

ALIGNING COMPLEX, ADAPTIVE SYSTEMS THEORY
AND DATA-LIMITED ASSESSMENT STRATEGIES
FOR IMPROVED FISHERIES MANAGEMENT

A DISSERTATION
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Abstract

By combining SCUBA fieldwork in southern Monterey Bay kelp forests with statistical modeling, this thesis addresses how to successfully implement, monitor, and assess the efficacy of ecosystem-based management¹ approaches, specifically applied to the California nearshore and U.S. West Coast fisheries. It explores the interaction between marine populations, with an emphasis on fish and fisheries management, and their broader environmental context—including the social-ecological and management context—with an aim to develop new tools for scientific understanding and improved management of these populations. Results include the characterization of how fish respond to coastal hydrodynamics on a local scale (e.g., ocean swell, water temperature, and dissolved oxygen) with insight into how to use this knowledge to inform future sampling in California's marine reserves, including adaptive sampling designs that incorporate effects of local hydrodynamic regimes. I then integrate local-scale SCUBA data on fish populations, collected on the scale of a single marine reserve, into fisheries models. In collaboration with NOAA Fisheries scientists, I propose a new analytical method that provides reference points to inform management. We call this method "reserve-based SPR." It is a practical, easy-to-implement, information-limited method (i.e., "data-poor method"). This work brings together conservation-based tools, specifically marine reserves, with fisheries management approaches. Data-poor methods like reserve-based SPR, although subject to many caveats, can often provide scientific guidance to reduce biological and management risks. To organize data-poor fisheries methods into one coherent landscape with case-study examples for managers to use as guidelines, I offer a new framework. This data-poor framework is designed to help managers and stakeholders consider and choose appropriate analytical methods for their specific context. No data-poor method is perfect but many produce "good enough" sustainable yield estimates or ecosystem indicators with bias that is risk-averse and precautionary for population sustainability. Collectively, this thesis is united in its theme of understanding uncertainty and complex, adaptive systems for applied science and management purposes.

¹ NOAA Fisheries definition of "ecosystem-based management":

An approach that takes major ecosystem components and services—both structural and functional—into account in managing fisheries. It values habitat, embraces a multispecies perspective, and is committed to understanding ecosystem processes. Its goal is to rebuild and sustain populations, species, biological communities, and marine ecosystems at high levels of productivity and biological diversity so as not to jeopardize a wide range of goods and services from marine ecosystems while providing food, revenue, and recreation for humans.

NOAA Fisheries. 2006. NOAA Fisheries Glossary (Revised edition, June 2006). United States Department of Commerce, National Oceanic and Atmospheric Administration Fisheries (NOAA Fisheries). NOAA Technical Memorandum NMFS-F/SPO-69. Silver Spring, MD. 61 pp.

Dedication

This thesis is dedicated to my beloved, late Mom, “Honey Honey,”

...and all my invisible helpers, watching over and helping me from above. Thank you.

Preface and Acknowledgments

I am grateful and feel blessed to finish my Stanford PhD. Very blessed. It was not an easy road, having faced two major personal crises amidst this professional journey. First, in what was supposed to be my last year of graduate school in 2009, I completely collapsed from late-stage Lyme disease that had gone to my brain. Who knew that tiny tick bites from back in 1999 could totally debilitate ten years later?!?! Second, one year into my expected two-year treatment plan for Lyme disease, my Mom committed suicide. Major trauma. Major grief, which not only tore my family apart but Mom's death also set back my Lyme recovery many months. How ironic. My Mom, who had been my greatest medical advocate and Lyme champion, who wanted nothing more than for me to recover, caused me harm and delayed Lyme recovery with her death. When Mom died, I was already on medical leave from Stanford University because of Lyme, but this November 2010 tragedy was a whole new level of pain for me and my entire family.

Such a shock... *Rest. Breathe. Sleep. Pray.* That was all I could do for many months during winter 2010-2011. This became my personal mantra: *Rest. Breathe. Sleep. Pray.*

Eventually, with unconditional love and generous support from a few close friends who are like family, I graduated to:

Rest. Breathe. Sleep. Pray.

Accept. Surrender.

Heal.

What doesn't kill us makes us stronger. I've always believed this and these past few years, when chaotic and unpredictable life events tested my limits, I took comfort in this thought. I still do today. Deep down, throughout my ordeal these past years, I somehow knew I'd find my way out of my Lyme disease and emotional grief. There was a way... somehow... somehow.

I'd remind myself of my long-held belief that the world doesn't give us more than we can handle. Somewhere, somehow—either out there in the world or inside within myself—all the tools and resources necessary to make it through exist... somewhere... somehow.

Well that somehow.... somehow... was the unconditional love and support from friends, faculty, and family. My friends and Stanford Committee didn't give up on me. Stanford University and my E-IPER department allowed me to take an extended leave of absence—2.5 years of medical accommodation and medical leave, total—so that I could find myself and deeply heal on all levels.

These past few years stripped me down to the core—literally. Lyme invaded my brain and (temporarily) robbed me of my thinking and bodily functions. I could no longer use my education or take care of myself to function independently, as a woman in her 30s should. Rather, my capabilities and Ego-self with past accomplishments faded away, far away. It was scary. It was serious. Lyme debilitated and humbled me. For a year, I was taking the same dementia medications as my grandmother. At my worst, I could not read, as these letters I'm typing now would look like crazy hieroglyphics or wingding font—nonsensical gobbledygook, which I could not comprehend, let alone build upon to finish my PhD. It wasn't

just my brain. My body also defied my wishes, as I faced daily, debilitating pain, MS-like numbness, and Parkinson's-like shakes as my neurological systems (really, all body systems) failed me.

I went from Stanford PhD to food stamps. Literally.

Alas, it was not forever. This too shall pass... and it did... with grit, tenacity, and surrender.

Ironically, what ultimately helped me through my trials was stopping to fight and embracing acceptance. Total acceptance. Surrender. There's great power in acceptance, forgiveness, and truly unconditional love. I won't lie to you. It wasn't easy. It was hard work, every day, for 2.5 years with nothing to show for my efforts. There were many days my Lyme pain and grief were so excruciating and debilitating that I wanted to give up. But, I didn't quit. I didn't quit life. I didn't quit my PhD. Both, major accomplishments, especially given the rocky ride and looking back from the other side. Wow. How love and light and life turns even the ugliest of lemons into lemonade.

My story is not unique, but inspired by those who come before me and taught us well. There are too many people to individually mention, many of whom I've never personally known but have shared their story through books and history (e.g., Mandela, Gandhi, Jesus, Siddhartha Gautama, Oprah Winfrey, Maya Angelou) to rise above by holding onto values and internal integrity and knowingness, more than any outside compass. Through life's challenges and ordeals, I can now say that I've been lucky enough to have been stripped down to the Core and "broken open" to discover a well of strength and Self, as I've never known before. Lyme has taught me much. Grief has taught me much. Arguably unfortunate in circumstances, I've been amazingly fortunate with exposure to stories of the world's greatest heroes and with in-person exposure to wonderful, real-life heroes.

My journey is very much a Dr. Steve Schneider "Patient from Hell" medical miracle. In fact—after six months of searching for the right team of doctors for my Lyme treatments and finally compiling my medial team of "Lyme Literate Medical Doctors"—I gave each of my four doctors a copy of Steve's book, "The Patient from Hell." Needless to say, I went through quite a few doctors before I found this "right" team of four. Together, we partnered and pioneered new Lyme protocols. Arguably risky, yes, but a risk worth taking in my opinion, given that my alternative was likely a lifetime of chronic pain, fatigue, and disability. I wanted my life back. I wanted my brain back. I wanted to be a scientist again, so I found the team to work with me and do whatever it would take. And that gamble paid off. Today, after 2+ years of conventional therapies augmented with experimental nano-mineral treatments for Lyme, I'm fully recovered and pleased to say I'm myself again—100% healthy again. This Stanford PhD is proof that my body and brain are back. Gratitude!

I am so grateful to have my clear thinking and full capacity back today. To get here, I had to pioneer experimental IV nano-mineral treatments (oligotherapy with nanosilver, nanogold, and trace minerals for immune system support). It was a lot of work amidst uncertainty—arguably enough research to earn a second degree in infectious disease and cellular biology. But, it was worth it. Knowledge is power and it gave me my life back. Desperation truly is the mother of invention.

I did not do it alone. Problem solving—whether problem solving my way out of Lyme disease or problem solving my way through my Stanford PhD—is a team effort. It takes a village and I’ve had the most excellent team. I thank my co-authors and friends for patiently sticking by me, even though I bottlenecked our research for 2+ years while healing: Xi He, Alec MacCall, E.J. Dick, Steve Ralston, Jason Cope, Jim Hastie, Fio Micheli, Mark Carr, Stephen Monismith, Paul Leary, Nuri Tessa Pierce, C. Brock Woodson, Jerry Moxley, Ashley Apel, and Rod Fujita. Thank you for waiting for me and being there on the other side—truly excellent colleagues.

Due to political and medical controversies currently dividing the Lyme world, I will not name my “Lyme Literate Medical Doctors” here. You know who you are. I thank you from the bottom of my heart for doing the work you do and saving my life. I would not be submitting this Stanford PhD without you. Please, keep up the good fight. Scientific integrity and medical truth will eventually prevail, until the Lyme medical community is no longer divided but simply focuses efforts on healing patients. I was fortunate to work with courageous doctors who kept that end goal in mind. Thank you.

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My “Oxytocin Time” gals with brie, chocolate, and good red wine helped me through more than a few stumbling blocks: Samantha Stoddard, Amber Morris, Wendy Vogt, Rachael Bleau, Wennie Liao, Yas Yadegar Baravarian, Chloe Sladden, Alanna Rich, Yasmin Lucero, Cristy Boone, Erica Smith, Sabrina Plante, Stephanie Brewster, Nicole Woodling Douglas, Meisha Key, Deborah Rogers, Joanne Gaskell, Kaitlin Shilling, Carolyn Snyder, Caroline Scruggs, Marilyn Cornelius, and so many more. Santa Cruz sailing with Scott Sorenson, Trevor Rhodes, and Amber Rhodes repeatedly grounded me and kept me afloat (pun intended). Twisted humor and laughs with Jim Hastie... and Cruz de Wilde... and lil’sis brusband. YES, to costume parties! YES to healing through laughter!

Big thanks and love to my big Irish family. I also thank my father, Stephen “Tim” Honey, for growing and learning with me, as we together discovered that unconditional love can heal all. I am grateful for kind words and well wishes from all the Honey family. I am also grateful for the love and compassionate example of Debra Andrews, who has infused the Honey family with love again. Of course, the next generation with Bit-O-Honey kids, Nyala and James Honey, effortlessly brings joy, laughter, and love into my life by just being themselves. Thanks kiddos!

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If I have a regret from my E-IPER time at Stanford, it is that my time was too short on the social side. Largely because illness physically limited my energy and capacity for life (including friendships), my outings and fun with E-IPER, EcoEvo, EFML, FioLab, and Hopkins friends grew more limited as I progressed in my degree. I would have liked to have been there more, as a friend. Please know that I truly appreciate and treasure our connections. We'll always be connected through Cardinal grad times. Forever friends.

In each PhD chapter, I include acknowledgements. Still, they deserve repeating here:

Chapter 1 Acknowledgements

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Gratitude!

Problem solving is a team effort
& I've had a great team.
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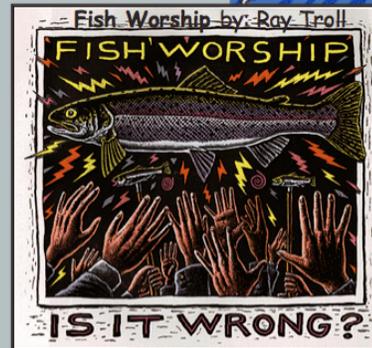
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I submit this thesis as a beacon of light and hope, as a symbolic triumph over adversity. I thank everyone who is reading this and who walked with me through the ups, downs, highs, lows, good, bad, ugly, and downright fugly. We made it! PhDone!

Remember, there is always hope. For those still struggling with Lyme or grief or other invisible illnesses, please know you are not alone. You, too, can get out of this mess. For tips and resources, please visit my Honey Honey Healing website: www.honeyhoneyhealing.com

Now, it's time to turn the page and to ring in a new chapter of life, as. Dr. Honey. I think of my next chapter as a new and improved Self—KTH 2.0, with many life lessons and character-building experiences internalized to my core. Whatever lies ahead, I embrace all my past events to serve as gifts—or, at least, opportunities—to learn, grow, and challenge myself to evolve into more of my full potential/Self than I've known before. New health... Self acceptance... New life... Self love to the deepest core. Literally, I was broken open... and am now pleased to submit this Stanford PhD as the new and improved KTH 2.0 with 100% health and optimism for what's to come.

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