Open Ocean • Training & Expedition Assessment Report

Deep Sea Camera System Training & Expedition Assessment Report 2019

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Introduction

In 2019, the MIT Media Lab (MIT), National Geographic Society (NGS), Lindblad Expeditions (LEX) collaborated to create a pilot Deep Sea Camera System training and deployment program.

The goals of the 2019 pilot were to:

1. Train MIT students/staff, LEX Undersea Specialists, and collaborating scientists on seagoing operations, including NG Deep Sea Camera System deployment, recovery, and data download.
2. Execute Deep Sea Camera System deployments in SE Alaska and the Galápagos Archipelago aboard LEX vessels.
3. Build a team for future tech development, exploration, community building, and expeditions aboard Lindblad vessels and beyond.

In March 2019, eight staff and students were trained during a 2-day workshop at the MIT Media Lab -- four from LEX and four from MIT. In August, we held an additional training at the MIT Media Lab for 13 people -- one LEX, two NGS, nine MIT, and one Charles Darwin Foundation (CDF). A total of 21 people were trained. We were able to increase the number of trainees in the August session because two of those trained in March and co-led instruction for new trainees in August.

Following the training workshops, 14 of the trainees were selected to deploy the NGS Deep Sea Camera Systems at sea aboard LEX-NG expeditions in Southeast Alaska in late June to early September aboard *NG Quest* and *NG Venture*, and in the Galápagos in Sep-Oct aboard *NG Endeavour II*. Over the course of 12 weeks at sea, 25 trainees sailed on LEX-NG expeditions, deploying the Deep Sea Camera Systems 53 times, and recording 126 hours of video and environmental data ([Figure 1](#), [Table 1](#)). Data collected are currently being analyzed. So far, one paper, led by Salomé Buglass, has been published, reporting on first records of the seven-gilled and six-gilled sharks found in the Galápagos Marine Reserve ([Buglass et al., 2020](#)).

Figure 1

Over the course of 12 weeks at sea, 25 trainees sailed on LEX-NG expeditions, deploying the Deep Sea Camera Systems 53 times, and recording 126 hours of video and environmental data in southeast Alaska (top), California (middle), and the Galápagos Archipelago (bottom).

Table 1. Deep Sea Camera System Training & Deployment Summary

	Alaska	Galápagos	Total
Number of trainees			25*
Weeks at sea	7	5	12
Deployments	20	33	53
Team members on board	1-4	5-7	1-7
Deployments per week	1-6	4-8	1-8
Depth range (m)	25-200	150-1800	25-1800
Hours recorded	48	78	126

The post-cruise survey was intended to assess the pilot training workshops and deployment operations, in order to collect feedback from participants and learn how we might improve this program in terms of both training

and at-sea operations about LEX-NG vessels in 2020 and beyond.

In addition to Deep Sea Camera System training and deployment, three new technologies developed by the MIT Future Ocean Lab and MIT Media Lab were tested aboard *National Geographic Venture* in SE Alaska and off the Channel Islands, CA. Deployment summaries are included in [Appendix A](#).

Survey Overview

Who Completed the Survey

This survey was distributed to those who were trained, ran, and assisted with the training workshops, as well as several people who worked with those who carried out deployments on LEX-NG expeditions in 2019, including Expeditions Leaders and Undersea Specialists.

A total of 21 out of 32 people completed the survey, 19 of whom participated in some kind of training (15 at MIT and 4 at sea). Respondents were a combination of students, staff, and research fellows from MIT, LEX, NGS, the Charles Darwin Foundation, and Galápagos National Park ([Figure 2](#)). 19 out of 21 were trained at MIT or at sea.

15 of the respondents sailed on a Lindblad-National Geographic Expedition in 2019 in Alaska and/or Galápagos; six did not sail in 2019, but would like to do so in the future if given the opportunity.

Figure 2

Survey participants. All five organizations were represented, and participants included undergraduate and graduate students, research fellows, and staff.

Recommendations for 2020

The following are eleven recommendations that can be implemented in 2020 and beyond, as we continue to build the Deep Sea Camera System team and expand the program.

Training

- Continue to expand LEX/NG/MIT training team. Burden of training doesn't have to be on the ExTech Lab, and results in a richer, more capable team for training.
- Build on lessons learned in 2019 to create in-country training workshops to be held in advance of expedition(s). Consider local customs, languages, etc.

Pre-Cruise Planning

- Determine expedition location(s) well in advance, ideally 12-18 months, to allow for collaboration with local scientists and securing permits for marine scientific research in US waters and foreign countries.
- Create a cruise plan for each expedition, or series of expeditions. KCB can provide recommendations for format.
- Create online resources for pre-training and/or refreshers.

Mission Planning

- Develop a framework for Mission Planning to ensure data validity and consistency. Include 2020 mission experiments for optimizing Deep Sea Camera System use.

Operations

- Equipment, bait & anchor storage and working space flagged as a major challenge. Consider options such as extra cabin, if available.

Software

- Software should be redesigned with three primary considerations in mind: (1) ease of use; (2) reduction of human error in data pipeline; and (3) data analysis capabilities.

Guest interactions

- Ensure that Deep Sea Camera System Team interacts with guests during meals and shore excursions, but keep in mind operational needs and the team's priorities on board. Manage guest expectations for interactions with the Deep Sea Camera System Team.

Team

- Expedition goal(s) should be considered when determining team size. Smaller teams (2-3 pax) are sufficient if priority is deployments; larger groups are possible if education/training is priority, but need to be managed as such.
- During every expedition, a single Team Leader should be designated to be responsible for the team, act as POC for the ship, and ensure project objectives are met.

Survey Results

Training

Participants were asked about their level of comfort with 13 skills. 19 respondents completed this section of the survey. Overall, for all participants and skills, more than 75% felt that they could perform that skill and/or teach someone else ([Figure 3](#)). Breaking it down further:

- **More than 84%** responded that they can do it and/or teach someone else: Deep Sea Camera System Deployment, Recovery, Setup, System Overview
- **74-79%** responded that they can do it and/or teach someone else: Mission/deployment planning, Yagi/RDF system, Loading mission programs, GPS operation, Communicating the project to guests.
- **58-68%** responded that they can do it and/or teach someone else: Data Download, Deep Sea Camera System Program History and Goals, Knots, Navigation.

Figure 3
Training Results. Participants were asked to rate how comfortable they were doing and teaching each of thirteen skills that were taught during the training workshops.

What worked particularly well?

Overall, participants felt comfortable deploying the Deep Sea Camera System after training. Five people each noted that the trainings were an effective use of time and schedule, and felt that the hands-on nature of the training workshops was useful to build skills and confidence. At least three people thought that the team building and co-training of LEX and MIT teams was positive.

Other notable positive takeaways for the MIT trainings include: small groups (2 people per Deep Sea Camera System team); station rotations allowed hands-on training for everyone; and, local boat for practice deployments.

One at-sea trainee noted good coordination with the boats and bridge to accommodate training as well as guest experience.

One respondent did not participate in training, but worked with many trainees at sea who were well trained, and felt that the trainings “did well to bring awesome people together.”

What could be changed and/or improved?

Overall, suggestions were positive, usually in the realm of “I wish we had time to do more....” Below is a ranking of activities that people who were trained at MIT (March and August combined) and thought there should be more of each activity, in order of preference:

- 4 - Practice deployments
- 3 - Data download
- 3 - Knots, Mission Planning, Loading Mission, GPS/Yagi
- 1 - Chart reading & how it relates to mission planning

- Three noted a desire for improved checklist and review of it toward the end of training to reinforce learned skills and knowledge.
- One requested training related to troubleshooting.
- One noted that peer2peer training will be possible as we grow the team.
 - *KCB Note: that is exactly what we did between March and August; we were able to train more people in August because two March trainees had had at-sea experience, and were able to train others.*

For those who trained at sea in Galápagos, the experience seems to have been less structured and consistent. Two major themes emerged:

- Three participants noted a desire for more consistent training time/materials.
- One noted that instruction in Spanish might be useful for local scientists, while the local scientist preferred instruction in English.

Is there anything else that you would like to share?

- Training prepared users for deployments. Deployment experience reinforces learning and prepared users to be able to teach others.
- Ensure trainings and deployments are within a short timeframe. Challenging to be trained in March and deploy in September.
 - *Recommendation: If there is a long time between them, schedule a refresher call with Deep Sea Camera System team immediately prior to deployment. Deploy systems more universally and consistently to become normal part of operations.*
- Mission programming was challenging.
 - *Recommendation: Mission program code writing and a gridded-style graphic explaining when and where you might alter the mission program in which way. This would be graphic and could be used to help troubleshoot when in the field.*
- Having new team members coming on board each week in Galápagos put extra burden on those who had to train them.
 - *Recommendation: Training on board should be more structured in terms of training resources, and possibly shared with another team member.*
- If training extension is possible, recommend adding training on field-study design, data analysis, and communication.

Pre-Cruise Planning

Of the 21 respondents, 15 were involved in pre-cruise planning in some way, and responded to this portion of the survey ([Figure 4](#)). This focused on Communication, Travel, Documentation, and Bait and Anchor sourcing. The following stats are for those who were involved in these aspects of pre-cruise planning (light blue in the chart indicates the % of people who were not involved):

- 100% of respondents agreed that Communication, Travel, Permitting, and Pre-expedition Documentation were great, or worked pretty well.
- 89% felt the same for Bait and Anchor sourcing, access, and storage. 11% felt that these aspects did not work well.

Figure 4

Pre-cruise Planning. Participants were asked how well pre-cruise planning activities were carried out. The vast majority thought that these activities were “great” or “worked pretty well.”

What worked particularly well?

Highlights include:

- Travel and logistics were smooth. We had all documents before departure.

- Looking at maps in advance to plan deployment locations
- Dividing tasks between the team members in preparation
- Regular pre-cruise meetings/briefings
- Group emails to keep all informed, as well as WhatsApp for cross-over information between teams (used during Galápagos)
- All went really well, thanks to our awesome team and leadership.

What could be changed and/or improved?

- 4 - Permitting for Alaska (or anywhere) well in advance
- Bait & anchors - Better estimate # of drops for planning bait, anchor weight. Bait procurement, storage wasn't great. [side note: sci value of bait?]
- Clearer repository of documentation, what to expect, repository for docs with easy access
- Communications with certain people in advance, including Expedition Leader and local/collaborating scientists.
- Knowing airline luggage restrictions in advance for bringing/returning with equipment.
- Other: storage space not in dive locker, jury-rigging the buoy wasn't great, set expectations for work/play in advance
- Having some things confirmed well in advance is best, such as number of people coming, and number of expected drops
- *More environmental data collection*
- *Recommend: How-To Deep Sea Camera System video for refresher*
- *Recommend: cruise plan doc for each expedition.*

Mission Planning

Fifteen people completed the section on Mission Planning, which refers to the day-to-day planning of Deep Sea Camera System deployment missions ([Figure 5](#)).

- 100% of those involved in planning missions felt that the following were great or worked pretty well:
Number of deployments per day, Deployment duration, Coordination between Deep Sea Camera System

team and Vessel (EL/Captain), and Site Selection.

- 93% felt that Coordination within the Deep Sea Camera System Team was great or worked pretty well. 7% thought that team coordination did not work well.
- 60% thought that planning site depth was great or worked pretty well. 33% thought that site depth planning did not work well.

Figure 5

Mission Planning. Most participants considered mission planning well done or very well done, with the exception of site depth which was challenging to estimate precisely from nautical charts.

What worked particularly well?

Overall, the team felt that Mission Planning went very well.

- 7 - great communication within the Deep Sea Camera System Team and with the ship's crew and team.
- 5 - noted that the LEX representative (Undersea Specialist or Naturalist) was very helpful in terms of communications, as well as knowledge of geography and route
- 2 - note that longer missions maximize time underwater and capture more data
- 1 - Created a diagram to aid in mission planning

What could be changed and/or improved?

There were several recommendations for improving Mission Planning:

- 4 - Smaller team more productive & lessen chances of mistakes.
- 3 - Two functioning systems would have allowed for more drops or alternating drops
- 3 - Having permits in advance would aid in deployments (AK)
- 2 - Develop a framework for mission planning; plan for next day earlier the day prior
- 2 - Would like more mission duration options

- 1 - Better team coordination could be done with daily stand-up meeting

Operations

Fourteen people were involved in Deep Sea Camera System Operations and completed this section of the survey. Overall, reviews were overwhelmingly positive ([Figure 6](#)):

- 100% felt that the following were great or worked pretty well: Pre-deployment Checklist, Deployment Operations, Recovery Checklist, and Recovery Operations.
- 86% thought that Equipment Storage and Working Space and Staging worked well. 14% did not, and were involved in Alaska operations, where staging occurred in the Mud Room/Dive Locker.
- Only 43% were involved with troubleshooting a Deep Sea Camera System, but of those who were, 100% felt that it went great or worked pretty well.

Figure 6

Operations. Fourteen people were involved in Deep Sea Camera System Operations and completed this section of the survey. Overall, their assessments were overwhelmingly positive.

What worked particularly well?

- 6 - Most people noted that everything worked well and as expected, and that deployments were generally very smooth and a good learning experience. One noted that the Zodiac driver was a particular highlight in making deployments successful.
- 4 - Extra cabin in Galápagos was fantastic for equipment storage and made it possible for large team to work together. Only possible because it was the low season.
- 3 - Checklists: 2 said that they were great, one noted redundancy between pre-deployment checklists.
- 2 - Mission planning: 2 cameras would have been nice to alternate mission planning and alleviate exhaustion. Night-before prep/programming made the next days smooth.

What could be changed and/or improved?

- Again, storage and working space was flagged as a major challenge.
- Checklists were revised throughout the trips to include post-video tasks and to include “time detected” to better estimate burn times.
- In the Galápagos, team coordination and communication could have been a little better, and the large team was nice but not critical to operations.
- Fitting into guest operations is always a challenge, but completely doable
- Equipment/capabilities:
 - Suggestion for second yagi antenna and tablet for GPS/mission planning
 - Get FathomNet working for post-deployment analysis

Software

Software was by far the area where most improvement can be made ([Figure 7](#)). Overall, scores were lower for how things went in this department, as well as lower involvement by all team members across the board. The team felt most comfortable with Naming Files, followed by the Excel Deployment Log, Downloading Data, and Data backups/hard drives (71% positive). Indicators of Program Status and Usability of Software was 57% positive, followed by Associated/Operational Photos and Video Highlights (43%). Finally, only 7% were comfortable writing Mission Programs, which is understandable given that no one was trained to do it, and some of us just figured it out and created new missions as-needed.

In terms of technical development, the most opportunities for future improvement in terms of usability and data quality control are in enhanced Software experience.

Figure 7

Software. Software was by far the area where most improvement can be made in terms of user experience.

What worked particularly well?

The response to this question was underwhelming. Some notes the checklists and documentation being good. One said the laptops were great, another noted that they didn't have software for video editing. Overall the process for downloading data worked OK with enough documentation and patience.

What could be changed and/or improved?

- 7 - Software was not user friendly, unreliable, and the process for data download is prone to human error.
 - Recommendation: redesigned app/GUI for programming, mission planning, data download, etc.
- 4 - Need software for video viewing/editing. FathomNet computer never worked on board.
- 2 - Data download took a long time. Having 2 functioning Deep Sea Camera Systems would help alternate between programming/using and downloading/analyzing.
- Other notes:
 - Want to know how to write mission programs
 - Ran out of hard drive space
 - Depth calculation had a bug (did it or was it measured in pressure?)

Guest Interactions

Overall, interacting with guests was a very positive experience for the Deep Sea Camera System team ([Figure 8](#)). We hope that the guests also enjoyed their experience, but we only have anecdotal evidence.

- 100% felt that Intro of the Deep Sea Camera System team and intro presentation on the Deep Sea Camera System was great or worked pretty well.
- 93% thought that interacting with guests on board was great or went well.
- 73% thought that interacting with guests on board was great or went well. 13% thought that it did not work well. (13% were not involved)
- 60% thought that the recap presentation went well. 13% thought that it did not work well. (27% were not involved).

Figure 8

Guest Interactions. Overall, participants enjoyed interacting with guests on board and ashore. Some improvement can be made in terms of expectations for interactions.

What worked particularly well?

- 8 - guests were very curious, extroverted, were eager to learn more and loved seeing equipment and video footage (past & present)
- 2 - mealtimes and shore excursions were good times to have interactions and conversation with guests
- 2 - Presentations (recaps and longer talks) were well received and invited more interactions with guests
- 2 - Inviting guests to come see us at work in the spare cabin (Galápagos), made a welcoming open drop-in experience for those who were more curious.
- 1 - Dedicated MIT team on board awesome, great info & value to guests

What could be changed and/or improved?

- There was general disagreement on the number of presentations that we should give per week. Some people suggested more, some suggested only one. Some said early in the week is better, some said to ensure an end-of-week presentation. After dinner is too late.
- 3 - Would like opportunity to share more footage
- 2 - Need talking points for what we can share/not share (Comms Guide)
- 1 - Make the "lab space" more official
- 1 - Share more meals with guests. Team started to become too exclusive
- 1 - Bring Deep Sea Camera System into lounge to show to guests
- Other Recommendations/notes
 - Suggest guest survey pre/post to understand reaction & understanding of our work. General impression was that the Deep Sea Camera System enhanced the guest experience and understanding of underwater world, but we have no way to confirm or quantify that.
 - Eat meals and go on shore excursions with guests to feel more integrated with them and the ship (possible solution to mealtime: and/or announce that we'll be eating 1 meal/day together to aid in science planning, but eat with guests for all others)
 - Would like to figure out how to involve guests more.
 - Communications with guests and the public need clarification:
 - Clarify collaboration roles and branding in advance so there isn't an issue for those on board
 - Possible website/brochure for more info
 - Talking points/media sharing clear and shared with team in advance
 - VC couldn't film in Galápagos (*Why? bc they couldn't be on the Zodiac?*)

Team

Team Size and Expertise

Team sizes ranged from 2-3 (Alaska) to 6-8 (Galápagos). Most people felt that 6-8 was too many people because there weren't enough things for everyone to do. One way of alleviating this was that the group was broken up into 2 teams that would split responsibilities. General consensus was that a team of 3-4 would be ideal.

KCB Note: while I agree with this assessment, I also think it is important to recognize what the goals are of the expedition and deployments. It is correct that if the only goal is to deploy the Deep Sea Camera System, then we do not need more than ~2 people on board. If the goal is to broaden participation and teach more people to use the system, then I think it is OK to have more people on board, because a wonderful, supportive team atmosphere was created, resulting in a significant amount of peer-learning; however, there must be clear roles and responsibilities so some people don't do everything and others don't do anything.

13 out of 14 people felt that there was an appropriate range of skills, training, and expertise to carry out the mission. One felt that the deployment was too long after the training, and as a result there was a very short and steep re-learning curve. Two also noted that if things broke further, then there might not have been the experience on board to fix it. However, there was a general consensus that the team was excellent and well-prepared.

Roles and Responsibilities

For team dynamics, this is where operational modalities diverged the most:

- Alaska: 1-3 people on board. When MIT team was on board, they spent the most time planning, data downloading, etc., with support from LEX for deployments and recoveries. When only LEX team was on

board, they did everything with other support staff for deployment operations.

- Galápagos: With a much larger team, there emerged a kind of ad hoc hierarchy. Those who had more experience tended to take lead roles, with others filling in where needed. Since there were so many people, and not enough to do, on the second leg, the group split into two teams to share responsibilities. This worked to varying degrees: in some cases it seemed to work well; in others, the more experienced people tended to take on more responsibilities and not delegate, leaving those with less experience to not have the opportunity to be involved in all aspects of operations.
 - *KCB note: a more clear structure of responsibilities and management should be established and communicated before each expedition so it is clear who is in charge and who will be delegating roles. This person should be competent and experienced, and also should have in mind the necessity for everyone to have the opportunity to be involved in all aspects of operations.*

12 out of 14 people thought that they had the opportunity to be involved in all aspects of the project. Two did not feel they had enough opportunity to be involved, particularly in site selection and mission planning. It is worth noting that these two were on board in Galápagos when the team was very large and there was not enough work for everyone to be involved in everything every day. That said, delegation should have happened more than it did to ensure that everyone had experience with all aspects of the program.

Is there anything else that you'd like to share?

“I’m so grateful to have been able to meet and work with such awesome people.”

“Teams were awesome. Friends for life.”

References

1. Buglass, S., Nagy, S., Ebert, D., Sepa, P., Turchik, A., Bell, K. L. C., Rivera, F., Giddens, J. (2020). First records of the seven-gilled *Notorynchus cepedianus* and six-gilled *Hexanchus griseus* sharks (Chondrichthyes: Hexanchiformes: Hexanchidae) found in the Galápagos Marine Reserve. *Journal of Fish Biology*, 97(3), 926–929. <https://doi.org/10.1111/jfb.14447> ↵