

N° XXIII.

A Thermometrical Journal of the temperature of the atmosphere and Sea, on a voyage to and from Oporto, with explanatory observations thereon.

Philadelphia, Sept. 18, 1792.

S I R,

Read Sept.
21st, 1792.

ON the 15th of June last Capt. William Billings of this city, commander of the ship Apollo, presented the journals of his voyages to and from Oporto, for the inspection of the American Philosophical Society. As they were not accompanied by any explanatory memoir, I have extracted from them what alone differs from sea reckoning in general, and inclose a thermometrical journal of the temperature of the atmosphere and sea, which evidently appears to be the object of the communication. As it was proper to show that these observations were not imaginary, and had arisen in the course of his voyages, Capt Billings presented his whole journals, consisting of 73 pages in folio, with all the detail of a log book, which in original are deposited among the society's papers. *

As the experiments of this intelligent navigator, appear to be repetitions of those I made near two years before, which are related in my memoir No. X. page 82 of this volume, I beg leave to make the following observations on them.

By these journals it appears that in June, 1791, the water on the coast was at the temperature of 61°. by Fahrenheit, and in the Gulph stream at 77°. By my journals it will be found that in November, 1789, the water on the coast

* The temperature of the water was tried several times every day, but in this extract it was thought proper only to notice the important changes, a succession of similar results being thought unnecessary.

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coast was at 47° . and in the gulph stream at, 70° . viz.

By Capt. Billings, 1791, June, coast, 61 do. Stream, 77 <hr style="width: 50%; margin-left: auto; margin-right: 0;"/> do. stream warmer, 16	By my experiments 1789 Nov. coast, 47 do. stream, 70 <hr style="width: 50%; margin-left: auto; margin-right: 0;"/> do. stream warmer 23	diff. between June and Nov. 14°. 7 <hr style="width: 50%; margin-left: auto; margin-right: 0;"/>
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Hence it may be concluded that although this difference of heat is more remarkable in winter than in summer, yet it is sufficient at all times to guide navigators, so as to take the benefit of its current in going from, and to avoid its opposition in coming to America.—In the latter case, it has this additional convenience in correcting a reckoning; for if a navigator can, by this means, know the moment he is within the stream, he knows at the same moment his relative situation as to the coast; and if by repeated experiment this mode of correction should be found solid, it amounts, in effect, to a certainty of the longitude, at the precise time when it is important to be accurate.

Captain Billings' course being nearly along the stream, he found only such alteration in the heat of the water as may be accounted for by the cooling of the stream itself, in its course to the northward, 'till he came to lat. 39. 00. N. long. 56. 00. W. (a breast of the Banks of Newfoundland) when the mercury fell 10° . Doctor Franklin, in November, 1776, on board of the Reprisal, in lat. 41. N. long. 46. W. found about the same difference; but the Reprisal had kept a course farther south and came into this cool water in a N. N. E. direction; while Captain Billings being farther North, came in an easterly direction, and of course might be as much within the influence

of that chain of banks which extends from the longitude 45 W. along the American coast, as the Reprifal was when so much farther to the eastward. In November 1789, I found the same difference in lat. 40. N. long. 49. W. after sailing in a direction about N. E. and a line being drawn from the place where Captain Billings's change happened, to that where Doctor Franklin's thermometer fell (in a direction about E. N. E.) would nearly intersect the place where I observed the same alteration; this is about the sweep of the banks, known by frequent founding, as will be found by consulting the best charts.—By the coincidence of these three journals, at so great a distance of time, and without any knowledge of, consequently without any connection with each other, this important fact seems to be established. *A navigator may discover his approach towards objects of danger, when he is at such a distance as to be able easily to avoid them, by attentively examining the temperature of the sea.*

After having passed the banks, Captain Billings found but little difference during 18 days sail, till he came near the European coast. The same uniformity appears in my journal on a voyage to England, Page 85 of this volume.

Captain Billings found the water to grow cooler three days before he made the land, and the mercury fell gradually from 65 to 60° when the land appeared: this was in June. In November I found on approaching the English coast a gradual fall from 53 to 48° and then we struck foundings. Here the difference between the sea and coast water was in both cases the same, though the heat of both varied with the season.

Returning from Oporto, Captain Billings marked his approach to, and departure from the western Islands by the changes of his thermometer, but in this case the difference was small; because, owing to the climate and size
of

of these Islands, the land cannot be so cold as a northern continent naturally must be. Indeed, the usefulness of the thermometer seems to be applicable to the more dangerous situations, and not to Islands in warm climates; I should suppose, for obvious reasons, that the changes would not be great about the Islands situated between the tropics. The shore of these Islands is generally bold, and the land being very high, may be seen at a great distance. The climate is not subject to fogs, snow storms, Islands of Ice, long nights, &c. so that, except hurricanes, (which are more fatal to ships in port than at sea) there seems to be but little danger in such navigation.

After leaving the western Islands, Captain Billings steered to the westward, being in nearly the same latitude on the 30th ($37^{\circ} 47'$ N.) that he was on the 17th of August. ($37^{\circ} 53'$ N.) but during the intermediate time he was driven, as winds prevailed, in a zig zag course, as far North as $39^{\circ} 04'$ N. and as far south as $36^{\circ} 26'$ N. It appears also during this time that his thermometer varied from 1° to 5° ; but it is to be remarked that there is a medium in his thermometrical variations answering to the medium of his latitude. When he was in $39^{\circ} 04'$. the thermometer marked 75° and when in $36^{\circ} 26'$. it also marked 75° but when in $38^{\circ} 12'$ it marked 70° . Now considering that he had the warm influence of the gulph stream to the Northward, and that the ocean water to the southward must naturally be warmer than that more North, out of the stream, there seems to be a perfect agreement between theory and fact with regard to the usefulness of the thermometer in discovering the course of this current. The same thing occurred in the course of my passage in the London Packet with Doctor Franklin, (see Vol. 2 page 329 of the Transactions of this society) in
 June

June 1785. The mean there was 73 while to the northward and southward the thermometer marked 77.

Returning towards the coast of America, Captain Billings discovered his passage across the gulph stream by a sudden fall in the mercury of 5° from noon to night, and about 5° farther West, by a further fall in the space of 8 hours run, he discovered the coast, where he got soundings, before he saw the land.

The usefulness of the thermometer as a nautical instrument is not confined to the discovery of an approach towards objects of danger *known to exist*; but it, may if attended to, discover others *not at present supposed to exist*, against which a navigator cannot be on his guard. Several charts, particularly one made by Governor Pownall, in September 1787, point out rocks and breakers in the middle of the ocean; some are said to be uncertain, others have been seen but once, and preserve the names of their supposed discoverers. These facts are generally doubted, and by some mariners have been ridiculed; but it should be considered that in every instance where the discovery of these hidden dangers have been fatal, no one could escape to tell the melancholy tale, and surely the number of missing ships justifies a conjecture that such misfortunes have happened, and ought to influence every navigator to make accurate observations on the temperature of the sea during the *whole* of his voyage.

A gentleman of undoubted veracity related to me some time since, the following fact, which I mention on account of its aptitude to this subject.

On a voyage from the West-Indies to England, the small vessel he was in, touched at Bermuda. On leaving that island, having fine weather and a smooth sea, they sailed along a ridge of rocks, seeing the bottom very plain-

ly all the time, till the island was out of sight; in this place they spoke a large ship, the Captain of which, had no idea of his situation; he had not noticed the bottom, and was sailing in full confidence of being far from danger. On being desired to look over the side of his ship, the whole crew was in the utmost consternation, and hove the ship too, with all her sails set. He was soon informed of his true longitude, and took a new departure. Had this Captain kept a thermometrical journal he would not, probably, have been so deceived, and had he at this time been in a gale of wind, his error might have been fatal. Every body in this city remembers the dreadful catastrophe of the ship Faithful Steward, which was lost, on this coast, with near 500 people on board, about seven years since. The Captain was so sure of having sufficient sea room, that he did not think of founding, the weather was not boisterous and had he known his situation he might have stood off during the night. But fearless of a danger he did not know, he stood on with full sails, and was in an instant lost: I think there were not above twenty souls saved. A thermometer regularly used would have given warning in time, and probably have saved these lives.

The impression such events have made on my mind, has induced me to be thus particular, and I the more readily do justice, to the judicious example given to other Captains, by Captain Billings, because I think the observations of a mariner, are more likely to be attended to by mariners, than any instruction given by a landsman. I think besides, that the merit of Captain Billings, ought to be rewarded, by a publication of his laudable conduct

that

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that he may enjoy the reputation to which he is justly entitled.

I am with great respect, Sir
 Your most obedient and
 Most humble Servant,
 JONATHAN WILLIAMS,
 { One of the Secretaries of the }
 { American Philosophical Society. }

A Thermometrical Journal of the temperature of the atmosphere and sea on a passage from Philadelphia to Oporto in the Ship Apollo, by Captain William Billings.

1791 Dates.	Time.	Places in at Noon		Temp. of		Notes.	
		Latt. N.	Lon. W.	Air.	Water.		
June 6.	Sun-rise.	38	56	75	07		Off Cape Henlopen.—N. B. The thermometer on Fahrenheit's scale and the longitude West from London.—The days are reckoned to begin at Noon and to end at the succeeding noon according to the usage of navigators. June 8th. at 10 A. M. being the first alteration in the heat of the water after leaving the coast it is supposed we entered the gulph stream. The course is not across, but rather along this current, somewhat diagonally however. June 10th at noon it is supposed we are in the middle of the gulph stream. June 14th noon this sudden fall of 9° is supposed to be owing to the influence of the banks of Newfoundland which bear about N. July 4th the water appears to have changed colour. Land in sight, but frequently obscured by fog. Land distant about 6 leagues. Land distant about 2 leagues being the high land of Braganea nova
	2 P. M.	38	38	74	28		
	Sun sett.					65	
	8 10 A. M.					70	
	8 Noon.	37	18	72	34	75	
	10 Noon.	38	03	68	49	73	
	11 Noon.	38	51	65	57	66	
	12 Noon.	39	02	63	22	71	
	14 Noon.	39	11	56	48	62	
	15 Noon.	39	37	53	43	71	
{ From this date to the 2d July the variations in } { the heat of the sea water do not exceed two de- } { grees, they need not therefore be noticed. }							
July 2d	Noon.	40	16	15	34	68	65
3	Noon.	40	05	13	23	68	64
4	Noon.	40	28	11	13	68	63
5	2 P. M.					68	63
	7 P. M.						60
	8 A. M.						57
	Noon.						55

A Thermometrical

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A Thermometrical Journal of the temperature of the atmosphere and sea, on a passage from Oporto to Philadelphia, in the Ship Apollo, by Captain William Billings.

1771 Dates.	Time.	Places in at Noon.		Temp. of		NOTES.
		Lat. N.	Long. W.	Air.	Wat.	
Aug. 4.	10 A. M.				57	Port barr : bearing ESE dist. 7 leagues.
	Noon.	41 07	9 04		60	
5	Noon.	40 39	13 06	69	61	
6	8 A. M.			69	65	
	Noon.	40 35	17 06	69	67	} But about half of degree difference of latitude during 5 days, and little or no change in the temperature of the sea.
7	10 P. M.	40 29	20 24	68	68	
8	No on.	40 24	22 01	69	68	
9	No on.	41 00	22 49	68	68	
10	No on.	40 13	22 39	68	68	
11	No on.	38 42	24 02	69	71	N. B. 1 and $\frac{1}{2}$ degree fouthing water 3° warmer.
	10 P. M.				70	At 4 P M made the island St. Michael
	Midnight				69	Island dist. 4 leagues, tack'd and flood
12	Noon.	37 57	24 55	72	70	off, at 5 A. M. tack'd and flood to the southward.
14	Noon.	38 45	27 07	73	71	Made the island Tercera. at 4 P. M.
15	2 P. M.			72	70	
	Sunfet.			72	69	
	Sunrise.				68	Near Tercera, St. Georges and Pico in sight:
16	2 P. M.	38 24	27 51	73	70	
	Sunfet.				69	
	10 P. M.				68	Clofe in with St. Georges.
	Midnight				69	
	Noon.	37 53	27 20	73	71	Land out of sight:
17	10 P. M.				70	
	No on.	37 07	27 39		73	
18	Noon.	36 36	28 44		73	
19	Noon.	36 09	31 39		73	
20	Noon.	36 26	34 31		75	
21	10 P. M.				74	
	10 A. M.				70	
	Noon.				69	
22	Noon.	38 24	36 48		69	
23	Noon.	38 43	38 49	74	73	
24	10 P. M.	38 43	38 49	74	73	
	Noon.	38 44	41 32		71	
25	Noon.	39 04	44 17		75	
26	Noon.	38 56	46 44		75	
27	Noon.	38 12	50 10		70	
28	Noon.	37 02	51 28		75	
29	Noon.	38 08	52 31	74	74	
30	Noon.	37 47	53 20	74	75	
31	10 P. M.				72	
	Noon.	39 20	53 20		69	
Sept. 1.	Noon.	40 41	54 07	71	74	
2	Midnight				72	

A Thermometrical Journal of the temperature of the atmosphere and sea, on a passage from Oporto to Philadelphia, in the ship Apollo, by Capt. William Billings, continued.

1791 Dates.	Time.	Places in at Noon.		Temp. of		NOTES.
		Lat. N.	Long. W.	Air.	Wat.	
Sept. 2	Noon.	40 57	55 26	70	72	
3	Midnight				71	
	Noon.	40 56	57 51	70	73	
4	Noon.	39 10	59 18	74	74	
5	Noon.	39 17	61 11	74	76	
6	Midnight				77	This rise indicates, the gulph stream.
	Noon.	40 06	63 20	74	78	
7	Noon.	40 36	66 03		75	
8	Noon.	40 01	67 23	73	77	
9	10 P. M.			71	73	This fall indicates the western side of the gulph stream.
	Midnight				72	
	4 A. M.				71	
	Noon.	39 29	71 17		73	
10	Noon.	39 19	72 08	73	73	
11	Noon.	39 04	72 33	74	75	
12	Noon.	38 57	73 21	74	74	
13	Noon.	38 53	72 31	74	75	
14	Noon.	39 21	73 31		75	
15	6 P. M.			74	69	
	8 A. M.				68	Sounded in 25 fathoms.

N°. XXIV.

First Memoir of Observations on the Plants denominated
Cryptogamick.

Nusquam natura major quam in minimis.

PLIN.

Read Feb:
17, 1792.

ALTHOUGH the process of nature in the formation and reproduction of all organised bodies is evidently uniform, yet there are philosphers and naturalists who scruple to admit this general principle in all instances, and think it still liable to some exceptions.

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