geological Survey of Great Britain* 37: 91–107.

- COSTA, P.J., C. ANDRADE, J. CASCALHO, A.G. DAWSON, M.C. FREITAS, R. PARIS & S. DAWSON. 2015. Onshore tsunami sediment transport mechanisms inferred from heavy mineral assemblages. *The Holocene* 25: 795–809. <https://doi.org/10.1177/0959683615569322>
- DAWSON, S. & D.E. SMITH. 1997. Holocene relative sea-level changes on the margin of a glacio-isostatically uplifted area: an example from northern Caithness, Scotland. *The Holocene* 7: 59–77. <https://doi.org/10.1177/095968369700700106>
- 2000. The sedimentology of Middle Holocene tsunami facies in northern Sutherland, Scotland, UK. *Marine Geology* 170: 169–79. [https://doi.org/10.1016/S0025-3227\(00\)00066-9](https://doi.org/10.1016/S0025-3227(00)00066-9)
- DAWSON, A.G., D.E. SMITH & D. LONG. 1990. Evidence for a tsunami from a Mesolithic site in Inverness. *Journal of Archaeological Science* 17: 509–12. [https://doi.org/10.1016/0305-4403\(90\)90031-Y](https://doi.org/10.1016/0305-4403(90)90031-Y)
- ESTÉVEZ, J. 2008. Catastrophes or sudden changes: the need to review our time perspective in Prehistory, in L. Buchet, C. Rigeade, I Séguy & M. Signoli (ed.) *Vers une anthropologie des catastrophes: actes des 9e Journées d'anthropologiques de Valbonne (22–24 mai 2007)*: 19–35. Antibes: APDCA.
- FIRTH, C.R. 1984. Raised shorelines and ice limits in the inner Moray Firth and Loch Ness areas, Scotland. Unpublished PhD dissertation, Coventry (Lanchester) Polytechnic.
- FRUERGAARD, M., S. PIASECKI, P.N. JOHANNESSEN, N. NOE-NYGAARD, T.J. ANDERSEN, M. PEJRUP & L.H. NIELSEN. 2015. Tsunami propagation over a wide, shallow continental shelf caused by the Storegga Slide, southeastern North Sea, Denmark. *Geology* 43: 1047–50. <https://doi.org/10.1130/G37151.1>
- GRAUERT, M., S. BJÖRCK & S. BONDEVİK. 2001. Storegga tsunami deposits in a coastal lake on Suðuroy, the Faroe Islands. *Boreas* 30: 263–71. <https://doi.org/10.1080/030094801317094137>
- GREGORY, R.A., E.M. MURPHY, M.J. CHURCH, K.J. EDWARDS, E.B. GUTTMANN & D.D.A. SIMPSON. 2005. Archaeological evidence for the first Mesolithic occupation of the Western Isles of Scotland. *The Holocene* 15: 944–50. <https://doi.org/10.1191/0959683605hl868ft>
- HAGGART, B.A. 1978. A pollen and stratigraphical investigation into a peat deposit in St. Michael's Wood, near Leuchars, Fife. Unpublished Master's dissertation, University of St. Andrews.
- 1982. Flandrian sea-level changes in the Moray Firth area. Unpublished PhD dissertation, University of Durham.

- HOLLOWAY, L.K. 2002. Sedimentary environments in the western Forth valley during the Late Devensian and early Holocene. Unpublished PhD dissertation, Coventry University.
- HORTON, B.P., J.P. INNES, I. SHENNAN, W.R. GEHRELS, J.M. LLOYD, J.J. MCARTHUR & M.M. RUTHERFORD. 1999. The Northumberland coast, in D.R. Bridgland, B.P. Horton & J.P. Innes (ed.) *The Quaternary of North-East England: field guide*: 146–65. London: Quaternary Research Association.
- HUTCHESON, A. 1886. Notice of the discovery of a stratum containing worked flints at Broughty-Ferry. *Proceedings of the Society of Antiquaries of Scotland* 20: 166–69.
- JORDAN, J.T., D.E. SMITH, S. DAWSON & A.G. DAWSON. 2010. Holocene relative sea-level changes in Harris, Outer Hebrides, Scotland, UK. *Journal of Quaternary Science* 25: 115–34. <https://doi.org/10.1002/jqs.1281>
- LACAILLE, A.D. 1954. *The Stone Age in Scotland*. Oxford: Oxford University Press.
- LONG, A.J., N.L.M. BARLOW, S. DAWSON, J. HILL, J.B. INNES, C. KELHAM, F.D. MILNE & A. DAWSON. 2016. Lateglacial and Holocene relative sea-level changes and first evidence for the Storegga tsunami in Sutherland, Scotland. *Journal of Quaternary Science* 31: 239–55. <https://doi.org/10.1002/jqs.2862>
- LONG, D. 2018. Cataloguing tsunami events in the UK, in E.M. Scourse, N.A. Chapman, D.R. Tappin & S.R. Wallis (ed.) *Tsunamis: geology, hazards and risks* (Geological Society Special Publication 456): 143–65. London: Geological Society. <https://doi.org/10.1144/SP456.10>
- NEWAY, W.W. 1965. Post-glacial vegetational and climatic changes in part of south-east Scotland as indicated by the pollen-analysis and stratigraphy of some of its peat and lacustrine deposits. Unpublished PhD dissertation, University of Edinburgh.
- NOE-NYGAARD, N., N. NIELSEN & S.U. HEDE. 2005. En tsunami i Danmark? *Geoviden. Geologi og Geografi* 4: 16–19.
- PRØSCH-DANIELSEN, L. 2006. Sea-level studies along the coast of southwestern Norway, with emphasis on three short-lived Holocene marine events. *AmS-Skrifter* 20: 1–94.
- RASMUSSEN, H., S. BONDEVİK & G.D. CORNER. 2018. Holocene relative sea level history and Storegga tsunami run-up in Lyngen northern Norway. *Journal of Quaternary Science* 33: 393–408. <https://doi.org/10.1002/jqs.3021>
- ROMUNDSET, A. & S. BONDEVİK. 2011. Propagation of the Storegga tsunami into ice-free lakes along the southern shores of the Barents Sea. *Journal of the Quaternary Science* 26: 457–62. <https://doi.org/10.1002/jqs.1511>

- RYDGREN, K. & S. BONDEVIK. 2015. Moss growth patterns and timing of human exposure to a Mesolithic tsunami in the North Atlantic. *Geology* 43: 111–14.
<https://doi.org/10.1130/G36278.1>
- SELBY, K.A. & D.E. SMITH. 2015. Holocene relative sea-level change on the Isle of Skye, Inner Hebrides, Scotland. *Scottish Geographical Journal* 132: 42–65.
<https://doi.org/10.1080/14702541.2015.1051102>
- SHENNAN, I., B. HORTON, J. INNES, R. GEHRELS, J. LLOYD, J. MCARTHUR & M. RUTHERFORD. 2000. Late Quaternary sea-level changes, crustal movements and coastal evolution in Northumberland, UK. *Journal of Quaternary Science* 15: 215–37.
[https://doi.org/10.1002/\(SICI\)1099-1417\(200003\)15:3<215::AID-JQS505>3.0.CO;2-#](https://doi.org/10.1002/(SICI)1099-1417(200003)15:3<215::AID-JQS505>3.0.CO;2-#)
- SISSONS, J.B. & D.E. SMITH. 1965. Peat bogs in a postglacial sea and a buried raised beach in the western part of the Carse of Stirling. *Scottish Journal of Geology* 1: 247–55.
<https://doi.org/10.1144/sjg01030247>
- SMITH, D.E. 1993. Norwick, Unst; Burragarth, Unst; Sullom Voe, Mainland, in J. Birnie, J. Gordon, K. Bennett & A. Hall (ed.) *The Quaternary of Shetland: Quaternary Research Association field guide: 52–56*.
- SMITH, D.E. & R.A. CULLINGFORD. 1985. Flandrian relative sea-level changes in the Montrose Basin Area. *Scottish Geographical Magazine* 101: 91–104.
<https://doi.org/10.1080/14702548508554960>
- SMITH, D.E., R.A. CULLINGFORD & W.P. SEYMOUR. 1982. Flandrian relative sea-level changes in the Philorth valley, North-East Scotland. *Transaction of the Institute of British Geographers (New Series)* 7: 321–36. <https://doi.org/10.2307/621994>
- SMITH, D.E., MORRISON, J., JONES, R.L. & R.A. CULLINGFORD. 1980. Dating the main postglacial shoreline in the Montrose area, Scotland, in R.A. Cullingford, D.A. Davidson & J. Lewin (ed.) *Timescales in Geomorphology: 225–245*. Chichester: Wiley.
- SMITH, D.E., R.A. CULLINGFORD & C.L. BROOKS. 1983. Flandrian relative sea level changes in the Ythan valley, northeast Scotland. *Earth Surface Processes and Landforms* 8: 423–38.
<https://doi.org/10.1002/esp.3290080504>
- SMITH, D.E., R.A. CULLINGFORD & B.A. HAGGART. 1985. A major coastal flood during the Holocene in eastern Scotland. *Eiszeitalter und Gegenwart* 35: 109–18.
<https://doi.org/10.3285/eg.35.1.14>
- SMITH, D.E., S.C. TURBAYNE, A.G. DAWSON & K.R. HICKEY. 1991. *The temporal and spatial variability of major floods around European coasts*. (Final report of Coventry Polytechnic, Contract EV4C 0047 UK (H)). Brussels: European Commission.

- SMITH, D.E., C.R. FIRTH, S.C. TURBAYNE & C.L. BROOKS. 1992. Holocene relative sea-level changes and shoreline displacement in the Dornoch Firth area, Scotland. *Proceedings of the Geologist's Association* 103: 237–57. [https://doi.org/10.1016/S0016-7878\(08\)80232-5](https://doi.org/10.1016/S0016-7878(08)80232-5)
- SMITH, D.E., C.R. FIRTH, C.L. BROOKS, M. ROBINSON & P.E.F. COLLINS. 1999. Relative sea-level rise during the Main Postglacial Transgression in NE Scotland, UK. *Transactions of the Royal Society of Edinburgh: Earth Science* 90: 1–27. <https://doi.org/10.1017/S0263593300002480>
- Svensden, J. 1985. *Strandforskyvning på Sunnmøre. Bio-og litostratigrafiske undersøkelser på Gurskøy, Leinøy og Bergsøy*. Bergen, Bergen 142p.
- SMITH, D.E. *et al.* 2004. The Holocene Storegga Slide tsunami in the United Kingdom. *Quaternary Science Reviews* 23: 2291–321. <https://doi.org/10.1016/j.quascirev.2004.04.001>
- Svensden, J.I. & J. Mangerud. 1990. Sea-level changes and pollen stratigraphy on the outer coast of Sunnmøre western Norway. *Norwegian Journal of Geology* 70: 111–134.
- TOOLEY, M.J. & D.E. SMITH. 2005. Relative sea-level change and evidence for the Holocene Storegga Slide tsunami from a high-energy coastal environment: Cocklemill Burn, Fife, Scotland, UK. *Quaternary International* 133–134: 107–19. <https://doi.org/10.1016/j.quaint.2004.10.007>
- VASSKOG, K., N. WALDMANN, S. BONDEVIK, A. NESJE, E. CHAPERON & D. ARIZTEGUI. 2013. Evidence for Storegga tsunami run-up at the head of Nordfjord, western Norway. *Journal of Quaternary Science* 28: 391–402. <https://doi.org/10.1002/jqs.2633>
- WADDINGTON, C. 2014. *Rescued from the sea: an archaeologist's tale*. Bakewell: Archaeological Research Services and Northumberland Wildlife Trust.
- WAGNER, B., O. BENNIKE, M. KLUG & H. CREMER. 2007. First indication of Storegga tsunami deposits from East Greenland. *Journal of Quaternary Science* 22: 321–25. <https://doi.org/10.1002/jqs.1064>
- WARREN, E.J. 1994. Coastal sedentism during the Atlantic period in Nordhordland, western Norway? The Middle and Late Mesolithic components at Kotedalen. Unpublished Master's dissertation, Memorial University of Newfoundland.
- 1995. Fra Sandlinsen til syndfloden. *Arkeo: Nytt Fra Arkeologisk Institutt Universitetet I Bergen* 2: 10–17.
- WORDSWORTH, J. 1985. The excavation of a Mesolithic horizon at 13–24 Castle Street, Inverness. *Proceedings of the Society of Antiquaries of Scotland* 115: 89–103.