

Petra Klepac

EDUCATION AND RESEARCH EXPERIENCE

- Oct 2015 - **Senior Mathematical Modeller**
Public Health England and Imperial College London
Spatiotemporal analysis of National Pandemic Flu Service data and development of a spatial, age-stratified model for influenza for England that will be later used for evaluation of pilot studies of immunizations with Live Attenuated Influenza Vaccine in school children. Evidence synthesis of multiple data from 2009 H1N1 pandemic influenza in England.
- Nov 2014 - **Visiting Research Fellow**
Cambridge University, Department of Applied Mathematics and Theoretical Physics
- 2012-2014 **AXA Research Fellow**
Cambridge University
Awarded a fellowship to study the potential of self-enforcing international agreements as a public health tool in regional control of immunizing infections in collaboration with economists. Created a model drawing on economic theory of optimal control and game theoretic approach to studying international agreements.
- 2009-2012 **Postdoctoral Research Associate and Lecturer**
Princeton University
Collaborated with economists and disease ecologists to develop a new theoretical framework focusing on economics of disease elimination.
Established collaborations with other postdocs to apply the framework on incorporating demography in epidemic models on available data for rubella.
- 2007-2009 **UNESCO-L'Oréal "For Women in Science" Postdoctoral Fellow**
Pennsylvania State University
Awarded a prestigious fellowship to investigate optimizing control strategies for immunizing infections with focus on measles. Compared the effects of reactive immunization on controlling measles outbreaks against the strategy of palliative care.
Continued the collaboration on incorporating demography in epidemic models resulting in a new framework to study effects of age-structure on the spread and dynamics of infectious diseases.
- 2001-2007 **PhD, Biological Oceanography**
Massachusetts Institute of Technology / Woods Hole Oceanographic Institution
Doctorate thesis: "Population interactions: hosts and pathogens, prey and predators" (advisor Michael G. Neubert)
Developed and analysed epidemic models for phocine distemper virus dynamics and fitted them to available European epizootic data to estimate vital

epidemiological parameters. Studied the effects of seal haul-out behaviour and timing of virus introduction on the final size of the epizootic.

Designed a model for stage-structured epidemics and established and international collaboration to apply this model to the available data from Dutch phocine distemper outbreak.

Developed new dispersal models for predator-prey metapopulations based on delayed-differential equations.

1996-2001 **dipl. ing. biology – ecology (Masters equivalent)**

University of Zagreb, Croatia

Thesis in ecology: “The effects of dispersal delays on dynamics of predator-prey metapopulations”

1994-1996 **International Baccalaureate**

XV. Gimnazija, Zagreb, Croatia

Extended essay in mathematics: “Approximation of irrational numbers using continued fractions applied on improvement of Bach’s well-tempered scale”

PUBLICATIONS

- 2017 ▪ **Klepac, P.** (2017) Linking levels of life: Comment on “Physics of metabolic organization” by Marko Jusup et al., *Physics of Life Reviews*, <http://dx.doi.org/10.1016/j.plrev.2017.01.024>.
- 2016 ▪ **Klepac, P.**, Megiddo, I., Grenfell, B. and Laxminarayan, R. (2016) Self-enforcing regional vaccination agreements. *Journal of the Royal Society Interface* **13**: 20150907.
- 2015 ▪ Heesterbeek, J.A.P., Anderson, R. M., Andreasen, V., Bansal, S., De Angelis, D., Dye, C., Eames, K. T. D., Edmunds, W. J., Frost, S. D. W., Funk, S., Hollingsworth, T. D., House, T., Isham, V., **Klepac, P.**, Lessler, J., Lloyd-Smith, J. O., Metcalf, C. J. E., Mollison, D., Pellis, L., Pulliam, J. R. C., Roberts, M. G., Viboud, C. and Isaac Newton Institute IDD Collaboration (2015) Modeling infectious disease dynamics in the complex landscape of global health. *Science*, **347**(6227), aaa4339–aaa4339.
- Lloyd-Smith, J.O., Mollison, D., Metcalf, C.J.E., **Klepac, P.** and Heesterbeek, J.A.P. (2015) Challenges in modelling infectious disease dynamics: preface, *Epidemics*, **10**: iii-iv.
- **Klepac, P.**, Sebastian, F., Hollingsworth, T. D., Metcalf, C. J. E. Metcalf and Hampson, K. (2015) Six challenges in eradication of infectious diseases. *Epidemics*, **10**: 97-101.
- Funk, S., Bansal, S., Bauch, C. T., Eames, K. T. D., Edmunds, W. J., Galvani and P., **Klepac, P.** (2015) Challenges in modeling the dynamics of behavior towards infectious diseases. *Epidemics* **10**: 21-25.
- 2013 ▪ **Klepac, P.**, Metcalf, C. J. E., McLean, A. and Hampson, K. (2013) Towards the endgame and beyond: complexities and challenges for the elimination of infectious diseases. *Philosophical Transactions of the Royal Society B* **368**: 20120137.
- Henderson, DA and **Klepac, P** (2013) Lessons from the eradication of smallpox: an interview with DA Henderson. *Philosophical Transactions of the Royal Society B* **368**: 20130113.
- Metcalf, C. J. E., Cohen, C., Lessler, J., McAnerney, J. M., Ntshoe, G. M., Puren, A., **Klepac, P.**, Tatem, A., Grenfell, B. T. and Bjørnstad, O. N. 2013. Implications of spatially heterogeneous vaccination coverage for the risk of congenital rubella syndrome in South Africa. *Journal of the Royal Society Interface* **10**: 20120756.

- 2012
- **Klepac, P.**, Bjørnstad, O. N., Metcalf, C. J. E. and Grenfell, B. T. 2012. Optimizing reactive responses to outbreaks of immunizing infections: balancing case management and vaccination. *PLOS ONE* **8**:e41428.
 - Metcalf, C.J.E., Lessler, J., **Klepac, P.**, Cutts, F., and Grenfell, B.T. 2012. Impact of birth rate, seasonality and transmission rate on minimum levels of coverage needed for rubella vaccination. *Epidemiology and Infection* **140**: 2290-2301.
 - Metcalf, C.J.E., Lessler, J., **Klepac, P.**, Morice, A., Grenfell, B.T. and Bjørnstad, O. N. 2012. Structured models of infectious disease: Inference with discrete data. *Theoretical Population Biology* **82**: 275:282.
- 2011
- **Klepac, P.**, Laxminarayan, R. and Grenfell, B. T. 2011. Synthesizing epidemiological and economic optima for control of immunizing infections. *Proceedings of the National Academy of Sciences USA* **108**: 14366–14370.
 - Metcalf, C. J. E., Bjørnstad, O. N., Ferrari, M., **Klepac, P.**, Bharti, N., Lopez-Gatell, H. and Grenfell, B. T. 2010. The epidemiology of rubella in Mexico: seasonality, stochasticity and regional variation. *Epidemiology and Infection* **139**:1029-1038.
 - **Klepac, P.** and Caswell, H. 2011. The stage-structured epidemic: linking disease and demography with a multi-state matrix model approach. *Theoretical Ecology* **4**:301-319.
 - Metcalf, C. J. E., **Klepac, P.**, Ferrari, M., Grais, R. F., and Grenfell, B. T. 2011. Modeling the first dose of measles vaccination: the role of maternal immunity, demographic factors, and delivery systems. *Epidemiology and Infection* **139**:265-274.
- 2009
- **Klepac, P.**, Pomeroy, L. W., Bjørnstad, O. N., Kuiken, T., Osterhaus, A. D. M. E., and Rijks, J. M. 2009. Stage-structured transmission of phocine distemper virus in the Dutch 2002 outbreak. *Proceedings of the Royal Society B* **276**: 2469-2476.
- 2007
- **Klepac, P.**, Neubert, M. G., and van den Driessche, P. 2007. Dispersal delays and the paradox of enrichment. *Theoretical Population Biology* **71**: 436-444.
- 2006
- Rapatski, B., **Klepac, P.**, Dueck, S., Liu, M. and L. I. Weiss. 2006. Mathematical epidemiology of HIV/AIDS in Cuba during the period 1986-2000. *Mathematical Biosciences and Engineering* **3**: 545-556.
- 2002
- Neubert, M. G., **Klepac, P.** and van den Driessche, P. 2002. Stabilizing dispersal delays in predator-prey metapopulation models. *Theoretical Population Biology* **61**: 339-347.

SELECTED AWARDS AND FELLOWSHIPS

- 2014
- Visiting Fellowship of the Isaac Newton Institute for Mathematical Sciences
- 2013
- Sackler and Cambridge Foundation Research Fellowship, Christ's College Cambridge
- 2012
- AXA Research Fund Fellowship €120,000
- 2007
- UNESCO-L'Oréal Fellowship for Women in Science \$40,000
- 2005
- Best poster award, European Conference on Mathematical and Theoretical Biology, Dresden, Germany
 - Bayesian Methods for Population Ecology, University of Cambridge
 - Society for Mathematical Biology Landahl Grant \$1500
 - Ocean Ventures Fund Award \$5000
- 2004
- Special Program on Infectious Diseases Summer School, Banff, Canada
- 1999
- "Best Presentation by a Young Scientist" Award, 2nd European Ecological Modelling Conference, 1999, Pula, Croatia
 - Summer Student Fellowship, Woods Hole Oceanographic Institution

GRADUATE AND UNDERGRADUATE TEACHING EXPERIENCE

- June 2016 *London School of Hygiene and Tropical Medicine*
Tutor in Introduction to Infectious Disease Modelling and its Applications
Lead the discussion on modelling the 2014 Ebola outbreak, tutored computer practicals on analysing infectious disease dynamics and effects of rubella vaccination in different transmission settings.
- 2013-2014 *Christ's College, Cambridge University*
Supervisor in Part 1A Mathematical Biology
Taught 11 first-year natural science students in small groups (two-to-one) on various topics covered in the course (population growth, interacting populations, spread and control of infectious diseases, probability and statistics, matrix algebra, calculus, analysis).
- Fall 2011 *Princeton University*
Lecturer in Theoretical Ecology, advanced undergraduate course
Taught a whole course to cover colleague's sabbatical leave. Developed lectures on population biology, infectious disease dynamics, game theory and optimization, ecosystem resilience and robustness, recruited 3 guest speakers, supervised one teaching assistant, designed exams, oversaw group projects, provided constructive feedbacks on drafts.
- Spring 2010 *Princeton University*
Guest lecturer in Disease Ecology, Economics and Policy, and Theoretical Biology courses on the topic of Vaccinations, Policy and Disease Eradication.
- June 2009 *Max Planck Institute for Demography*
Assistant Lecturer in *Frontiers of Formal Demography*, summer school
Helped develop and teach a course for matrix model approaches in demography (with precepts in R and Matlab)
- Fall 2007 *Pennsylvania State University*
Co-lecturer in Population Biology, graduate course
Developed, prepared and delivered a block of 5 lectures (on host-parasitoid models, predator-prey dynamics, equilibrium and stability analysis, control of invasive species), designed homework problems and exam questions.
- Spring 2006 *Massachusetts Institute of Technology / Woods Hole Oceanographic Institution*
Teaching Assistant in "An introduction to Mathematical Ecology", graduate course
Collaborated on curriculum development and designed and taught a lecture on modelling of infectious diseases as well as separate recitation lectures. Held weekly office hours and individual appointments with students. Graded all homework.
- 1997-1998 *Zagreb, Croatia*
Tutor in computer science for high school students – theory and programming.

EDITING EXPERIENCE

- 2013-2014 *Epidemics, The Journal on Infectious Disease Dynamics*
Guest editor for the Special issue on the Challenges of the Infectious Disease Dynamics. Selected reviewers and provided feedback and input on four manuscripts in the special issue.
- 2012-2013 *Philosophical Transactions of the Royal Society B*
Proposed, co-compiled and co-edited a special issue entitled “Towards the endgame and beyond: complexities and challenges for the elimination of infectious diseases” with more than half of open access contributions. Decided on a theme, selected topics and invited authors to contribute manuscripts covering very relevant yet underpublicized work regarding disease eradication. Provided feedback and direction on manuscripts in their draft stage, invited reviewers, edited submissions and finalized the issue on a firm deadline. Available on <http://rstb.royalsocietypublishing.org/content/368/1623.toc>

ORGANIZATIONAL SKILLS

- 2011-2012 **Chair of EEB Society of Fellows**
Princeton University
Coordinated scientific and social events for postdoctoral fellows.
- 2010 **Symposium co-organizer**
Ecological Society of America Annual Meeting, Pittsburgh
“The Invasion Ecology of the Disease: Understanding the Drivers of Microbial Community Assembly and Host-Microbe Dynamics in the Human Body”
- June 2008 **Workshop Organizer**
Center for Infectious Disease Dynamics, Pennsylvania State University
Designed and organized a 2-day international workshop on “Control and management of infectious diseases” with aims to synthesize and improve the latest control and management methods in disease control and prevention. The workshop was highly inter-disciplinary, and it brought together experts from different areas that approach control of infectious diseases from public health, economic, epidemiological and ecological perspectives.

PUBLIC ENGAGEMENT

- January 2014 **Mathematical Sciences Showcase – Centre for Mathematical Sciences, Cambridge University**
Presented a poster to help showcase recent research to delegates from industry, government and academia
- April 2012 **First European Girls’ Math Olympiad - Cambridge, UK**
Invigilator and volunteer.

SELECTED MEDIA COVERAGE

“A quoi sert la vaccination?”, L’Express Chercheurs d’actu blog,
http://www.lexpress.fr/actualite/societe/sante/a-quoi-sert-la-vaccination_1511433.html

“Mathematics and epidemiology: Neighbourly advice”, The Economist, Science and Technology blog: <http://www.economist.com/blogs/babbage/2012/01/mathematics-and-epidemiology>

“Love thy neighbor(s): The Need for Herd Immunity”, Center for global development, Global Health Policy blog: <http://blogs.cgdev.org/globalhealth/2012/01/love-thy-neighbors-the-need-for-herd-immunity.php>

INVITED TALKS AND SEMINARS

- 2017 “Cooperation and control of infectious diseases.” Centre for Mathematical Biology Seminar. Department of Mathematics, University of Bath, UK.
- 2016 “Heterogeneity in influenza dynamics and modelling.” Invited speaker in the Symposium on The impact of mathematical modelling of influenza: better decisions for Public Health, Public Health England, London, UK
- 2014 “Eradication of infectious diseases.” Dynamics of Infectious Diseases guest lecture, University of Cambridge, UK
“The spread and control of infectious diseases.” Emerging Research Seminar Series, Christ’s College, Cambridge, UK
- 2013 “Eradication efforts in the 21st century: marriage of epidemiology and economics.” Warwick Infectious Disease Epidemiology Research Seminar, University of Warwick, UK
“International agreements for optimal disease control.” MBI workshop: rapid evolution and sustainability, Mathematical Biosciences Institute, Ohio State University, Columbus, OH, US
“International agreements and optimal control of immunizing infections.” Infectious Disease Dynamics Workshop, Isaac Newton Institute for Mathematical Sciences, Cambridge, UK
“Free-ride or cooperate? Economic incentives and immunizations.” Ecology and Evolution of Infectious Diseases, Pennsylvania State University, PA, US.
- 2012 “To eradicate or not to eradicate: economic optima for spatial immunizing infections.” Natural Resources Modeling Symposium, Joint Mathematics Meetings, Boston, US.
- 2011 “Synthesizing economic and epidemic optima for spatial vaccination programs.” University of Oxford, UK.
“Economic and epidemic optima for control of immunising infections.” Queens’ College, University of Cambridge, UK.
- 2010 “Economic optima for spatial vaccination programs”. “Disease in motion”, Princeton University, NJ, US.
- 2009 “Population modeling with disease parameters to achieve more realistic outcomes.” Symposium on “Pathology and Medicine in Marine Ecosystem Conservation”, International Marine Conservation Congress, Washington, DC, US
“Vaccine Supply Logistics Modeling.” World Health Organization. Geneva, Switzerland.
- 2008 “Modeling and control of infectious diseases.” Ruđer Bošković Institute, Zagreb, Croatia.
- 2007 “Phocine distemper virus outbreaks in European harbor seals.” Ecological seminar at Pennsylvania State University, PA, US

- “Matrix models for stage classified epidemics.” Ecological Society of America Annual Meeting, San Jose, CA, US.
- “The dynamics of phocine distemper virus epizootics in European harbor seals.” Harvard School of Public Health, Boston, MA, US
- 2006 “Seasonal haul-out behavior and the dynamics of the phocine distemper virus.” Center for Infectious Disease Dynamics Seminar, Pennsylvania State University, PA, US.
- “Seasonal haul-out behavior and the dynamics of the phocine distemper virus.” Biology Department Seminar, Woods Hole Oceanographic Institution, MA, US
- “Sezonsko ponašanje običnih tuljana i matematička epidemiologija virusa Phocine distemper.” 29. Kolokvij Hrvatskog društva za teorijsku i matematičku biologiju. University of Zagreb, Croatia.
- 2005 “Epidemiology of the harbour seal plague.” The Göteborg Network for Theoretical Biology, Göteborg University, Sweden.

SELECTED CONFERENCE PRESENTATIONS

Klepac, P. 2016. Incorporating demographic heterogeneity in epidemiological models for better public health decision-making. Modelling infectious disease minisymposium at ECMTB 2016, Nottingham, UK.

Klepac, P. 2013. Free-ride or cooperate: regional control of immunizing infections. Epidemics4, Amsterdam.

Klepac, P., Laxminarayan, R. and Grenfell, B. T. 2011. Synthesizing epidemiological and economic optima for control of immunizing infections. Ecological Society of America Annual Meeting, Austin.

Klepac, P., Bjørnstad, O. N., Grais R. F. and Grenfell, B. T. 2009. Optimizing reactive responses to outbreaks of immunizing infections – case management vs vaccination. Ecological Society of America Annual Meeting, Albuquerque.

Klepac, P. 2008. Dynamics of Phocine Distemper Virus outbreaks in European harbor seals. European Wildlife Disease Association Conference, Rovinj, Croatia.

Klepac, P., Caswell, H. and Neubert, M. 2007. Matrix models for stage classified epidemics. Ecological Society of America Annual Meeting, San Jose. (invited talk)

Rapatski, B., **Klepac, P.**, Dueck, S., Liu, M., Weiss, L.I. 2006. Mathematical epidemiology of HIV/AIDS in Cuba. SIAM Annual Meeting, Boston.

Klepac, P., Neubert, M. G., and Harding, K. 2005. Poster: Seasonal haul-out behavior and the dynamics of the phocine distemper epizootics. ECMTB/SMB Conference, Dresden, Germany.

Chang, E., Dueck, S., **Klepac, P.**, Liu, M., Weiss, L.I., and Rapatski, B. Talk: Modeling the HIV/AIDS epidemic in Cuba 1986-2000, PIMS-MITACS-MSRI Special Program on Infectious Diseases, Research Conference 2004, Banff, Canada

Klepac, P., Neubert, M. G., and van den Driessche, P. 2003. Poster: Stability and dispersal delays in predator-prey metapopulation models. Alcala 2nd International Conference on Mathematical Ecology.

Neubert, M. G., Gulmann, L., Hunter, C., Klanjšček, T., **Klepac, P.**, Martins, C. A. 2003. Talk (on behalf of M. Neubert): Chargoggagoggmanchauggauggogggchaubunagungamaugg. Alcala 2nd International Conference on Mathematical Ecology.

Klepac, P. and Neubert, M. 1999. Talk and poster: The effects of travel time on predator-prey metapopulation dynamics, 2nd European Ecological Modelling Conference.

PROFESSIONAL AND SCIENTIFIC MEMBERSHIPS

Member of: Ecological Society of America, European Society for Mathematical and Theoretical Biology, Society for Mathematical Biology

Reviewer for: American Naturalist, Journal of Mathematical Biology, Journal of the Royal Society Interface, Mathematical Biosciences, Mathematical Medicine and Biology, PLoS Computational Biology, Proceedings of the National Academy of Sciences, SIAM, SIAP, Theoretical Population Biology, Vaccine

SKILLS AND LANGUAGES

Languages: Croatian (native), English (fluent), German (intermediate), French (basic)

Computer: Matlab, R, Mathematica, Latex, Microsoft Office

Photography: 7 Photos exhibited at Fowler Art Show, Woods Hole, MA 2006

Other: Boat Leader License (certified in 1994), Driving License, Scuba diving (NAUI certified in 2000)