Environmental Studies Program: Ongoing Studies

Study Area(s): Beaufort Sea

Administered By: National Program

Title: Cumulative Effects of Arctic Oil Development – Planning and Designing for Sustainability (ArcSEES; NT-13-x11)

BOEM Information Need(s) to be Addressed: BOEM needs information on the effects of oil and gas infrastructure and climate change to support future planning and decision-making. NSF's Arctic Science, Engineering and Education for Sustainability (ArcSEES) program is an is a multi-year, interdisciplinary program, supported by an international partnership among BOEM, NSF, USGS, USFWS, EPA, and a consortium of French agencies, that seeks to evaluate the sustainability of the Arctic's human-environmental system and to provide community-relevant sustainability pathways and engineering solutions. BOEM's participation in the ArcSEES program will facilitate a better understanding the complex feedbacks that control the overall evolution of the Arctic system for timescales ranging from a few days to several years. Findings from this and other ArcSEES projects will support NEPA analyses for potential future lease sales, review of EPs, DPPs and other reviews for BOEM decision-making and mitigation.

BOEM Contribution: $300,000 plus Joint Funding

Period of Performance: FY 2013-2018

Conducting Organization: NSF, ArcSEES

BOEM Contact: Dr. John Primo

Description:

Background: Further development of oil and gas resources and associated infrastructure in the Arctic is possible, and BOEM, other agencies, and the private sector need more information on the infrastructural effects of such activity, and particularly on the thawing of permafrost. This vital component of the arctic ecosystem plays a substantial role in supporting system processes; including subsistence activities in the region.

Additional information is needed so that current international initiatives related to the Arctic may better address cumulative effects of extensive networks of infrastructure needed for resource development. This is important as local people are directly impacted by the effects of oil and gas development and associated infrastructure. The opening of arctic lands and seas to transportation and development is occurring against a backdrop of sea-ice loss, dwindling resources elsewhere in the world, and competing geopolitical interests. It is inevitable that considerably more infrastructure than presently exists will be required to develop these areas.

Objectives: The overarching goal of this study is to better understand the cumulative environmental and social effects of developing oil and gas resources in the Arctic, and to support the creation of a comprehensive adaptive planning approach toward

infrastructural development. In doing so, the study aims to meet the following objectives:

- An enhanced understanding of the infrastructure-related permafrost/landform/ vegetation succession in terrain undergoing thermokarst formation
- The creation of an arctic infrastructure action group to develop adaptive management strategies that address the unique issues related to networks of infrastructure in arctic permafrost environments
- The development of future arctic scientists with an understanding of the effects of industrial development and the potential for adaptive management

Methods: This study will include an examination of infrastructure and landscape change at multiple scales, an evaluation of adaptive management planning for infrastructure in northern Alaska and cumulative effects studies associated with the Iñupiat village of Nuiqsut. The study will also support several workshops bringing a diversity of scientists and local people together to develop adaptive management strategies that address issues related to the effects of infrastructure development in arctic permafrost environments. Lastly, training for students on arctic systems and on issues related to industrial development and adaptive management will be administered through a college course.

Current Status: Ongoing

Publications Completed:

Baggio, J. A., S. B. BurnSilver, A. Arenas, J. S. Magdanz, G. P. Kofinas and M. De Domenico. "Multiplex social ecological network analysis reveals how social changes affect community robustness more than resource depletion," Proceedings of the National Academy of Sciences, v.113, 2016, p. 121. doi:10.1073/pnas.1604401113

Bhatt, U. S., Walker, D. A., Raynolds, M. K., Bieniek, P. A., Epstein, H. E., Comiso, J. C., et al.. "Changing seasonality of panarctic tundra vegetation in relationship to climatic variables," Environmental Research Letters, v.12, 2017, p. 055003. doi:http://doi.org/10.1088/1748-9326/aa6b0b

Bhatt, U. S., D. A. Walker, J. E. Walsh, E. C. Carmack, K. E. Frey, W. N. Meier, S. E. Moore, F.-J. W. Parmentier, E. Post, V. E. Romanovsky, W. R. Simpson. 2014. Implications of Arctic sea ice decline for the Earth system. Annual Review of Environment and Resources, 39:57.

Bieniek, P. A., U. S. Bhatt, D. A. Walker, M. K. Raynolds, J. C. Comiso, H.E. Epstein, J. E. Pinzon, C. J. Tucker, R. L. Thoman, H. Tran, N. Mölders, M. Steele, J. Zhang, and W. Ermold.. "Climate drivers of changing seasonality of Alaska coastal tundra vegetation productivity," *Earth Interactions*, 2016.

Bjella, K., Kanevskiy, M., and Hinkel, K.. "The Use of Electrical Resistivity Methods for Ground Ice Characterization for Engineering," *Congress on Technical AdvancementCold Regions Engineering*, v.2017, 2017, p. 59.

Buchhorn, M., Raynolds, M. K., Kanevskiy, M., Matyshak, G., Shur, Y., Willis, M. D., Peirce, J.L., Wirth, L.M., Walker, D.A. (2016).Presented at the. "Effects of 45 years of heavy road traffic and climate change on the thermal regime of permafrost and tundra at Prudhoe Bay, Alaska (p. Abstract 811).," *11th International Conference on Permafrost, Potsdam, Germany.*, 2016.

Buchhorn, M., Prakash, A., Hampton, D. L., Cristóbal-Rosselló, J., Waigl, C. F., Stuefer, M., D.A. Walker. "HyLab: Alaska?s in-state capability for Aairborne imaging spectroscopy ?

applications for permafrost. Abstract 882.," *11th International Conference on Permafrost, Potsdam, Germany*, 2016.

Buchhorn, M., D. A. Walker, B. Heim, M. K. Raynolds, H. E. Epstein, M. Schweider. 2013. Hyperspectral characterization of Low Arctic tundra vegetation along environmental gradients. Remote Sensing, 5:3971-4005.

Brinkman, T. J., W. D. Hansen, F. S. Chapin, G. Kofinas, S. BurnSilver and T. S. Rupp. "Arctic communities perceive climate impacts on access as a critical challenge to availability of subsistence resources," Climatic Change, v.139, 2016, p. 413. doi:https://link.springer.com/article/10.1007/s10584-016-1819-6

BurnSilver, S., Magdanz, J., Stotts, R., Berman, M., and Kofinas, G.. "Economies Persistent or Transitional? Evidence Using Social Networks from Arctic Alaska," American Anthropologist, v.118, 2016, p. 121. doi:DOI: 10.1111/aman.12447

Farquharson, L. M., Romanovsky, V. E., W, C., & Walker, D. A.. "Widespread and rapid thermokarst development in a region of very cold continuous permafrost in the Canadian High Arctic," AGU Fall Meeting , San Francisco, 12-16 Dec, 2016. doi:Abstract GC33G?06

Fortier, D., Strauss, J., Sliger, M., Calmels, F., Froese, D., and Shur, Y.. "Late Pleistocene yedoma in south-western Yukon (Canada): a remnant of Eastern Beringia?," 5th European Conference On Permafrost ? Book of Abstracts, 23 June - 1 July 2018, Chamonix, France, 2018, p. 637.

Frost, G. V., Christopherson, T. C., Liljedahl, A. K., Macander, M. J., Walker, D. A., & Wells, A. F.. "Regional patterns and asynchronous onset of ice-wedge degradation in Arctic Alaska.," 11th International Conference on Permafrost, Potsdam, Germany., 2016, p. 32.

Frost, G. V., Epstein, H. E., Walker, D. A., & Matyshak, G.. "Changes to Permafrost active-layer temperature after tall shrub expansion in low arctic tundra.," 11th International Conference on Permafrost Book of Abstracts, Potsdam, Germany, 2016, p. 410.

Frost, G. V., Epstein, H. E., Walker, D. A., Matyshak, G., & Ermokhina, K.. "Seasonal and long-term changes to active-layer temperatures after tall shrubland expansion and succession in arctic tundra," Ecosystems, v.16, 2017, p. 1296. doi:http://doi.org/10.1007/s10021-017-0165-5

Gilbert, G.L., Kanevskiy, M., and Murton, J.B.. "Recent advances (2008?2015) in the study of ground ice and cryostratigraphy," Permafrost and Periglacial Processes, v.27, 2016, p. 377. doi:DOI: 10.1002/ppp.1912

Grosse, G., Goetz, S., McGuire, A., Romanovsky, V. and Schuur, E. 2016. Review and synthesis: Changing permafrost in a warming world and feedbacks to the earth system. Environmental Research Letters, 11(4):040201. doi:10.1088/1748-9326/11/4/040201

Heim, B., Bartsch, A., Beamish, A., Stettner, S., Buchhorn, M., Duguay, C., ?Walker, D.A. ...et al.. "User and expert-supported validation and evaluation experiments for high latitude permafrost landscapes: ESA DUE PERMAFROST (2009-2012) and ongoing EnMAP, PAGE21, and HGF-EDA programs.," 11th International Conference on Permafrost Book of Abstracts, Potsdam, Germany, 2016, p. 904

Kanevskiy, M., Jorgenson, M.T., Shur, Y., O'Donnell, J.A., Harden, J.W.,Zhuang, Q., Fortier, D. 2014. Cryostratigraphy and permafrost evolution in lacustrine lowlands of west-central Alaska. Permafrost and Periglacial Processes, 25:14-34.

Kanevskiy M., Shur, Y., and Jorgenson, T.. "Ice-wedge thermokarst: Past, present, and future.," 5th European Conference On Permafrost ? Book of Abstracts, 23 June - 1 July 2018, Chamonix, France, 2018, p. 647.

Kanevskiy, M., Shur, Y., Jorgenson, T., Brown, D. R. N., Moskalenko, N. G., Brown, J., et al.. "Degradation and stabilization of ice wedges: Implications for assessing risk of thermokarst in northern Alaska.," Geomorphology, v.297, 2017, p. 20. doi:doi: 10.1016/j.geomorph.2017.09.001

Kanevskiy, M., Shur, Y., Strauss, J., Jorgenson, M.T., Fortier, D., Stephani, E. and Vasiliev, A.. "Patterns and rates of riverbank erosion involving ice-rich permafrost (yedoma) in northern Alaska.," *Geomorphology*, v.253, 2016, p. 370.

Kanevskiy, M., Shur, Y., Walker, D. A., Buchhorn, M., Jorgenson, T., Matyshak, G., et al.. "Evaluation of Risk of Ice-Wedge Degradation, Prudhoe Bay Oilfield, AK.," *Poster presented at the 11th International Conference on Permafrost, Potsdam Germany.*, 2016.

Kofinas, G., Curry, T., Streever, B. & Bader, H.. "Adaptive management of cumulative effects: theory vs. reality.," *Talk presented at the Arctic Change 2014 conference*, 2014.

Lapointe Elmrabti, L., Talbot, J., Fortier, D., Fréchette, B., Strauss, J., Kanevskiy M., and Shur, Y.. "Middle to late Wisconsinan climate and ecological changes in northern Alaska: Evidences from the Itkillik River Yedoma," Palaeogeography, Palaeoclimatology, Palaeoecology, 2017. doi:doi: 10.1016/j.palaeo.2017.08.006

Liljedahl, A. K., Boike, J., Daanen, R. P., Fedorov, A. N., Frost, G. V., Grosse, G., .,?Walker, D.A.,...et al.. "Recent circum-Arctic ice-wedge degradation and its hydrological impacts," AGU Fall Meeting , San Francisco, 12-16 Dec, 2016. doi:Abstract GC33G?08

Liljedahl, A. K., Boike, J., Daanen, R. P., Fedorov, A. N., Frost, G. V., Grosse, G., Hinzman, L. D., Iijima, Y., Jorgenson, J. C., Matveyeva, N., Necsoiu, M., Raynolds, M. K., Romanovsky, V. E., Schulla, J., Tape, K. D., Walker, D.A., Wilson, C. J., Yabuki, H., Zona, D. "Pan-Arctic ice-wedge degradation in warming permafrost and its influence on tundra hydrology.," *Nature Geoscience*, v.9, 2016, p. 312.

Raynolds, M. K. and Walker, D. A. 2016. Increased wetness confounds Landsat-derived NDVI trends in the central Alaska North Slope region, 1985□2011. Environmental Research Letters, 11:085004. doi:10.1088/1748-9326/11/8/085004

Raynolds, M. K., D. A. Walker, K. J. Ambrosius, J. Brown, K. R. Everett, M. Kanevskiy, G. P. Kofinas, V. E. Romanovsky, Y. Shur, P. J. Webber. 2014. Cumulative geoecological effects of 62 years of infrastructure and climate change in ice-rich permafrost landscapes, Prudhoe Bay Oilfield, Alaska. Global Change Biology, 20:1211-1224.

Romanovsky, V., Nicolsky, D., Cable, W., Kholodov, A., Farquharson, L., Panda, S,?Walker, D.A., et al.. "Measured and modeled changes in permafrost along North American Arctic Transect," Arctic Science Summit Week, Prague, 31 Mar-07 Apr., 2017, p. 141.

Shur, Y., M. Kanevskiy, D. A. Walker, M. T. Jorgenson, M. Buchhorn, M. K. Raynolds. "Permafrost-related causes and consequences of Sagavanirktok River flooding in Spring 2015," Abstract 1065. Talk presented at the 11th International Conference on Permafrost, Potsdam, Germany., 2016.

Stephani, E., Kanevskiy, M., Darrow, M., Croft, P., Drage, J., and Wuttig, F.. "Early self-stabilization conditions of a retrogressive thaw slump, North Slope, Alaska," 5th European Conference On Permafrost ? Book of Abstracts,, 2018, p. 207.

Trochim, E.D., Schnabel, W.E., Kanevskiy, M., Munk, J., Shur, Y.. "Geophysical and cryostratigraphic investigations for road design in northern Alaska," Cold Regions Science and Technology, v.131, 2016, p. 24. doi:doi: 10.1016/j.coldregions.2016.08.004

Walker, D. A.. "Hierarchical arctic vegetation mapping, classification, and transects: A framework for examining arctic terrestrial change," 48th International Arctic Workshop, 2018, p. Abstract. doi:from http://instaar.colorado.edu/meetings/AW2018/abstract_details.php?abstract_id=15

Walker, D. A., Daniëls, F. J. A., Alsos, I., Bhatt, U. S., Breen, A. L., Buchhorn, M., et al.. "Circumpolar arctic vegetation: A hierarchic review and road map toward a consistent international approach to survey archive and classify plot data.," *Environmental Research Letters*, v.11, 2016, p. 055005.

Walker, D. A., Daniëls, F. J. A., Matveyeva, N. V., ?ibík, J., Walker, M. D., Breen, A. L., et al.. "Circumpolar Arctic Vegetation Classification," Phytocoenologia,, v.48, 2018, p. 181. doi:http://doi.org/10.1127/phyto/2017/0192

Walker, D. A., Kanevskiy, M., Shur, Y., Raynolds, M. K., & Buchhorn, M.. "Cumulative effects of climate change and ice-wedge degradation on infrastructure and ecosystems in the Prudhoe Bay oilfield, Alaska," AGU Fall Meeting, San Francisco, 12-16 Dec, 2016. doi:Abstract GC33G?01

Walker, D. A., Kanevskiy, M., Shur, Y., Raynolds, M., Buchhorn, M., & Matyshak, G.. "Rapid transitions caused by infrastructure and climate, Prudhoe Bay Oilfield, Alaska,," Arctic Science Summit Week, Prague, 31 Mar-07 Apr, 2017, p. 171. doi:O 115

Walker, D. A., Peirce, J., Kumpula, T., Leibman, M. O., Matyshak, G., Streletskiy, D., et al.. "Rapid Arctic Transitions due to Infrastructure and Climate (RATIC): An ICARP III initiative focusing on the cumulative effects of Arctic infrastructure and climate change.," *Abstract 499. Poster presented at the 11th International Conference on Permafrost, Potsdam, Germany.*, 2016.

Yu, Q., Epstein, H., Engstrom, R., & Walker, D.. "Circumpolar arctic tundra biomass and productivity dynamics in response to projected climate change and herbivory," Global Change Biology, v.94, 2017, p. 713. doi:http://doi.org/10.1111/gcb.13632

Zhang, X., Bianchi, T. S., Cui, X., Rosenheim, B. E., Ping, C.-L., Hanna, A. J. M., Kanevskiy, M., Schreiner, K.M., Allison, M. A.. "Permafrost organic carbon mobilization from the watershed to the Colville River delta: Evidence from 14C ramped pyrolysis and lignin biomarkers," Geophysical Research Letters, v.44, 2017, p. 11491. doi:doi: 10.1002/2017GL075543.

Zhou, Jiake, Laura Prugh, Ken D. Tape, Gary Kofinas, and Knut Kielland. "The role of vegetation structure in controlling distributions of vertebrate herbivores in Arctic Alaska," Arctic, Antarctic, and Alpine Research, v.49, 2017, p. 291.

Affiliated WWW Sites: http://www.boem.gov/akstudies/
http://www.nsf.gov/funding/pgm_summ.jsp?pims_id=503604
http://www.nsf.gov/awardsearch/showAward?AWD_ID=1263854
https://marinecadastre.gov/espis/#/search/study/100074

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