OceanBights

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Catalina Marine Society
15954 Leadwell St
Van Nuys, CA 91406
www.catalinamarinesociety.org

Publication Committee
Michael Doran
Karen Norris
Craig Gelpi

Editor
Craig Gelpi

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The Catalina Marine Society is a nonprofit membership corporation founded in 2009 in Los Angeles to marshal volunteer resources to study the marine environment of Santa Catalina Island and the Southern California Bight.

Submissions. The magazine may publish submitted articles that pertain to our mission statement. Contact the e-mail address below for more information.

Letters to the editor should be sent via e-mail to the address below.
information@catalinamarinesociety.org

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Happenings

As usual, the Catalina Marine Society has been very busy. We participated in the Aquarium of the Pacific Diver Day and in their Citizen Science Symposium. And of course, we were at the SCUBA Show, all taking place in Long Beach. Not in Long Beach was our first out-of the country presentation made in Croatia.

We made a change to our mission statement, including the word "conservation" as there is much interest in conserving our environment and many of our research activities are designed to help us understand our ocean so we can conserve it.

Following that theme, we have an article in this issue by Angela Kemsley, describing MPA Watch, an effort to monitor the newly established Marine Protected Areas. These are described for Santa Catalina in detail in the article.

Data are pouring in from our field activities. The David Tsao Continental Thermograph Array (DTCTA) has expanded and volunteers are regularly sending in retrieved instruments. The web site where the data are stored has been revamped to reflect the larger number of sites and datasets.

Our other field effort, the Catalina Dynamic Ocean Chemistry (CDOC, "sea doc")

effort is composed of two parts: a depth profiling component and a scientific mooring one. Depth profiling has been very active and the mooring effort is becoming so and is described in a separate article.

Note that both of our field programs have received funding from philanthropic foundations this year. This is a substantive nod to the efforts of our volunteers, who "bring home the data-bacon".

Finally, in 2018 CMS made scientific presentations in Portland, Pomona, La Jolla and, as alluded to, Dubrovnik. Scientists from throughout the world are exposed to, and applaud, our activities and achievements.■

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MPA Watch: Take a Walk on the Beach and Help Protect Catalina's Marine Protected Areas

Angela Kemsley

Close your eyes for a moment and imagine a scientist. What do you see? Is it a man with crazy hair and a lab coat? Is it someone who looks nothing like you? This idea that science is done by someone else, that it is not a part of our everyday lives, is prevalent in our society. In reality, however, to see a scientist all you have to do is look in the mirror.

California is amazing. And huge. So huge that professional scientists just cannot collect all of the data they need by themselves. To this end, professional scientists have begun recruiting the largest and most powerful workforce in the world...the general public! Through a field known as citizen science, increasingly being referred to as community science, professional scientists are joining forces with everyday people to collect and analyze real scientific data on everything from birds to DNA to human use of natural resources.

WILDCOAST, an international team that conserves coastal and marine ecosystems and wildlife, coordinates one such innovative, impactful, and enjoyable community science project, Marine Protected Area (MPA) Watch, in an effort to

Angela Kemsley

protect one of California's most treasured resources...the ocean!

California's coastal and marine ecosystems are some of the most iconic and important resources in the state and contribute greatly to the history, identity, and economy of the area. Unfortunately these same ecosystems are also some of the most exploited and without proper care their long-term health is in jeopardy.

Recognizing the need to safeguard California's coastal and marine ecosystems the state legislature passed the Marine Life Protection Act (MLPA) in 1999. This act aims to protect California's precious marine resources by creating a statewide network of marine protected areas (MPAs).

Just as state and national parks protect resources on land, MPAs protect resources in the ocean by managing human activities within biologically important areas. These "underwater parks" not only protect the biodiversity and abundance of marine life, but also provide amazing opportunities for snorkelers, surfers, kayakers, divers, beachgoers, fishers, and anyone else who loves hanging out at the beach by providing some of the best recreational opportunities in the state.

California now boasts the largest integrated network of MPAs in the world. Through a network of 124 sites managed by the California Department of Fish and Wildlife (CDFW), MPAs now protect over sixteen percent, or 850 miles, of the California coast and near-shore waters.

Catalina Island is home to nine MPAs which fall into three categories:

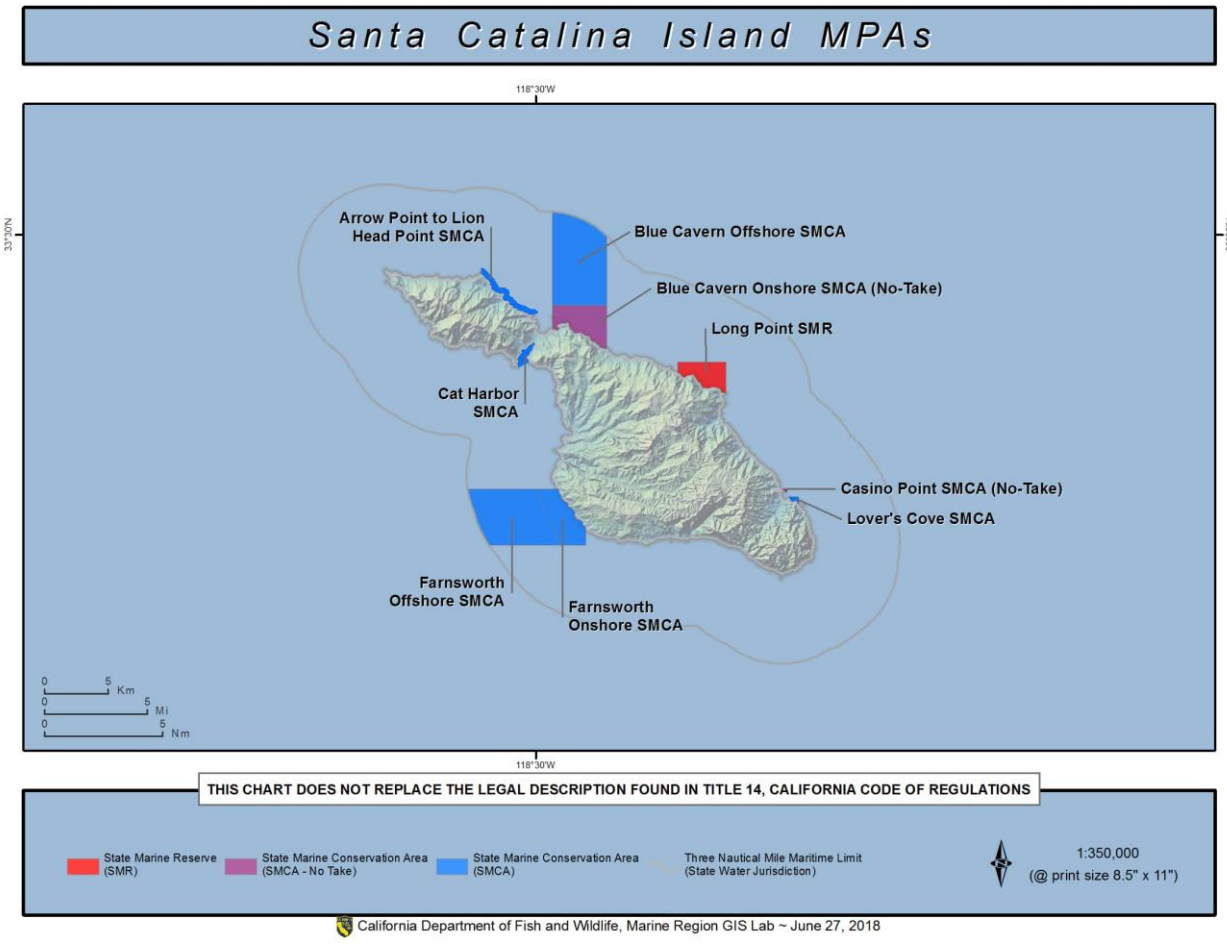
1) State Marine Reserve (SMR) - Take, damage, injury, or possession of any marine resource (living, geological or cultural) is prohibited. Recreational activities are encouraged. Catalina Island has one SMR: Long Point.➔*next page*

CMS in Croatia and elsewhere

The Catalina Marine Society made its first presentation outside the United States last October. Although we routinely present at international conferences, this effort represented ➔*see Croatia pg. 17*

2) No-Take State Marine Conservation Area (SMCA) - Take, damage injury, or possession of any natural resource (living, geological or cultural) is prohibited. Catalina Island has two No-Take SMCAs: Casino Point and Blue Cavern Onshore.

3) State Marine Conservation Area (SMCA) - Take, including fishing/harvest of some marine resources is permitted. Some consumptive recreational and commercial activities are allowed at specific locations. Regulations vary by SMCA. Catalina Island has six SMCAs: Arrow Point to Lion Head, Blue Cavern Offshore, Lover's Cove, Farnsworth Onshore, Farnsworth Offshore, and Cat Harbor.



A full list of MPAs and MPA regulations may be found on the CDFW website at https://www.wildlife.ca.gov/Conservation/Marine/MPAs

MPAs are predicated upon the idea that limiting consumptive behavior in biologically important areas will result in higher biodiversity and abundance than in unprotected areas. Several peer-reviewed studies suggest that MPAs, especially no-take areas such as SMRs and No-Take SMCAs, are effective at restoring and preserving biodiversity as well as enhancing ecosystem resilience. In some instances the biomass of whole fish assemblages has been observed to be up to 670% greater, on average, in marine reserves than in adjacent unprotected areas.➔ *see MPA Watch pg. 12*

The Impacts of Global Warming on Upwelling in the California Current

Mary Ann Wilson

From southern British Columbia to the Baja California Peninsula (with the exception of the SoCal Bight), winds blow southward along the coast. Combined with the rotation of the earth, these winds cause the surface layer of the ocean to move offshore. Seawater then wells up from beneath the surface to replace the water that was pushed away. This deep cold water brings nutrients which are more abundant at depth than they are at the surface. The sunlit nutrients stimulate blooms of microscopic phytoplankton—the base of the marine food web—which propagate up the food chain to zooplankton, filter feeders, fish, marine birds, top predators, and marine mammals.

This is the process of upwelling in the California Current, a coastal upwelling zone which exists along the edges of eastern boundary currents in the northeastern Pacific. Its abundant concentration of phytoplankton renders it among the most productive of the world's marine ecosystems. Many species that rely on its food source live here year-round; others migrate from quite a distance—like leatherback turtles from Papua New Guinea, shearwaters from New Zealand, and tuna and loggerhead turtles from Japan.

The first hypothesis about how upwelling might be affected by climate change was put forth in 1990 by Andy Bakun, a professor of marine biology and fisheries at the Pew Institute for Ocean Science. He proposed that increasing greenhouse gas concentrations would strengthen winds in the California Current and similar upwelling systems: the Benguela Current off southwestern Africa, the Canary Current off northwestern Africa including its northern extension off the Iberian Peninsula of southwestern Europe, and the Peru-Humboldt Current off western South America.

May Ann Wilson

During the warmer months, Bakun observed that air over land warms more rapidly than air over the ocean, which causes the low-pressure system over the land to intensify relative to the high-pressure system over water. The increasing pressure gradient between them results in stronger upwelling-favorable winds. Hence, greenhouse warming leads to an acceleration of coastal upwelling. Since then there have been several studies assessing trends in upwelling-favorable winds, with mixed results.

However in 2014, a coherent pattern emerged. William Sydeman, president and senior scientist at Farallon Institute for Advanced Ecosystem Research, produced a meta-analysis of published studies, each with more than 20 years of observational or model-derived data. Results showed this upwelling intensification trend is observed at higher latitudes, specifically the California, Benguela, and Humboldt upwelling systems, which he thought "may reflect stronger warming trends observed toward the poles than the equator."➔*see Impacts pg. 9*

DTCTA Growing

The David Tsao Continental Thermograph Array continues to expand with the California Science Center starting and managing more sites, especially in northern LA county. In

addition to the number of sites increasing, the established sites continue to yield data. So much so, that the analysis of the thermograph data has taken top priority among the research goals of CMS. One of the first issues is to determine the correlation of temperatures among nearby sites. As much data has been collected near Laguna Beach, we will determine how correlated are the data there on 12- and 24-hour time scales, i.e., those corresponding to tides.■

Thanks to the Max and Victoria Dreyfus Foundation for contributing to our David Tsao Continental Thermograph Array

Mathematics and Me

Craig Gelpi

Mention math to anyone out of high school for longer than 2 days and you are likely to see a glazed look or a face of fear. But they are not me. I am one of the few people on earth who seldom is conscious during a day without a thought of an equation going through my head. But I am not thinking of equations for equations' sake; more often than not I am concerned with a significant problem that I am trying to cast into a mathematical form.

But what do I use math for? Well, I use it for four distinct purposes. First, I use it to think. Second, I use it to calculate, i.e., arrive at numbers, numbers that can be compared to intuitive notions or independent measurements. I rather think than calculate, but every now and then, I have to calculate to make sure my thinking is correct. Third, I use math as a language. I can convey thoughts and information economically, concisely, and usually with little ambiguity.

Regarding thinking, I know that rigorous mathematical procedures, those that are common, are logical, so that if I start with equations that I believe describe my thoughts on a problem, then any formal mathematical manipulations I make on these equations will maintain the initial information though place it in a new form, a form derived from logical thinking. This form may be very enlightening and lead to new insights on the problem. The math can be performed with relatively little thinking just by following procedures we learn in school. However, the first step is the cast the problem into equation form.

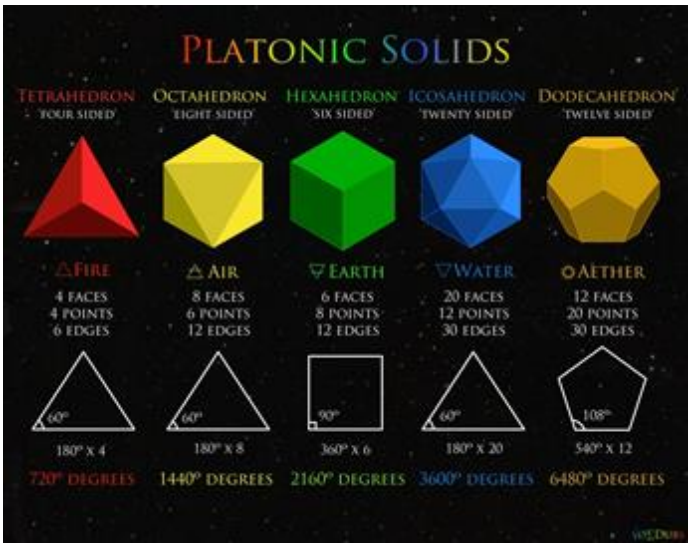
These equations will include symbols for important quantities and their relationship with other important quantities. Although this sounds like I already know the information I seek, it doesn't take much effort until the relationships among parameters not directly thought about are found. Further mathematical manipulations on those equations will usually uncover the ramifications of my initial position. Often, those consequences are not obvious, and sometimes (more than I care to state) they are ridiculous. This is a sure indication that my original thoughts are wrong headed and they are discreetly discarded. Hopefully this expe-rience improves my thinking.

More often than not, though, I do not follow a rigorous mathematical procedure in reducing equations to new types. Such procedures may lead to unbearably complicated forms from which I cannot see the consequences of my starting thoughts. Or the mechanical procedures, though strictly logical, keep unimportant detail that logically must be there but has no significance to what I want to learn.

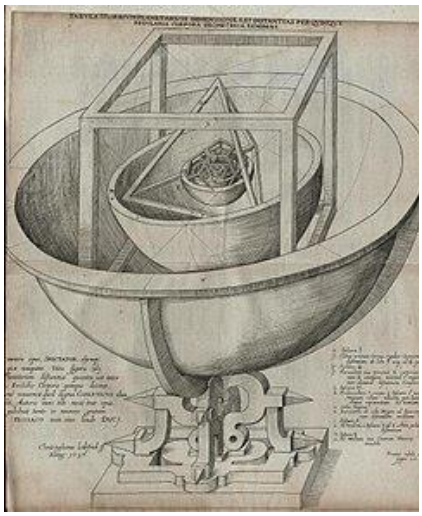
For example, if you need to determine your retirement income prospects and how to save more money from your salary, you would analyze your income and expenditures. Presumably you would limit your analysis to major expenditures and investments and not how much money you lose in the washing machine when you leave loose change in your pockets. Accounting for the latter, and the resulting interest lost or taxes saved over many years can be very complicated, but I suspect (and hope) that it has no importance to you.

Most of these complications are generated by keeping too much detail, and then keeping track of too much detail until the wealth of detail overwhelms the major picture that is the point of my study. Hence, I try to shed as much detail as possible when I begin thinking on a problem. If you neglect too much detail, then you may lose sight of the problem you are trying to solve or colloquially, throw the baby out with the bath water. Not enough detail, and you can't solve the problem. But more detail is generated the further the problem is worked, so one must constantly consider and determine what is important to keep and what can be safely discarded. In this way, we can decide that the contribution to the 401(K) is important but the daily adult beverage need not be sacrificed. By the way, I am always surprised by how much detail people who are just out of school keep. Apparently, the ability to shed detail is an acquired skill that takes considerable experience.

Engineers and their ilk (e.g., financiers) also use math to calculate. Engineers have to calculate the effects and safety of their designs, the integrity of structures, the robustness of software, or the expected voltage appearing in a circuit. They need numbers. Numbers which have meaning. Numbers that describe safety or cost or schedule. Very important numbers, indeed.



No useful chemistry, but nice art



No celestial physics, but still nice art

Math is also a language, a way of communicating thoughts, some very complex, with little ambiguity and amazing conciseness. However, it is a language without the nuances of a language such as English. It is also precise, in the same way scientific nomenclature of species is precise. However, this precision does not allow the interplay that normal language permits. An exclamation point symbol in an equation does not denote excitement. I sometimes use math as a language, but not often. For math is essentially a secret language, accessible to only those who have dedicated significant effort to understand it.

Mathematicians, in my view, use math almost as a recreation, building logical structure from which they deduce interesting results, results that often are not seen in the original structures. When these structures occasionally can be found to correspond to some bit of physics, the physicist makes use of the logically-derived results of these structures to obtain more information. Indeed, the beauty of a physical law often comes from its mathematical form, which may seem very neat, or the results obtained

from it, which may seem miraculous. If the math doesn't correspond to physics, then the mathematical constructs are simply art or recreation. Examples include the old theories of how the platonic solids either corresponded to the fundamental elements, or the distance between the 5 at-the-time, known planets (see the figures). These models didn't pan out.

So, we can enjoy math, too. This leads to a fourth use of mathematics, as art. The internal consistency is something to be admired, it is a thing of beauty. And the consequences of starting propositions can be truly amazing and extraordinarily useful. The structures that mathematicians develop, in my view, are human creations, like the Mona Lisa. They would not exist if mankind did not exist. I had forgotten about this component of mathematics until preparation for a trip to the Greek Islands reminded me. Real mathematics, that is, these logical structures, began with the ancient Greeks, the first geeks. In contrast, calculation, the manipulation of numbers, occurred much earlier as driven by the need to conduct business or build pyramids.

Returning to the first purpose of mathematics, on the practical side, we often see how a little correct thinking saves an incredible amount of effort, permits accomplishments that heretofore seem unlikely or even impossible, and has enabled our technology-driven world. Many of these latter accomplishments are deadly serious.

But there is the playful side of this too. Just as the SCUBA diver takes pride in using little air, the ham radio operator in achieving distant contacts and the amateur astronomer in viewing faint and rare celestial objects, the physicist/mathematical thinking game is to derive as much information from as few facts as possible. Everyone is a winner when this game is played by few.■

Volunteer for our Depth-Profiling Program

Can you deploy a 3-lb instrument from a boat or kayak? CMS has an active program to measure ocean chemistry around Santa Catalina Island and we could use your help. Contact us for more information.

Student researchers wanted!

Want to distinguish yourself for job and school applications and learn useful skills? Consider engaging in a research project for CMS. We can tailor a project to meet your schedule and abilities.

Missing Mussels

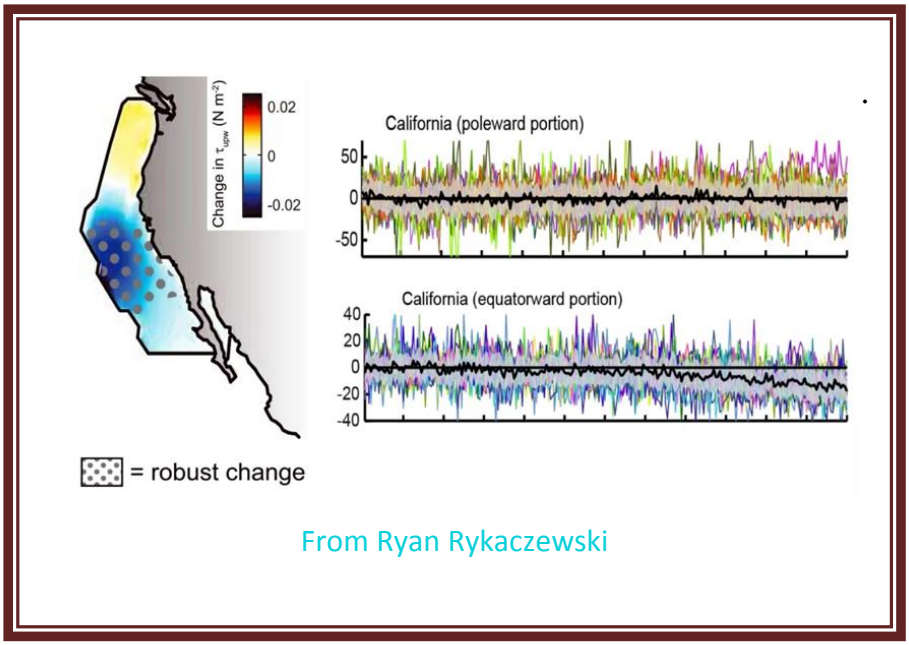
CMS president Jim Updike and chief scientist Craig Gelpi made a successful mussel gathering trip to Malibu during extreme low tide. See *OceanBights* Vol. 5#1 for a description of a typical mussel-hunting expedition. Unfortunately, the Woolsey fire burned that week to the ocean at the mussel bed location and several adjacent structures were lost there.

The mussels were great. However, we got the impression that the mussel beds were not as extensive as in years past. When pictures of past expeditions were consulted, the feeling was verified. This bed shrinkage is occurring despite the fact that one local mussel predator, sea stars, was nowhere to be found.

So the question is, what is happening to them? Are they suffering from the warmer water we have been experiencing? Are they overfished? Will we have a source of wild mussels in the future? ■

Impacts ➔

A 2015 study confirmed these findings and projected the trend would continue. Ryan Rykaczewski, a fisheries oceanographer at the University of South Carolina, compared estimates of historical greenhouse gas concentrations from 1861-2005 to projected greenhouse gas concentrations from 2006 to 2100 if global temperature rises 4 to 5 degrees Celsius. That's the "business as usual" scenario, which is the worst trajectory and the one we're on. His analyses of 21 coupled atmosphere-ocean general circulation models showed increased coastal upwelling toward the pole and decreased upwelling toward the equator. "The high-pressure system over the ocean is expected to move towards the pole with future global warming," Rykaczewski said. "This means that the location of the maximum gradient in pressure—and hence, the location of strong, upwelling favorable wind—will move towards the pole (or north, for those of us in the northern hemisphere) as well." What that means for the California Current is shown above, in the outline of the west coast on the left, with projected changes in upwelling illustrated in color. Yellow and red indicate increased upwelling, which is what Bakun's hypothesis says we should expect. Blue means decreased upwelling. The dotted areas are where the changes are large enough that it's statistically significant. In the north there's little to slightly positive change, but south of the California-Oregon border there's decreased upwelling. You can also see it in the plots to the right—the colored lines represent different models and the thick black line is the mean of all those models.



From Ryan Rykaczewski

The scenario is as Bakun had described: During the warmer months, a strong pressure gradient forms between the continental low pressure system over California (and the desert southwest) and the North Pacific high-pressure system that is found offshore California. By Bakun's account, this should increase upwelling-favorable winds everywhere. But Rykaczewski suggested two elements were absent from his hypothesis:

1) The influence of humidity on atmospheric pressure—that is, pressure is a function of temperature and humidity, not just temperature alone.
2) The potential movement of the pressure systems.

"It's the movement of the high pressure system that is the most obvious and consistent of these elements, at least in the projections of climate models," he said. "The actual reason that the high-pressure system moves north is still an area of scientific research, but likely has to do with the increased heating in the tropics and the greater convection that is stimulated as a result."

Could the ridiculously resilient ridge (RRR) put the brakes on the North Pacific high pressure system? The RRR is an area of high atmospheric pressure that has disrupted the North Pacific storm track since 2012. While it is typical for a high-pressure ridge to form over the West Coast during winter, which explains why eastward-moving Pacific storm often veer north before reaching California, this ridge has become in-

creasingly persistent and pronounced since 1948.

Rykaczewski did not think that the presence of the RRR would prevent movement.

Thanks to the Kenneth T. and Eileen L. Norris Foundation for their continued support of our Catalina Dynamics Ocean Chemistry program.

"Rather, I think the question is whether the presence of the RRR is somehow related to the poleward movement of the North Pacific High overall," he said. "The scientific jury is still out. The complication is that things like the RRR are episodic and last for a period of months, while the shift in the high pressure system is something that occurs over a period of several decades."

When stronger upwelling-favorable winds occur, they bring a surge of nutrients to surface waters. But they can also harm marine life by causing turbulence in surface waters, disrupting feeding and worsening ocean acidification. That's because upwelled water is naturally rich in carbon dioxide. The earth's oceans have already absorbed about a third of the CO_2 that humans have emitted into the atmosphere since the beginning of the Industrial Revolution. This increased CO_2 causes upwelled water to be more acidic, threatening calcifying species, including oysters, clams, sea urchins, shallow water corals, deep sea corals, and calcareous plankton.

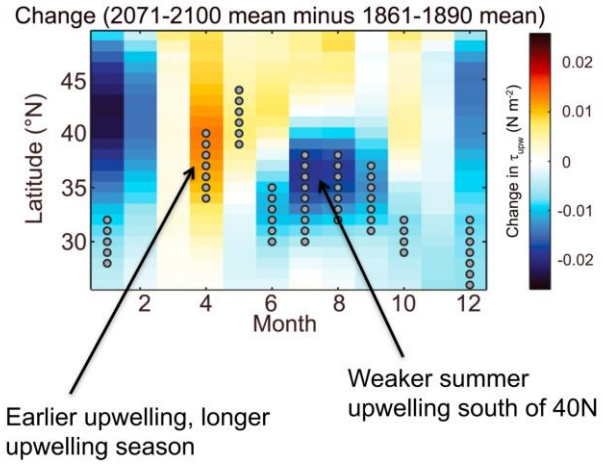
Also, when there's an abundance of phytoplankton, those that are not eaten eventually die and float down into deeper waters, where bacteria use available oxygen to decompose them. When too much oxygen in the deep waters is used for this bacterial decomposition of the phytoplankton, the result is a condition known as hypoxia. This could harm bottom-dwelling marine life, shrink open-water habitat for top predators, and increase the number of invasions by hypoxia-tolerant species like Humboldt Squid, a species thought to have benefited from an expansion of hypoxic waters and which rapidly expanded its range into the northeast Pacific Ocean in the late 1990s.

Ryan Rykaczewski
by Amanda Netburn

On the other hand, weaker upwelling may limit nutrients at the surface, negatively affecting primary production. Winters with extremely weak upwelling are associated with slower growth in fish and lower reproductive success for seabirds.

Studies have shown that certain species are more sensitive to different periods of the year in terms of upwelling. Some are more sensitive to the variability in the winter-time upwelling, and some are more sensitive to the variability in the summer-time upwelling. Over recent decades, the timing of upwelling has trended toward later and shorter upwelling seasons in the northern portion of the California System and longer upwelling seasons in the southern portion.

However, Rykaczewski's projections show the opposite will happen. This figure shows the same changes as the previous figure, but as a function of the month of the year along the horizontal axis and the latitude along the vertical axis. In the central and Northern California coastline, models project intensification in April and May (note the strong upwelling beginning in April, which may indicate a longer upwelling season). But south of the 40th parallel (Mendocino) you see a weaker upwelling in late July to early August at the peak of the upwelling season.



From Ryan Rykaczewski

A seasonal-scale change can predict animal distribution as well as survivability. For example, in 2005 central California seabirds and rockfish as well as Oregon zooplankton were hit hard by a weak and delayed upwelling. It was particularly hard on species whose reproductive cycles depend on early upwelling, rather than the cumulative amount. The northern portion of the California Current had one of the most delayed onsets in the 40-year record, and resulted in the reproductive failure of Cassin's Auklet.

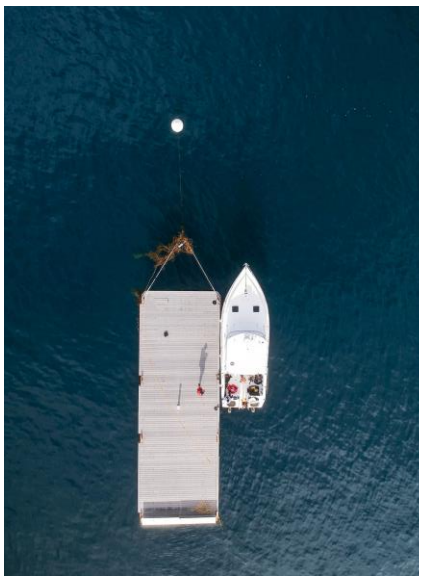
It can take a long time for the signal of a trend to be greater than the natural variability that happens on shorter time scales. Anthropogenic changes in upwelling will emerge primarily in the second half of the century. Still, it is apparent that ecosystems respond to even small changes in average conditions of pH and CO_2, even within the context of a larger range of natural variability. Even more worrisome is that climate change is likely to produce a combination of stressors for which we may have no reference. ■

Mary Ann is a regular contributor to ***OceanBights****.*

CMS Scientific Mooring returns

CMS has reestablished a temporary scientific mooring in Two Harbors as part of its Catalina Dynamic Ocean Chemistry (CDOC) program. The mooring is the work of many volunteers. Many thanks to Ted Sharshan, who machined a heavy-duty housing which supports the sonde on the mooring line. A deployment team was led by Aquarium of the Pacific Assistant Dive Safety Officer Desda Sesson and CMS vice president (and AoP and WIES diver) Dirk Burcham. They had to determine requirements, document the proposed diving procedure and have it approved by their respective institutions. Once approved, deployment and retrievals dates are set and volunteer divers sign up to participate. The sonde is calibrated and delivered to the team, which transports it to Two Harbors, then takes a small boat to the mooring. From there, they dive

➔*see mooring pg. 16*



Mooring as seen from above. Credit: Adam Fram

Adopt-A-Thermograph Program

The CMS is seeking donors and site managers for its Adopt-A-Thermograph program. These sponsors will extend and complete the David Tsao Continental Thermograph Array that is currently under development. For more details, contact Karen at karen@catalinamarinesociety.org or Craig at craig@catalinamarinesociety.org.

MPA Watch ➔

The efficacy of MPAs is reliant upon human knowledge and understanding of and compliance with site specific regulations. Additionally, the increase in biodiversity and abundance often found within MPAs would suggest that these protected areas may also inherently provide recreational, aesthetic, and educational benefits. Despite the importance of anthropogenic-use data in MPA management, there were no coordinated, statewide efforts to collect such data in California. MPA Watch was created in 2008 to fill this gap in knowledge.

MPA Watch is a network of programs that support healthy oceans through community science by collecting human use data in and around our protected areas. MPA Watch volunteers monitor human use of MPAs by walking on the beach, counting people, and recording observed activities. The program currently monitors beaches in half of all MPAs in California, including sites in every county along our coast.

Data are collected by walking along the mean high tide line of predetermined routes, referred to as transects, and observing and recording all people and boats on the beach or in the water. Observers count and record activities into the appropriate category on the MPA Watch datasheet. To avoid bias only the activity the subject is engaged in as the observer passes is documented. Each person or boat counted gets a tally in only one category. Data categories include on-

Collecting Data
Photo by: Octavio Aburto

shore and offshore as well as consumptive and non-consumptive activities including beach recreation, wildlife watching, tidepooling, surfing, offshore recreation, fishing, and boating. Full data-collection protocols and datasheet may be found at www.mpawatch.org under the "Resources" tab.

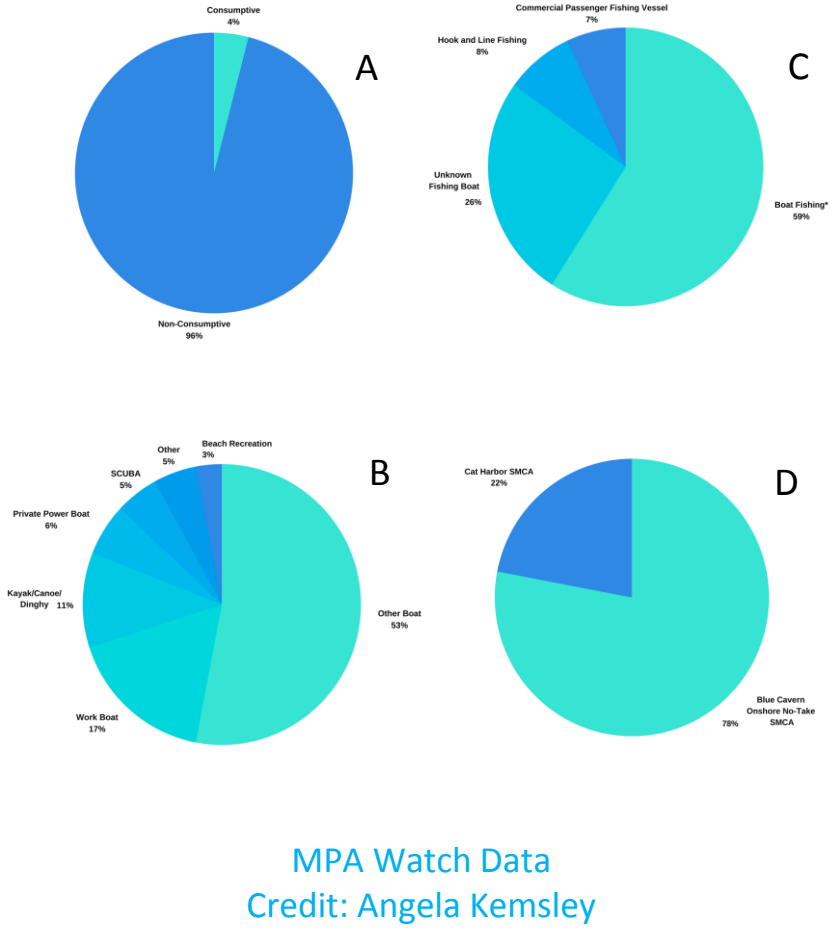
MPA Watch data for Catalina Island were collected between March 2017 and November 2017 within Cat Harbor SMCA and Blue Cavern Onshore No-Take SMCA along four transects.

Cat Harbor SMCA allows the recreational take of: finfish by hook and line or by spearfishing; market squid by hook and line; and, spiny lobster and sea urchin. It allows the commercial take of sea cucumbers by diving only, spiny lobster and sea urchin, and aquaculture of finfish pursuant to any required state permits.

Blue Cavern Onshore No-Take SMCA prohibits all take, except as pursuant under federal law for scientific and emergency response purposes with authorization.

The majority of activities observed during the 2017 season were non-consumptive, accounting for 96% of all observations (see A in figure).

Over half (53%) of non-consumptive activities (B in figure) observed were miscellaneous non-fishing boats, consisting of boat types not on the datasheet or non-fishing boats unidentifiable by researchers. Other offshore boating, such as work boats, private power boats, and kayaks accounted for another 34% of recorded observations. Onshore activities, such as beach recreation, accounted for less than 4% of total recorded observations.



MPA Watch Data
Credit: Angela Kemsley

Consumptive activities (C) accounted for only 4% of total activities, with boat fishing (*traps, lines, nets, dive, and spear) and unknown fishing boats accounting for 85% of all observed consumptive activities. Onshore consumptive activities, including hook and line fishing, accounted for less than 8% of all recorded consumptive observations.

Potential violations were observed and reported via CDFW's reporting system CalTIP (https://www.wildlife.ca.gov/En

forcement/CalTIP) on 21% of data collection trips. All potential violations reported were within the Blue Cavern Onshore No-Take SMCA, which overall accounted for 78% of all observed instances of consumptive activity (D) despite being a no-take area.

Data suggest that Catalina Island MPAs have experienced higher than average levels of poaching since their implementation in 2012. The amount of potential violations observed by MPA Watch volunteers at Catalina Island (21% of all surveys) was over twice as much as the statewide average for observed potential violations (9% of all surveys). Additional data from CDFW reports similar data, with Catalina Island accounting for 85% of all MPA-related violations in Los Angeles County during a study conducted from 2012-2015. Whether these data accurately represents the amount of poaching at Catalina Island compared to other sites or rather is an artifact of more robust monitoring at Catalina Island compared to other sites has yet to be seen and warrants further research.

Despite, or perhaps especially because of these high levels of poaching, Catalina Island MPAs deserve special attention to protect the amazing ecosystems and wildlife literally found nowhere else in the world. Catalina Island is home to over 60 endemic species, many of which rely on the island's coastal resources. Not to mention the amazing snorkeling, kayaking, diving and myriad of other recreational opportunities afforded by these important places.

HOW TO GET INVOLVED

Volunteers are currently needed to monitor sites all around Catalina Island. In other words, you can help protect California's beautiful beaches and oceans just by taking a walk on the beach! There are opportunities to monitor Catalina MPAs by land through WILDCOAST and by sea through Los Angeles Waterkeeper's boat-based MPA Watch program (see http://lawaterkeeper.org/mpa-watch).

If you are ready to unleash your inner scientist or if you just really enjoy long walks on the beach, consider becoming an MPA Watch volunteer! The data you collect will be added to a database of over 20,000 surveys and used to inform the management, enforcement, and science of California's MPAs and help protect the amazing ecosystems and wildlife right in your own backyard.

Beautiful Santa Catalina, worth saving
Credit: Brian Skeery

Visit www.wildcoast.org and www.mpawatch.org or contact WILDCOAST's MPA Watch Coordinator at angela@wildcoast.org for more information!■

CMS and Climate Change

There is climate change, but to be more specific, the globe is warming. Some of the effects of global warming are self evident to the most casual

observer: glaciers in retreat or disappearing almost everywhere, especially in California; spring comes earlier now than 20 years ago; winter is a month shorter in the Pacific Northwest; temperate-loving animal and plants move to higher and cooler elevations and our Bristlecone pines are being invaded by limber pines taking advantage of the climate; ocean temperatures are warming, and tropical marine fauna moving northward in response, such as the scythe butterfly fish now often found at Catalina. At this rate, when will there be lobsters in Monterey Bay?

All these observations fall neatly into the paradigm that temperatures are increasing. But nature is oh, so much more complicated and increasing temperatures will have many other effects, including non-intuitive ones. We need to know how global warming will affect us so that as a civilization we can make adjustments to minimize changes to our culture and lifestyle, or at least allow us to make intelligent choices on how to deal with global warming.

So how will global warming affect us? We really don't know. Its specific effects will depend on local conditions. What we do know is that as the air and water get warmer, there will be more evaporation. Warm air holds more water than cold air, so if there is a reservoir of water to evaporate, there will be more water in the atmosphere, and that will lead to more rain. If there is no such source of water, the air will just get hotter. Considering the ocean, evaporation is a desalination process, leaving salt in the ocean as fresh water evaporates. But more rain will lead to more fresh water at the surface, which will also be warmer, and therefore less dense than deeper layers. Hence there will be less mixing and fewer nutrients will come to the euphotic zone.

On the other hand, storms redistribute energy around the globe, taking energy from the tropics and bringing it to higher latitudes. We can expect more storms. Storms mix the ocean, bringing nutrients upward and counterbalancing the effects of stratification. We know that ocean productivity increases after the passage of hurricanes. How these different phenomena interact is not known. Stratification may dominant in some locations while increased mixing will be found in others.

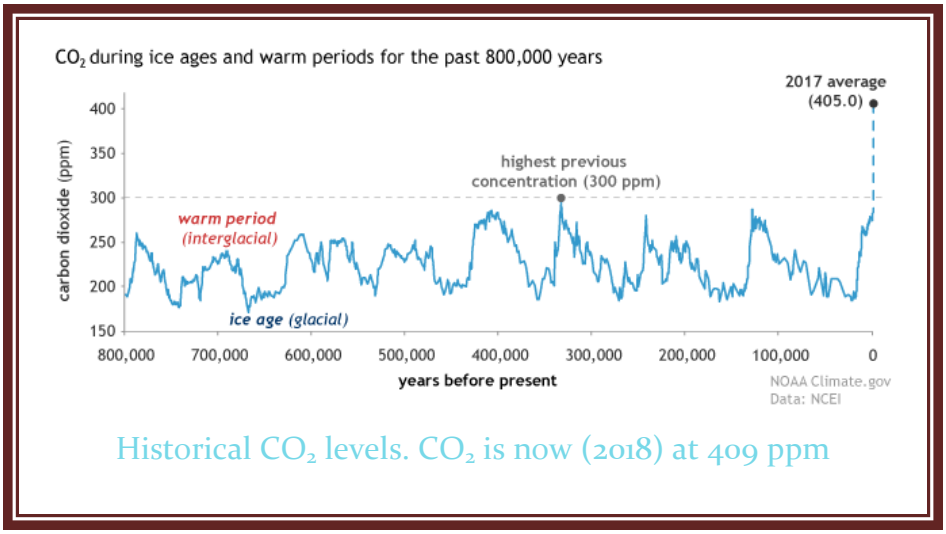
However, we can expect record temperatures and record rains, in places where it already rains much. As a former Houstonian, I am well aware of the rainstorms that frequent that city and the flooding that often results. However, there has been increasing flooding in Houston (and in Baton Rouge) over the last decade, due entirely to heavy rains. And this was before the record rains associated with Hurricane Harvey (an astounding 50 inches!).

Of course, it is difficult to attribute specific storms or weather activity to climate change. The increasing damages produced by hurricanes are conflated not only by the intensity of the storms, but also the susceptibility of the landscape to damage as we continue to build on more land and to higher density. We also have higher sea levels to contend with, which when added to water rise due to storm surge, increases flooding.

Changes in ocean temperature are like changes in the stock market, they are never smooth and steady, but chaotic. If the market value is said to increase an average of 7% a year, there may never be a year that it actually increased 7%, but rather it exhibits over time small movements and large movements (especially when the movement is down). Trying to ferret out the direction of the market, and specifically what stocks will increase are akin to ferreting out the direction of local climate and what strategies to bet on.

But we must intuitively know that we cannot keep pumping tons of CO_2 into the atmosphere and expect there not to be consequences. See the figure. The immediate work is to determine what the local consequences may be. What we are doing, in our small way, is helping to understand our local environment. To that end we have studied ocean temperatures and how they have changed over decades. They have increased, and the increase has not been steady, but rather appears as episodic increases. How come?

Besides taking strategic action to reduce the amount of carbon dioxide released into the atmosphere, tactically we should accommodate expected changes generated by a warming globe. However, we are not sure what those changes will be.



Historical CO_2 levels. CO_2 is now (2018) at 409 ppm

And, what can we do about it? Well, we can work to understand our environment as it is and as it changes. This will enable us to predict. Such understanding will be invaluable as decisions are made to maintain, adjust or modify our environment. Future decisions on industrial locations and practices, location of marine reserves and extraction practices, coastal use regarding expected increases in storm activity, and shoreside erosion. Mariculture. Recreational activities. etc

As we reported elsewhere, giant kelp, *Macrocystis pyrifora*, is returning to the Avalon Dive Park. It disappeared during a warm water spell, allowing an invasive sargassum to flourish in its place. Was the warm water spell due to global warming, or just a freak occurrence, perhaps due to shifting currents from the south. If it was due to global warming, then we can expect more warm spells to occur in the future, and the kelp will likely disappear again and again. How should we plan for this eventuality? Develop genetically modified kelp that can survive on the reduced nutrient flow? Transplant kelp variants from other locations that normally survive in conditions we expect to happen? Move our recreational diving to points further north? One innovative project I have heard is to have a kelp elevator, that will lower into deeper water so it can absorb nutrients, then move the kelp into the photic zone so photosynthesis can happen.

There will be less shore-diveable days due to enhance storm activity. Storms, especially hurricanes, are nature's way of equilibrating energy around the planet. We can expect more large storms, both locally, in Alaska and also in the southern hemisphere. And we will know it through the decrease in shore-diveable days.

Fishing practices will change. Now, the ocean adjacent to Los Angeles and surrounding Santa Catalina, the Southern California Bight, is home to diverse species, due to the large range of ocean temperatures encountered here. We get cold water from the north and warm water from the south, enabling species of both northern and southern affinities to hang out in close proximity. If our local ocean warms enough, the species with northern affinities will vacate the area and our species diversity may decline.

There will be more extreme weather events. More tornadoes, more hurricanes, more monsoons, more and greater heat waves, more wildfires, the latter being the most concern to California.

We, as the social Society, love the local ocean, and we contribute our skills acquired in playing with the ocean toward making scientific measurements in an effort to understand better the ocean. Any understanding and insights we achieve will be added to the vast store of existing knowledge and enable others to build upon our studies as we build upon other's work.■

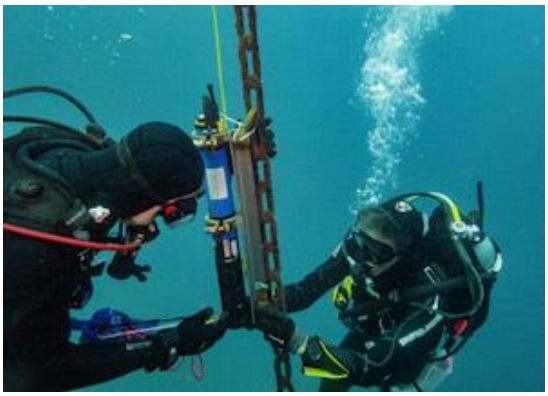
Mooring ➔ the sonde and mount it and a series of thermographs along the mooring line.

After about 3 weeks, the procedure is reversed and the

sonde returned to the mainland. The data collected are downloaded, quality assured and uploaded to the website.

The scientific mooring has been re-established with the new sonde purchased last year. Data collection has been great and should inform us much about pH variations off Two Harbors.

We aspire to place more instruments on this and other moorings. These sensors would include a pressure gauge to measure water level, and a current meter to measure water flow.



Divers attaching sonde. Credit: Adam Fram

Croatia➔ a new, higher level of visibility for the organization.

The conference was the Ocean Optics XXIV meeting, organized by The Oceanography Society (TOS). You may ask what is CMs doing at an optics meeting? Well, in addition to the data gathered by our field programs, there are lots of data available for free that are measured by the government and other institutions. We utilize these data, which include satellite measurements, data collected by buoys and shipboard measurements.

Venue for CalCOFI, screens open during break, revealing beautiful La Jolla

The issue we are studying is how Santa Catalina differs from the other Channel Islands, specifically in the seasonal growth of phytoplankton. To do so, we used a decade of color measurements made by the Earth Observing Satellite Aqua. This is where the optics comes in.

The study relied on past CMS work, which involved the analysis of buoy data, old-CCD temperature measurements, CalCOFI shipboard measurements and data from a weather station at Two Harbors.

We find that San Clemente is most like Catalina, but that our island differs markedly from San Nicolas and the Northern Channel Islands.

Various components of this study have also been presented at the Ocean Sciences 2018 meeting and recently at the California Cooperative Oceanic and Fisheries Investigation (CalCOFI). For more details, see the papers on our website or search for our article published by the Western North American Naturalist. ■

Upcoming Meetings

Southern California Academy of Sciences Annual Meeting, May 3, 2019, Cal State Northridge.

SCUBA Show 2019, May 4-5, Long Beach.

Ocean Sciences Meeting 2020, Feb 16-21, San Diego.

Catalina Marine Society Membership

Catalina Marine Society Members support the goals of the Society through their dues and also elect the Society's directors. Membership is described in the bylaws and is granted to those who: 1) agree with the mission statement; 2) pay the annual dues (currently $20); and, 3) submit an application that is approved by the board. An e-application is available on

http://www.catalinamarinesociety.org/CMSMembership.html

Manual Membership Application

Please send the following required information to the Catalina Marine Society via e-mail or post to the address below.

Name, e-mail address, postal address, reason you wish to join the Society, and that you agree with our mission statement.

Dues can be paid through the "Donate" link or checks made payable to the "Catalina Marine Society" sent to the following address:

Catalina Marine Society
15954 Leadwell Street
Lake Balboa, CA 91406

If you are interested in contributing to the work of the Society in other ways, please let us know. Categories and examples of needed volunteer work are listed below.

Lab	Field	Office
Data analysis	Boating	Web design/programming
GIS	Diving	Graphics
Programming	Instrument calibration	Photography/Videography
	Hardware/Equipment fabrication and mounting	

Magazine/newsletter	Fund raising	Press/publicity
Reporting	Event planning	Public speaking
Publishing	Event volunteer	Newspaper articles
Editing	Grant writing	
Departments		