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Technological Change and the Form of Science Research Teams: Dealing with the Digitals

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ABSTRACT *During the late 1990s, photography moved from being a primarily analogue medium to being an almost entirely digital medium. The development of digital cameras and software for working with photographs has led to the wholesale computerization of photography in many different domains. This paper reports on the findings of a study of the social and organizational changes experienced by marine mammal scientists who have changed from film-based photography to digital photography. This technical change might be viewed as a simple substitution of a digital for an analogue camera, with little significance for how scientists do what they do. However, a perspective anchored in social informatics leads to the expectation that such incremental technical changes can have significant outcomes, changing not only how scientists work, but also the outcomes of their research. This present study finds that key consequences of this change have been the composition of the personnel working on the scientific research teams for marine biology projects and the ways in which these scientists allocate their time.*

Keywords: digital photography; marine biology; social informatics; technological change

Introduction and Background

Digital photography is an innovation in information technology that has been widely and rapidly adopted across a variety of domains since the late 1990s. To understand the role of digital photography as a technology used in scientific work, this study examined marine mammal researchers who use photo-identification as a tool for gathering, organizing and analyzing data about whales, dolphins, otters, seals, manatees, and other marine animals. Many marine mammal researchers have recently switched from film to digital photography. This seemingly minor change has contributed to a number of fundamental alterations to the ways in which they do their scientific work.

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The study examined digital photography as an entry point for examining the role of new technologies entering scientific practice and regular use. Orlikowski calls this perspective the 'practice lens' for studying technology:

> Rather than trying to understand why and how a given technology is more or less likely to be appropriated in various circumstances, a practice lens focuses on knowledgeable human action and how its recurrent engagement with a given technology constitutes and reconstitutes particular emergent structures of using the technology (technologies-in-practice).[1]

The project was conceived and designed as a social informatics research study. Social informatics in North America is a relatively new approach to studying socio-technical systems,[2] first entering regular use[3] at a meeting of similarly minded researchers who gathered for an NSF-workshop at Indiana University in 1997 to examine 'the integration of computerization and networked information into social and organizational life, and the roles of information and communication technology (ICT) in social and organizational change'.[4]

Since that time, there have been several notable efforts aimed at explicating some of the central propositions in social informatics.[5] Three key themes are central to much of SI research: embeddedness, configuration, and duality.[6] Embeddedness is the notion that technologies are not isolated from their social and institutional contexts. Configuration captures the degree that uses of an ICT are not completely determined by the design of the ICT; there is flexibility in how they are used. This in turn influences the consequences of using the ICT. Finally, duality means that 'ICTs have both enabling and constraining effects'.[7]

All three of these key themes emerge in the present study. However, this article is focused primarily on the evidence of the embedded nature of digital photography: how the possibilities and limitations of photography influence interactions with wild animals, how researchers spend their time after a day collecting photographs, how they spend their time back at the lab, how work is divided, and what scientific results are available.

Much of social informatics research is anchored in a recognition that technology does not independently cause changes in the social order; instead, it often has measurable consequences, both positive and negative, both intended and unintended, in social settings where technology is put to use in ways shaped by the choices of users and other key actors.

Marine Mammal Photo-Identification

There are an estimated 2,000 practising marine biologists who carry out research on a variety of species of whales, dolphins, seals, manatees, and sea otters. Their methods vary and include acoustics, genetics, and the technique that sits at the focal point of this research, photo-identification. Briefly, the general photo-identification process is that field biologists on small boats approach an animal or group of animals and take photographs that can be used for identifying individual animals. The most important feature for identification varies by species. Humpback whales are identified by the coloration and patterns of marks on their flukes (tails), while blue whales are identified by the blotchy patterns of coloration on their backs. Bottlenose dolphins are identified by the nicks and notches in their dorsal fins, while manatees are identified by scars on their backs, received primarily from boat hits.

Once these photographs are made in the field, they are brought back to the lab and undergo an extensive process involving documentation, organization, and categorization. One of the most time-consuming aspects of the entire process is 'matching', the process of starting with a photograph of an unknown animal collected in the field and comparing it to all previously identified known animals to look for a match, thus allowing a positive identification of the new animal. These identifications are then used for a wide variety of scientific purposes.

Marine mammal science is a highly visible field due to the level of public interest in marine mammals. While the scientific publications are not necessarily consumed by the public, the research process and the activities of the scientists are frequently reported in the media and through environmental organizations and their publications. The public nature of this field has resulted both in increased funding and in increased scrutiny and regulation.[8] Both of these have in turn influenced the development of non-lethal and minimally invasive methods such as photo-identification. Because photo-identification meets the criteria both of being non-injurious to the animals and of being an excellent scientific tool for gathering the data needed to answer scientific questions, photography has become a mainstay in the field. For example, many of the participants in this study report spending between half and nearly all of their time working with photography in one way or another. As a result, this scientific field offers an excellent case study for understanding how digital photography might play a role in this and other research domains which rely heavily on photographic data.

Digital Photography

Even though there has been extensive writing and research about the nature of photography, the artistic elements of photography and about the social roles of photography, there have been relatively few attempts to understand photography from a socio-technical perspective. Most studies treat cameras as mere artefacts, put into use by their human users. This study, on the other hand, will examine how a seemingly innocuous three-pound hunk of metal can have widespread consequences throughout a domain or a community of practice.

Research Questions

The main study from which these data are drawn had nine research questions. The data in this article were collected to answer the following two research questions:

1. Who are the relevant actors within the systems supporting photo-identification research?
2. Who becomes involved in the photo-id process for the first time when scientists adopt digital photography; which formerly involved actors and technologies are excluded; and how are peripheral actors affected?

There are at least three possible sets of expectations. From a strictly technical perspective, the substitution of one piece of equipment would be expected to have mainly incremental effects. The new equipment is merely a three-pound device which has digital sensors instead of film. One might expect, then, that any changes in scientific activity would be minor elaborations, such as improvements in the efficiency, of previous patterns.

A second, more technologically utopian point of view would suggest that this innovation would free the scientists from the necessity of dealing with film and the accompanying issues of processing and storage, which in turn could free them up to do more science. The efficiencies of digital photography over film photography would, from this perspective, allow scientists to reduce staff size, take more photographs, incur fewer expenses, and generally do 'better' science.

The third scenario is the social informatics point of view, in which even incremental technological changes are understood frequently to result in unintended consequences. These consequences can be either positive or negative (as seen from the point of view of the actors), but are largely unexpected by the actors in the system. From this perspective, new technologies often shift patterns of work and can have implications throughout a domain. In this sense, technological change is likely to reconfigure how scientists do their work, as well as the outcomes of their work.[9]

A classic example of this perspective is the work on the productivity paradox. The productivity paradox discussed the fact that although considerable sums were spent implementing technology programmes that were expected to increase productivity, actual measurable productivity had stagnated throughout the 1970s and 1980s.[10] By the late 1990s, however, new research showed both that productivity related to information technology investment was increasing and also identified many of the other impacts of new information technologies beyond simply productivity.[11] This social informatics point of view informs the present study, leading to the hypothesis that the seemingly simple change in camera technology will have a number of unintended consequences throughout the domain of marine mammal science. Some changes may be viewed positively by the scientists, others may be viewed negatively, but the changes will extend into unexpected areas of their scientific practice.

Research Methods

Studying digital photography use by scientists could be approached in a number of possible ways, but this study employed a multi-site case study approach. Marine mammal researchers operate within a bounded system of scientists, which makes them amenable to the case study approach.[12] Furthermore, the reason for studying this multi-site case[13] was to develop an instrumental case study that helps to pursue an external interest of refining theory, as opposed to developing an intrinsic case study designed primarily to understand the phenomenology of a particular case.[14] The theory that the main study was seeking to refine was Kling's STIN strategy for social informatics research.[15] The refinements made to this strategy are discussed elsewhere.[16]

Sample

The research sites selected for this study were identified through a purposive method involving an examination of recent research articles in marine mammalogy using photo-identification methods, by talking with every available scientist presenting a paper or poster using photo-identification methods at the 2005 Society of Marine Mammalogy biennial meeting, and by asking them to recommend others who might participate in this project. This sample was expanded through a 'snow-ball' sampling procedure. While this sort of purposive sample has limitations, in a small field such as the subject of this study it can be the most efficient way to gain access to 'information rich' participants in the domain.[17]

Marine mammal researchers are located in a variety of public, private and educational institutions around the world, and there is no specific organization[18] or special interest group dedicated to photo-identification methods. Thus, there was no practical way to establish a population from which to draw interview subjects randomly. In addition, since the author travelled to the laboratory locations, some practical limitations of logistics had to be taken into account. However, the researchers and research sites chosen were often referred to, unprompted, during interviews at other, unrelated sites, indicating that they are part of a shared network of scientists. Many have been involved in this work for a considerable period of time.[19] This sample represents a significant component of ordinary scientific practice in the marine mammal photo-identification subfield.

Field Sites

The sites chosen for this study demonstrate the variety in the types of organizations involved in marine research. Non-profit organizations ranged from very small institutes with just a few employees in an out-of-the-way location to large campuses with multiple buildings and hundreds of employees. Some of the facilities were closed to the public, while others had public outreach facilities such as museums, aquariums, and boat trips. The colleges and universities were on campuses familiar to anyone in higher education, and the facilities housing the scientists were typical university office and laboratory spaces. The government facilities tended to be large campuses with multiple large buildings housing hundreds of employees, but the animal research programmes share these campuses with many other marine biology and oceanographic research programmes. The study included non-profit organizations (three small, one mid-sized, and three large non-profits), higher education institutions (one each of a liberal arts college, a teaching university, and a research university), and government agencies (three in total).

While a non-representative case study could have been produced by visiting just one site, by comparing and contrasting what occurs at the different research centres, this study is able to reach some general conclusions about the *field* of marine mammal photo-id research. This is preferable to being able only to consider what happens at a single, possibly idiosyncratic, location. The multi-site method of creating a case study from a number of sub-cases provides a higher degree of certainty that this research is more representative of this sub-field.

During the site visits, participants were generally interviewed in their offices or laboratories. In most cases, they were near their computers and could demonstrate examples of their work on their computer screens. They were also asked to show how they did their work, and at many sites it was possible to observe various stages of the photo-id process, including data collection on the water and photo matching from both paper-based and computer-based catalogues. For this research project, the site visits were relatively brief, ranging from one to three days each, depending on the number of people being interviewed. While short visits of this nature are not ideal compared to extended interactions, the relatively large number of interviews done during multiple site visits mitigates some of the weaknesses of this data collection strategy.

The specific data collection methods included semi-structured interviews (41 interviews in total, lasting a total of 54 hours and transcribed for a total of 1,132 pages of transcribed interviews), analysis of photographs (405 images), and analysis of documents such as manuals, memos, reports, articles, newsletters, and websites (115 documents containing 1,098 total pages). As Yin points out, 'these and other types of documents are useful even though they are not always accurate and may not be lacking in bias … the most important use of documents is to corroborate and augment evidence from other sources'.[20] In other words, documentation helps the analyst triangulate accounts of events using multiple sources of evidence.

Another type of evidence was collected through direct observation of scientists in their work settings. During a field visit, the case study researcher recorded observations of environmental conditions and social behaviours. As Yin points out, 'if a case study is about a new technology, for instance, observations of the technology at work are invaluable aids for understanding the actual uses of the technology or potential problems being encountered'.[21] While observing may seem like a natural and somewhat passive activity, a researcher must plan carefully to avoid being either marginalized or influencing the observation setting too greatly. Creswell[22] identifies a series of steps for observing social environments. These include identifying gatekeepers and key informants for access into the observational setting; recording notes in the field of both a descriptive and a reflective nature; recording details about individual behaviours, the physical setting, events and activities as well as one's own reaction to these details.[23] These procedures were followed by this study and documented in the case study database.

Using multiple methods with careful attention to the compilation of a case study database addresses some of the shortcomings that occur too frequently in qualitative research. The use of triangulation, or multiple methods, reflects an attempt to secure an in-depth understanding of the phenomenon in question, since objective reality may be difficult or impossible to capture.[24] Case studies generally use triangulation as a way to clarify meaning through both verifying that an observation is replicable and, conversely, identifying ways the phenomenon is seen differently by different actors.[25]

Findings and Discussion

Some of the relevant actors in the marine mammal photo-identification system are obvious, others less so, and in this paper we will discuss only those most relevant to demonstrating the nature of the changes in the work processes that have developed to expedite photo-identification of marine mammals.

Among the more obvious participants are the investigators, researchers, technicians, field personnel and support staff involved in gathering and using the scientific data to identify and track various marine mammals. Investigators are the primary leaders of the scientific projects, exercising autonomy in decision-making and acting as leaders in generating research and funding. Investigators are generally senior scientists who oversee the operations of their studies, although they may delegate specific day-to-day decisions to trusted others. The involvement of an investigator in hands-on research depends on the study. The researchers, on the other hand, are less senior scientists and are nearly always heavily involved in the day-to-day science but are less responsible for organizational issues than the investigators. Technicians are often less well-credentialed (often holding undergraduate degrees) and are in many cases younger participants in the scientific projects. For instance, the average age for technicians in this study was 28, compared with 34 years old for researchers, and 56 for investigators.[26] Technicians are generally much less autonomous with regard to their work assignments.

Even though the fact that a research scientist is an actor in a system of scientific knowledge production is wholly unsurprising, the investigators are actually quite surprising in a number of ways. First, a naïve assumption held prior to doing this research was that most of the leaders of the scientific projects studied would be PhD-holding academics. In fact, however, this was true only of the participants at universities and government agencies. At projects centred in colleges or universities (*n*=3), four PhD-level scientists were part of the study, representing all of the principal investigators (PIs) and one-third of all participants at those sites. Likewise, at government agencies (*n*=3), PhD scientists led four of the five projects, and made up one-half of the participants at the sites. At non-profit organizations, however, PhD scientists led the projects at only two of the seven sites studied, representing only one-tenth of the participants. Indeed, several of the scientists had relatively little formal academic training, holding a Bachelor's degree or a lesser credential.

The path of entry into many of the non-profit organizations is often somewhat informal, through such opportunities as apprenticeships and volunteer opportunities. While most of the technicians who participated in this research held Bachelor's degrees in a biology-related subject, getting hired to work with marine mammals in many cases involved a 'foot in the door' approach rather than an academic route. The following three examples illustrate this point:[27]

Anna Hawes: I started here [at Pacific Whale] as an intern. I interned for two quarters, volunteered for two quarters, and now I'm a paid employee.

Amy Kirkwood: Came to Atlantic Dolphin in 2002, I believe. Started out as a volunteer, and then got hired. Began volunteering and then I was hired as (name)'s admin assistant. And with all my other experience I was eventually able to move over to photo ID.

Kathryn Stamps: I went from my internship right to my part time job with the state just to pay the bills basically, because I volunteered here for some time before they could pay me.

Many of the younger technicians at the non-profit organizations reported similar stories of creatively finding ways to gain leverage into an organization through internships, volunteering, and holding a variety of low-paid, temporary jobs either in or out of science to be able to pay their bills. Most, however, either had plans to get their Master's degree or were actively enrolled in a Master's programme, as they learned by experience the truth of one investigator's observation that to be taken seriously in the field today, 'you have to have at minimum a Master's degree'. Many of the students interviewed at the universities involved in this study had done work in the field before returning to get their Master's or PhD degrees:

Cynthia Conlin: I travelled a fair bit and then I got a job as a research assistant … studying nesting sea turtles and I did that for about seven months and then got the job in New Zealand basically starting as a volunteer research assistant and through that got to know Gerald [Lemoine, the investigator at her current project].

While solid practical experience was once a ticket into marine mammal science, particularly when it was a younger field, today the experience must, in most cases, be combined with formal academic credentials in order to advance in the field.

Other important actors related to the performance of the ordinary scientific activities in these organizations are the support personnel. Once the photographs are collected in the field, one of the chores upon returning to shore is to download the digital images from memory cards to hard-drive storage which will later be transferred to computers and/or servers back at the lab. This is obviously a change from the period when the field was film-based, and represents both a new set of activities and a new set of actors, the information technology (IT) support personnel.

Whether IT support is just another role played by a researcher or technician or whether there are staff dedicated to this role depends partly on the size of the study. If there are dedicated IT staff members, they are unlikely to be in the field at the time data are downloaded and backed up, but they will have helped set up procedures for dealing with technical aspects of storing and backing up data. Several of the larger projects had very detailed procedures manuals with specifications for each step of this process. Others appointed someone who seemed to have an affinity for data management to overseeing the IT work:

> John Maze: I studied Marine Science, concentration in Marine Biology … [and now] I basically manage the data collection, train people that are in the field, like the new grad students and research assistants. I schedule all the field work, who the captains are going to be, who the observers are going to be. Just manage the computers, the space, intern acquisition and placements, just all that jazz.

The next step after collecting the images and associated log data in the field is to download the data onto computers, back everything up, and then start to process the images and record the data into a database. This step is one that has shifted from the film era to the digital era. With film, the images take far longer to be processed, sometimes at the end of the field season altogether. Digital images are available immediately, which means in most studies, people start working on organizing them right away, even if they are in field locations distant from their labs.

> Dr Rita Price: So we get back and usually what we do is we have all these images. And what happens with the digital? You take more pictures. There's more data to go through. [laughs] … I'd think at least twice as much … [slight groan] because we don't delete things in the field. We don't do that … What we do is we try to go through … those digital files and we try to pick the best picture of an individual and put them in the best folders for that encounter. So when you come home, there are the five whales that were in the best photo of each one. Usually we don't get that done because we're just really tired.
>
> RP cont.: But the other thing we do, years ago when we first started the digital stuff, I'd get an external hard drive and we'd back everything up on the external hard drive. Plus, we'd make CDs of everything. So, the problem was, you know, before all I had to do was make a label and put it around the film. Now, I'm processing and batching and renaming and trying to find all these, okay now it's 07CA001 (for roll '1'), 'D' for digital, 00 for Orcinus Orca, 001 for frame 1; and it's just like, 'Oh my god'. And me being not raised up with computers and stuff … I mean

it was a cool tool and everything like that; I loved it. But all of a sudden when we got back to the ship we're processing all this stuff and you're looking at a couple hours worth of work … And all of a sudden my computer that I had initially was [working] all night long [on] the batch rename or converting to .tiffs or something; I can't remember which one it was. It took forever, you know? I'd wake up in the middle of the night and I'd see the thing flashing that it got stuck, and I'd have to … oh god! [laughing] So anyway. That's kind of the deal with the digitals.

One of the Atlantic Dolphin Research Institute technicians described how ADRI researchers deal with their data at the end of a day on the water:

Emma Hatcher: We come back in immediately because it takes several hours to download those four gigs of images usually. We'll drop the card on the hard drive, we'll go clean the boat, and we'll pull off all the data sheets and start entering the data sheets. Somebody will clean, somebody will enter, and usually it's enough of a timeframe that you get in that late at night in the dark, so we'll leave the card, we'll drop and leave the card then lock everything down. In the morning, we'll compare the card to what was dropped to make sure it's equal. We won't use that card the next day to make sure that it gets backed up, but overnight technically at 11 o'clock everything should be backed up.

Many of the projects also invested in either dedicated or shared information technology (IT) experts. Database design, network server administration, and computer support all require specialized skills. In some cases, computer experts were brought in, while in others existing staff with a talent for working with a programme like Microsoft Access had part of their time devoted to designing databases. The following excerpt describes a complex database project that was initiated at the Atlantic Coast Marine Center (ACMC):

Brandon Lindell: I actually have been working with a programmer for quite a few years on and off. We used to have all of our data in dBASE and then I sort of envisioned a much more flexible and user-friendly environment, so we moved into Access. So, he helped us with that and we had a little matching programme that folks from [a funding organization] helped set up and he helped sort of finish off. So, I've been working with him for years and he actually helped write some of the technical aspects of the grant, but unfortunately once we got the grant he was no longer available to work on it. He basically didn't have a whole lot of hope that it would work out and, you know he had to pay the bills and stuff. So, anyways, that was a fairly disturbing turn of events. And he had actually even started a little prototype of what we're moving towards. So then we had to put it out to bid and that was pretty difficult because this guy I've been working with, he really understood the database and he'd been working with it in a lot of different ways and understood

> how we worked because a lot of computer programmers really don't get it. They're used to people who are not as computer-adept and, you know they're used to financial stuff or healthcare systems primarily … So, I basically sat down with all of the people I worked with and designed every single interface that we would ever need with our data … you know, every screen we would need and every field in our database and it was pretty detailed and I think both exciting to the people who have been on it and a little overwhelming because there was so much information.

ACMC provided the details of this project that was put out to bid, and the prototype interface was laid out in Excel spreadsheets, using the cells as a grid to simulate a screen and included information on required fields and the behaviour of each field. A total of 53 Excel documents were required to specify the design that the biologists needed from the computer programmers. When the project was awarded, 'they said, "Yup, we can have it done in six months". And two years later, they had it done' (Brandon Lindell). Here is a similar experience at Whale Canada:

> Paul Dawkins: We had a specially designed database for us on the Mac. We have all the data for that animal's sightings over the years, all the details, associated animals, any new scars, things of that nature, the depth, the atmospherics … we can get everything from that day. And the photographs are linked to that. We're working on a new thing right now because of all these new pictures coming in; it's a little scary because, you know, before we had contact sheets and all that. Things were more tangible. And so because there's so many different people working on this we have a thing we call [name] that we've created with some software developers. And we're hoping to have that in place this year so that we have a much more standardized way of putting the pictures in, after each day. So it's not just so much of a mess. You know, it can get quite messy on computers if each person's putting their files and stuff. We've had a little … it's been a little slower getting that up and going than we'd hoped because the software guys didn't quite click on what needed to be done. But, I think, we might be getting there.

The Atlantic Dolphin Research Institute (ADRI) also used expert help to design their databases and talked about the length of time required to build a system:

> *Interviewer:* *How about the database that they showed me? They tell me you designed that? Did you also do the programming part of it?*
>
> Faye Hampton: No, I worked with a programmer here … That has been ongoing. It took a year or more and we still tweak it.

Coming up with a database to track information about the photographs and about the other data collected in the field has been a major issue for most of the projects. Some projects took a different approach from ACMC or ADRI, and chose to have biologists working on the project pick up database skills:

Ellen Batton: Would you like to see our in-house database …? [This] is the first database that I designed and from there things have kind of grown from it … What users see typically when they open the database is … I think it's about five different tables. First tier of data being effort, so you have one record per day, general information about that day. You know, who, which boat, where, how long were you out? Keeps a log of events throughout the day and a log of conditions throughout the day. So from here, if you enter this, you can have several options of where to go from here and one is … to add sightings to this particular survey, so it will automatically build a link to this day … You can also filter sightings, so you can view sightings from the survey …, the next here is sighting information and each sighting is given a unique number and this is all the … forms … for information: lat, longs, start, end times, species, number of animals, behaviour, you know, various permit information. All pretty big.

Regardless of whether projects chose to use in-house staff or to bring in outside experts, a common theme throughout the sites was that the information systems required to track all of their digital information had grown far more complex than they had originally envisioned and that maintaining the systems and upgrading their features had become a growing task for all the projects. The expertise to build and maintain these systems, then, is a resource that the marine mammal scientists have had to enlist either by hiring experts or by developing the skills of scientists.

These examples illustrate some of the more obvious actors in the system of marine mammal photo-identification. Investigators, researchers and technicians all fall within the overall category of *scientists*, while field support and IT support personnel may or may not also fall into that category. However, there are some less obvious actors in this socio-technical system.

Volunteer workers play several important roles on many of these scientific projects. As mentioned above, some students and recent graduates volunteer for research organizations with an eye toward eventually being hired into full-time staff positions.

Another type of volunteer is also an important actor in this system, the eco-volunteer. Eco-volunteers sign up to participate in research during their vacations and provide both labour and participation fees. While the most well-known institution organizing eco-volunteer trips is Earthwatch, some of the projects recruited volunteers through other organizations or even recruited volunteers directly.

Many of the projects encourage the participation of eco-volunteers on their field research trips and gain several benefits from this interaction. First, they have additional hands available on the boat to handle activities such as logging data and serving as spotters for animals in the water.

Cynthia Conlin: So generally, my setup was that I was drive, because it was just a little boat, like a five and a half meter boat. I would be driving the boat, I would have a photographer and I would have maybe two or three volunteers who would basically record data that I would call out. And I found that system worked really well for me to be able to always keep my eye on the dolphins at all times. Because often, you know, you can't do everything.

Depending on the project, the expectations for the eco-volunteers can vary:

Paul Dawkins: We really try to minimize whale watching. We really make it clear to people that they're coming with a research team. And, that we're not going to cater to tourism. So if they have any doubts about coming out with us, don't. [Laughs]

The volunteer contribution is not limited to labour, however, as the following pair of comments by research investigators illustrate:

Dr Gerald Lemoine: Each volunteer needs to pay Earthwatch; I think it's now $2,100 or $2,200 to be with us for two weeks. And they help, it's variable, depending on their background and capabilities and interests. But some are of tremendous help, intellectually and physically. But they help financially, for sure, all of them.

Dr Gary Lewin: Earthwatch has been a sustaining source of support for us. It's somewhat less so now than it used to be. We're down to half as many teams now as we used to have. But, we've been working with them since 1982 and it's been a source of support, as well.

Who are these volunteers? There doesn't appear to be a single type, as comments from two of the researchers illustrate:

John Maze: Oh, all kinds. There are a few types [of volunteers]. There's the high school student who's interested in doing science type, there's the high school student who got it as a gift type, there's older people that just want a vacation, sort of alone and away from anything. And then there are single people and married people that just, it sounds terrible to say, but it's not really, if they want a break from their jobs, from their kids, from their house, from their friends, just want to get away and do something for themselves. I get a lot of those people. I get people that are biologists, that want to come and study different biology, different sorts of things. Every once in awhile we get college undergraduates that are interested in the field, but we generally steer them towards internships. It's a full length internship just because they can get more out of that. It's more designed for them, but sometimes they can't with their schedule, so it's better for them to come [as volunteers].

Holly Kershaw: I'd say the most common would be middle aged single women, so maybe in their early 40s or late 30s. We get a lot of teachers because teachers can get grants through Earthwatch to come so they have their way paid to come on the trip. Then they have to create a lesson plan out of what they learned and bring it back to the classroom. So we usually have at least one teacher on every trip but it's mostly women that come in that 40-year-old range I'd say.

One downside to volunteer labour is that when dealing with complex systems, volunteers often do not participate long enough to be able to contribute:

Amy Kirkwood: We have volunteers that have gone out on boats with us, and that have helped us with little things in the lab, but generally there's such a high turnover with volunteers, that it would take them too long to teach them how to use all of this.

Another issue is the time that the care and feeding of short-term volunteers takes the researchers and technicians during their field season:

Interviewer: What are some of the costs and benefits?

Holly Kershaw: Well, the benefit of course is that you get money. Also you're hopefully educating some of these people so they'll go and spread the conservation message basically to others. The cost is that it does take away from the research sometimes because some of these people, a lot of them are there on vacation and things. We're there trying to get our research done, but you have to spend more time training. You get more individuals in, more teams in every two weeks so you have to start over with training and spend more time with that. Then also we have a lot of bad weather days due to high winds and then you have to [entertain them], especially if we're in a remote place. [In this remote location], you know, you can't go to a movie or to the pub so you have to find activities to keep them happy and all that. So it's more work than if you didn't have them but we couldn't be there unless we had them so …

The decision about how much to rely on volunteer labour both on the water and back in the lab depends not only on the preferences of the project personnel, then, but also on the complexity of the tasks that need to be performed. At least one organization used to use volunteers more extensively during the film era than they do now that they have transitioned to digital photography. The Pacific Whale Project used to rely on volunteers to use their darkroom and print out black and white prints of the photographs that would be used for identification. Now that they have transitioned to digital photography, however, they turned their darkroom into a room for other uses and no longer use as many volunteers. Instead, full-time staff handled most of the steps in organizing and processing the digital images.

There are a number of other actors and non-human actants involved in the photo-identification system too numerous to discuss in detail. Some of these are philanthropists, professional societies, funding agencies, governmental organizations, photography systems, information systems, animals, and ecosystems.

Exclusion of Actors

What about excluded actors in this socio-technical system? Has the influence and participation of some types of actors been reduced with the change from film photography to digital photography? Some of the excluded actors are fairly obvious (film-processing laboratories, film manufacturers, companies to ship the film), and not really terribly interesting from our analytic perspective since they were primary external participants in the system. For the purposes of this paper, we will focus on discussing the most mentioned change in human participants at marine mammal labs: the shift from volunteer labour to paid staff positions throughout the photo-identification process. This shift has resulted in a linked pair of included and excluded actors: the paid staff members are newly included, and some, but not all, of the roles played by volunteers are newly excluded. There are costs and benefits of this change to the practice of marine mammal science.

The logging of data on the boat is an important role volunteers play in many of the projects:

> Christine Showers: I guess the primary help [the eco-volunteers provided for] my research was to record data. So, we had data sheets that we recorded surface data, like environmental data or the different behaviours or numbers, so it's good because typically, one researcher will need to watch the dolphins to call out the behaviour accurately, so it's helpful if you have a volunteer that's actually recording that data while you watch the dolphins. I guess they also help in terms of maintaining equipment and cleaning equipment up at the end of the day and they actually helped quite a bit this last season in terms of analyzing data on the computer.

However, a trend was noted that had been discussed by a South European Dolphin Center researcher toward changing habits in the field regarding logging data about photographic images:

> Leah Tull: With the slides, I would call out every picture I took. I would say left dorsal, right dorsal, and if possible the animal and if I wouldn't know the animal I would say A1 or C1 or whatever just to indicate it's the first adult … [A volunteer] would definitely hang on my lips and write [everything] down … Unfortunately, now we don't still do that.

Several people commented that the involvement of eco-volunteers in the field was highly variable, and some believed that as the equipment got more complex, there were fewer tasks that they could trust volunteer outsiders to do accurately. The real shift, however, was noted at some of the sites that previously used local volunteer to do a number of the tasks related to maintaining the office, keeping track of data, processing images, and matching images. Our investigator noted that the move away from volunteer interns and toward permanent staff is more efficient, but also more costly. One of the researchers on the same project described it this way:

> Ellen Batton: I think that it's very different. I mean, our interns come in and they're handed stock photos and this is a humpback whale, that's the catalogue, go look for it. And it's changed so much in the last few years, because when it was still in film, the other thing that interns did as they came in—they didn't actually develop the film, but the negatives would need to be printed and it would be like here's a list. One of the staff would review the list to be printed and matched and we'd show them how to use the darkroom and then they would spend days and days and days in the darkroom printing photos. So that was a little bit

> more of a hands-on approach, but this system has taken the place of the interns, basically, so now you can't really have an intern. You will need to have somebody who's got some skill married to the programme and that's a shift that we're still dealing with that we just don't have the—we used to really need a lot of unskilled labour and now we struggle for finding things for unskilled labour to do.

The costs of this change are obvious from the point of view of the volunteers and interns who want to work with an organization that was struggling to find things for them to do. Many interns go to non-profits to enhance their education in biology, and also to increase their ability to get hired later, either by the same organization or by another one. Many of the current technicians occupying paid staff positions had gained entrée to the organization as unpaid interns or volunteers. If there are fewer opportunities for interested people to make meaningful contributions and demonstrate their commitment to marine biology, this narrows one opportunity for long term participation in marine mammal science. It is somewhat ironic that the flip side of this trend is that some of the same organizations are hiring full-time staff (either permanently or on temporary contracts) to do the more complex and technical work that unskilled interns and volunteers used to do. Open questions remain as to whether those interns are finding their way into these paid positions without having the requisite experience, and if so, how are they doing so?

The benefits from this change accrued to two different parties. First, newly employed paid employees benefited financially, particularly if their other option would have been to either do the same work for free or work in another organization about which they may not have the same passionate interest. Second, the organization benefited from having a well-trained, stable workforce over which they have more control that they would over unpaid workers. Several respondents noted that the current system which relied on paid staff was more efficient, especially in terms of time, which helps advance the organization's scientific agenda. The opposing cost from the organization's point of view was economic—staff needed to be paid regularly, and that meant the organization would have to ensure a continuing flow of money or risk watching their scientific programme grind to a halt.

Conclusion

The results reported here are part of a much larger study examining the role of a specific technological change (the switch from film-based to digital photography) in enabling and influencing changes in organizational settings. This analysis suggests that marine mammal scientists have altered the makeup of their project teams in response to the demands of the new technology of digital photography. Most of the scientists with whom we spoke were somewhat surprised by the extent to which their staffing needs had changed and in some cases there appeared to be some concern that securing sustainable funding to continue to support the additional staff members could be difficult in the future. The need to hire new staff or retrain existing staff to deal with increasingly complex databases, information systems, and computer networks is a new cost for most of the projects. In the past, when using film-based photography most of the studies found their computer needs to be relatively modest since much of their data were stored not in computer format, but in binders containing photographic slides or prints.

These increasingly computer-based systems for saving, storing, moving, documenting and analysing digital photographs have led to a reduction in the reliance on volunteer workers and an increase in paid scientific staff. Whereas volunteers represented either free labour or a source of project income, paid staff technicians are an ongoing operating expense. Also, it is not clear whether this increase in reliance on paid staff will affect the possibility of gaining entrée to the system for uncredentialed newcomers. A number of the younger staff members had begun their careers as volunteer staff (mostly while the organizations were still using film photography) and worked their way into permanent positions. If these opportunities become less available, it could affect the supply of new scientists in the field in the future.

Even more importantly, many of the scientists have shifted their allocation of time. Many of the scientists and their staff members now spend considerable time at the end of a field day and during their time back at the lab dealing with the demands of computer-based photography. Instead of labelling a canister of film and mailing it to a processor at the end of a long day in the field, the scientists now spend time downloading, organizing, renaming, archiving, and maintaining their digital photographs. In the lab, they spend considerable amounts of time categorizing, organizing, identifying, and working with these digital photographs. While some of these jobs are similar to those done when they used film, many have intensified in terms of time demands, and others are new tasks entirely.

The seemingly simple change of swapping a three-pound piece of analogue camera equipment for one equipped with a digital sensor has clearly had consequences in this domain. While the many positive consequences reported elsewhere[28] are strong enough that no scientists in the study are considering switching back to film-based photography, the unintended consequences regarding the form of scientific research teams and how the scientific work gets done and who does it will have continuing impacts on the practice of marine mammal science.

Notes and References

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3. Kling mentions that the idea of coming up with a better term for this type of research first arose at an NSF-funded workshop on digital libraries held at UCLA in 1996, and social informatics was one possible term offered as a replacement for the variety of terms in use ‘including “social analysis of computing”, “social impacts of computing”, “information systems research”, and “behavioral information systems research”’. See Rob Kling, ‘What is social informatics and why does it matter?’, *D-Lib Magazine*, 5, 1, 1999, p. 13.
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14. Stake, *op. cit.*
15. Rob Kling, Geoffrey McKim and Adam King, 'A bit more to it: scholarly communication forums as socio-technical interaction networks', *Journal of the American Society for Information Science and Technology*, 54, 1, 2003; Eric T. Meyer, 'Socio-technical interaction networks: a discussion of the strengths, weaknesses and future of Kling's Stin model', in Berleur *et al.* (eds), *op. cit.*
16. Meyer, 2007, *op. cit.*
17. M. Q. Patton, *Qualitative Evaluation and Research Methods*, Sage, Newbury Park, CA, 1990. Cited in Janice M. Morse, 'Designing funded qualitative research', in Denzin and Lincoln (eds), 1998, *op. cit.*
18. While the Society for Marine Mammalogy (SMM) is the major professional affiliation for the scientists in this study, the society itself also has many more members not engaged in photo-related work. Other common techniques include genetics research, acoustics, and invasive health assessments. With no way to reliably identify which SMM members used which technique, drawing a representative sample would have had its own inherent limitations.
19. Most of the sites included are shown in a table of photo-identification projects listed in a 1988 report on a symposium convened to bring photo-identification researchers together for the first and apparently only time: Philip S. Hammond, Sally A. Mizroch and Gregory P. Donovan, *Individual Recognition of Cetaceans: Use of Photo-Identification and Other Techniques to Estimate Population Parameters (Report of the International Whaling Commission Special Issue 12)*, International Whaling Commission, Cambridge, MA, 1990; Mizroch, personal communication, December 2005.
20. Robert K. Yin, *Case Study Research: Design and Methods*, Sage, Newbury Park, CA, 2003, p. 87.
21. *Ibid*, p. 92.
22. Creswell, *op. cit.*
23. *Ibid*, pp. 125–6.
24. Norman K. Denzin and Yvonna S. Lincoln, *The Handbook of Qualitative Methods*, Sage Publications, Thousand Oaks, CA, 2000, p. 2.
25. Stake, *op. cit.*
26. Technicians (n=13), mean age=27.5, range=20–35, s.d.=4.1; researchers (n=14), mean age=33.7, range=27–45, s.d.=6.2; investigators (n=14), mean age=55.6, range=50–62, s.d.=4.0.
27. All names of people and places in this article are pseudonyms.
28. Meyer, 2007, *op. cit.*