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Sunglint Patterns: Unusual Dark Patches

to submarine eruptions may use potential attributed to secondary, posteruptional process-es such as those due to seawater alteration, growth of Mn crusts on the surface of beselts, or formation of Mn to submarine eruptions may thus possibly be

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Abstract. Anomalous dark areas in sunglint patterns are occasionally seen in photographs taken by the Applications Technology Satellite. These dark areas appear to be caused by relatively calm surface conditions against a background of higher sea states. Evidence of cold water temperatures suggest the presence of upwelling. These sightings may thus be of importance to the fishing industry.

With the initiation of the geosyn-During a study of these full-disk, chronous Applications Technology Satellite (ATS) series in December 1966, continuous monitoring of specific geographic areas first became possible. From their orbiting height of approxidiurnal changes in various features at

ATS picture sequences, a number of irregularities in the overall sunglint patterns were noted (1). In the course of a day, the sunglint may be observed to move from east to west across the face of the earth at a latitude intermediate between that of the satellite and the sun. Isolated areas appeared within the sunglint pattern which were alternately dark, bright, and then dark again relative to their background as



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the center of the sunglint area passed over them. These observations seem to be best explained by a model where the isolated dark patches represent areas of relatively calm surface conditions against a background of higher sea states.

If the sea were perfectly calm, sunglint would consist of a small, very bright specular reflection at that point on the earth determined by the laws of geometric optics. Because the sea is not smooth, sunglint always appears as a larger, more diffuse area. According to this model, a patch of calm water not at the center of the sunglint pattern would show up as a dark spot against the sunglint background. If the center of the sunglint pattern were to pass through this area of calm water, it would become considerably brighter than the background due to specular reflection. As the center of the sunglint pattern then moves out of the calm area, it would once again become darker.

Figure 1 shows a typical sunglint sequence. These data were recorded by the ATS-III satellite on 27 March 1968. In Fig. 1A, a dark area may be seen just west of the Galapagos Islands at about 1°S and 92°W. In this frame (at 1757Z) the Galapagos Islands are within the sunglint area, but still to the west of the specular center. At this time of year, the sunglint moves westward along the equator, and in Fig. 1B (at 1843Z) a bright specular reflection occurs in the formerly dark area. The primary islands of the Galapagos can be clearly seen against the bright background. In Fig. 1C (at 1945Z) the waters west of the Galapagos are still within the sunglint pattern, but now lie to the east of the specular center and once again appear darker than the background.

Although the area just west of the Galapagos Islands is one of the most persistent regions for the occurrence of this phenomenon, a number of other locations have been found where these sunglint variations may frequently be seen. (Because of the equatorial orbit of the ATS satellite, observations are limited to a relatively narrow equatorial belt extending from about 11°S to 11°N.) Other such areas include the region just west of the Gulf of Guayaquil off the coast of Peru, an area north of the mouth of the Amazon River at about 4°N, and a mid-ocean area at approximately 7° to 10°N and 35° to 40°W. An examination of ATS-I data over the Pacific Ocean has yielded

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Fig. 2. Mean monthly sea surface temperature analysis, March 1968.

additional examples of this sunglint phenomenon, occurring either as isolated patches or as elongated east-west bands along the equatorial regions.

The assumption that the anomalous dark areas represent regions of relatively calm water is well supported by other sunglint studies (2). In fact, the rate of the transition from brightness at the center of the sunglint to darkness at the outer edge has been suggested (3) as a means to infer sea state.

All of the examples up to now fall within areas of potential upwelling. Upwelling occurs along the western coasts of continents, in the lee of islands, over shoals or seamounts, and at water mass boundaries. Upwelling also occurs in twin bands across both the Atlantic and Pacific oceans at about 10° N and at the equator (4). The shape of these latter upwelling areas would account for the elongated bands found in the mid-Pacific. Analyses of ship reports also support the upwelling theory. In Fig. 2 the accumulated ship reports for the month of March 1968 in the vicinity of the Galapagos Islands are plotted (5). Comparison with Fig. 1 reveals a close correspondence between the cold upwelled water and the anomalous dark area. Further study of the available satellite pictures has shown that in some cases convective cloud buildup occurs around but not within the darker patches, again suggesting the presence of colder water. Other investigators, in studying the lower-level Gemini and Apollo color pictures, have

also associated darker areas with the presence of upwelling (6).

Upwelling brings colder, nutrientrich water to the ocean's surface. Hence, it may be expected that a surface film or slick will be found above regions of upwelling, due to the biological activity within such water. The presence of capillary waves on this surface (which has very low surface tension) will be much reduced (7). The turbulent transfer of energy from atmosphere to ocean will accordingly be lessened. This effect will be enhanced by the relatively calm winds expected in the stable atmosphere overlying such a cool ocean surface. The result is that there will be a greatly reduced number of short wavelength, high sloping ripples in the region: the ordinary diffuse sunglint pattern will be absent.

However, it may be anticipated that long wavelength swells of more modest slope will penetrate the region unimpeded. Indeed, analysis of several series of ATS photographs indicates that specular reflection lasts for up to the order of 1 hour in a region of about 2° longitudinal extent. This implies seasurface slopes of about 5° to 10° , which are consistent with the expected largescale waves.

Because the upwelled waters are also rich in nutrients, they are capable of supporting an abundance of marine life and thus become prime targets for exploitation by the fishing industry. A coordinated effort might be envisioned

whereby the fishing industry could be provided with the locations of stationary or transient upwelling areas based upon examination of satellite photographic data.

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Cyclic Guanosine Monophosphate: Effects on Short-Circuit Current and Water Permeability

Abstract. In the isolated toad bladder, cyclic guanosine monophosphate induces an increase in short-circuit current similar to that produced by cyclic adenosine monophosphate. In contrast, cyclic guanosine monophosphate has no effect on water permeability in this organ. This finding raises the possibility that different and independent intracellular secondary messengers may exist.

3'5'-Adenosine monophosphate (cyclic AMP) has been well established as an intracellular messenger mediating a variety of hormonal effects (1). In both the toad bladder (2) and the frog skin (3), cyclic AMP appears to mediate the increases in sodium transport and water permeability which occur in the presence of vasopressin. The observations that cyclic AMP mimics the hydroosmotic effect of vasopressin in isolated renal tubules (4) and that cyclic AMP is present in urine support the thesis that the physiological effects of vasopressin in the kidney are also mediated by cyclic AMP. Urine contains 3'5'-guanosine monophosphate (cyclic GMP) as

well as cyclic AMP (5). To explore the significance of this latter finding, we have studied the effect of cyclic GMP and other cyclic nucleotides on sodium transport and water permeability in the isolated toad bladder.

Urinary bladders were excised from large toads (Bufo marinus) obtained from the Pet Farm, Miami, Florida, during February and March. Shortcircuit current, which represents net sodium flux in this organ, was measured (6) with a $2-cm^2$ segment of bladder between two halves of a Lucite chamber. Osmotic water flow was measured by the method of Bentley (7). Unless otherwise specified, the Ringer solution (final pH 7.4) contained (mmole/liter): sodium, 111; potassium, 2.5; calcium, 1.4; magnesium, 2.0; chloride, 119; phosphate, 1.0; and glucose, 10. Substances tested were dissolved in Ringer solution and added to the solution bathing the serosal surface of the bladder (8). A final nucleotide concentration of 2 mmole/liter was used.

The effects on the short-circuit current of equimolar concentrations of cyclic AMP and cyclic GMP, the shortguanosine monophosphate), cyclic CMP (3'5'-cytidine monophosphate), and cyclic TMP (3'5'-thymidine monophosphate) are shown in Table 1. With both cyclic AMP and cyclic GMP, the shortcircuit current increased after a lag of 3 to 5 minutes, reached a peak value within 15 minutes, and then generally declined gradually toward base-line values (Fig. 1). With both nucleotides the transmembrane potential increased much less than the short-circuit current, implying that there was a fall in electrical resistance. In marked contrast, 5'-GMP (a noncyclic derivative of cyclic GMP), cyclic CMP, and cyclic TMP did not increase the current.

The effects of cyclic AMP and cyclic GMP on osmotic water flow across isolated toad bladder sacs were also determined (Table 2). Addition of cyclic AMP to the serosal bathing solution gave the expected increase in net water loss from the hypotonic mucosal solution. The response was greater at a concentration of 5 mM than at 2 mMcyclic AMP. The same concentrations of cyclic GMP had no effect on net water flow. Cyclic TMP was also ineffective.

Thus cyclic GMP reproduced the well-documented effects of cyclic AMP on short-circuit current but not on water permeability. The effects of vasopressin on osmotic water flow and shortcircuit current have been separated previously. Certain analogs of vaso-



Fig. 1. Effect of 2 mM cyclic AMP and 2 mM cyclic GMP on short-circuit current across the isolated urinary bladder of the toad.

Table 1. Effects of cyclic nucleotides and 5' GMP on short-circuit current across isolated toad bladder membranes. Results are expressed as the mean \pm S.E.M. of the percentage increase (+) or decrease short-circuit current, at the peak of the response. Each nucleotide was present at a final concentration of 2 mmole/liter. Half of the experiments were performed in a modified Ringer solution with a final pH of 8.0 obtained by substituting 1.0 mM sodium phosphate for 2.5 mM tris(hydroxymethyl)aminomethane-hydrochloride. The mean \pm S.E.M. base-line short-circuit current for the 34 experiments was $61 \pm 4.1 \ \mu a/2 \ cm^2$.

Nucleotide	Experi- ments (No.)	Short- circuit current (percent change)	
Cyclic AMP	10	$+33 \pm 5.9$	
Cyclic GMP	11	$+28 \pm 4.2*$	
5'-GMP	5	$+ 4 \pm 0.7$	
Cyclic CMP	4	-2 ± 1.7	
Cyclic TMP	4	-13 ± 1.1	

* Significantly different from 0 (P < .005) but not different from the change produced by cyclic AMP (P > .4).

Table 2. Effects of cyclic AMP and cyclic GMP on net water flow across isolated toad bladder sacs. Each hemibladder, with the mucosa inside, was filled with 2.5 ml of hypotonic Ringer solution (22 mM sodium chlorand immersed in 20 ml of regular ide) Ringer solution (110 mM sodium chloride) After the weight loss during three control periods of 15 minutes was measured, the sacs were transferred in 20 ml of the same Ringer solution in which cyclic nucleotides had been added. After equilibration for 15 minutes, the weight loss by the bladder sac was measured at 15-minute intervals during the next 45 minutes. Values in the table are the means of each set of three periods.

Experiment	Nucleo- tide concen- tration (mM)	Weight loss (mg/min)			
Experiment		Cyclic AMP	Cyclic GMP		
Experiment 1					
Before nucleotide		0.9	1.1		
After nucleotide	2	6.4	1.3		
Experiment 2					
Before nucleotide After nucleotide	5	1.1 9.5	$1.2 \\ 1.1$		

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