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# William (Bill) Peterson's contributions to ocean science, management, and policy

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## ABSTRACT

In addition to being an esteemed marine ecologist and oceanographer, William T. (Bill) Peterson was a dedicated public servant, a leader in the ocean science community, and a mentor to a generation of scientists. Bill recognized the importance of applied science and the need for integrated “big science” programs to advance our understanding of ecosystems and to guide their management. As the first US GLOBEC program manager, he was pivotal in transitioning the concept of understanding how climate change impacts marine ecosystems to an operational national research program. The scientific insight and knowledge generated by US GLOBEC informed and advanced the ecosystem-based management approaches now being implemented for fishery management in the US. Bill held significant leadership roles in numerous international efforts to understand global and regional ecological processes, and organized and chaired a number of influential scientific conferences and their proceedings. He was passionate about working with and training young researchers. Bill's academic affiliations, notably at Stony Brook and Oregon State Universities, enabled him to advise, train, and mentor a host of students, post-doctoral researchers, and laboratory technicians. Under his collegial guidance they became critical independent thinkers and diligent investigators. His former students and colleagues carry on Bill Peterson's legacy of research that helps us understand marine ecosystems and informs more effective resource stewardship and conservation.

## 1. Introduction

William T. (Bill) Peterson (1942–2017) was an insightful and productive scientist, with over 200 highly cited publications on a diversity of oceanography, marine ecology, and fisheries topics (Fig. 1). His research included analyzing and relating long records of physical oceanography and marine organisms (e.g., Miller et al., 2017, one of his last publications), investigating zooplankton biology and production (Dam et al., 1994; Gómez-Gutiérrez and Peterson, 1998; Peterson et al., 2002; Feinberg et al., 2007), characterizing the impacts of regime shifts and climate change on the ecology and biology of marine zooplankton and fish (Peterson and Schwing, 2003; Hooff and Peterson, 2006), and forecasting salmon returns based on ocean conditions (Burke et al., 2013).

Bill was recognized internationally as a scientist and leader of a diverse research program to understand how lower trophic level variability influences marine fishery resources. His Newport (Oregon)

Hydrographic Line sampling program initiated in 1996 set a standard for long-term surveying and analysis of physical and biological conditions that enabled him and many other investigators to characterize, understand, and forecast how ocean ecosystems respond to physical forcing and climate-scale variability. Highlights of Bill's research career have been summarized in Gómez-Gutiérrez et al. (2018) and are incorporated into some of the companion papers in this special volume (Dumelle et al., this issue; Fisher et al., this issue; Gómez-Gutiérrez and Peterson, this issue, Zeman et al. this issue). A complete listing of his peer-review publications is provided as an appendix to this paper (Table S1).

Yet Bill's influence on marine ecosystem research and management extended beyond his lab and field work, academic meetings, and scientific publications. He also was a long-term leader of US and international programs supporting marine ecosystem research and resource management, and a caring and effective mentor to numerous young scientists. Here we review Bill Peterson's significant contributions to

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Fig. 1. Bill Peterson (second from left) as a PhD student in 1978 on the R/V Cayuse conducting a survey off Depoe Bay, Oregon. (Photo courtesy Waldo Wakefield).

establishing and leading science programs in the US and internationally, his role as an advisor and mentor to students and young investigators, and his legacy to ocean science research, management, and policy.

## 2. US national science programs and policy

Some of Bill Peterson's greatest contributions to ocean science were his leadership in establishing and guiding highly influential national and international science programs. The foundation for Bill to take "center stage" in US ocean research was laid in the 1980s and early 1990s. This was a period when large programs involving several countries, many scientific institutions, and innumerable researchers drove ocean science to both advance fundamental understanding and address topics with real world implications (Table 1). Collectively these programs contributed to our basic understanding of ocean dynamics, and supported the formulation of global climate change programs. They also emphasized and strengthened the interdisciplinary approach needed to address problems in ecosystem research, an approach that Bill substantively advanced and is now the expected norm in major oceanographic research programs.

Perhaps inspired by the excitement and successes of earlier big science programs, ocean science leaders began crafting a "big ocean science program" on marine animals. The program included key fish populations and was aimed at advancing fishery management capability. This naturally led to a critically important partnership between academic and government scientists, particularly those from the National Oceanic and Atmospheric Administration (NOAA) where Bill worked during the early 1990s. The importance of fish and fisheries in this movement is indicated by a series of reports referred to as Fish Ecology I and II, culminating in 1982 in Fish Ecology III (Rothschild and Rooth 1982). A subsequent workshop identified the principal areas of future research in the field of marine zooplankton biology, a key trophic link to fish populations (Marine Zooplankton Colloquium 1, 1989). These reports gave momentum to the creation of the US GLOBEC (GLOBal Ocean ECosystems Dynamics) Program and its counterpart GLOBEC International Program, and were quite influential in shaping their science plans.

The initial US GLOBEC Steering Committee was established in 1988 with a membership recommended by John Steele (Woods Hole Oceanographic Institution) and other prominent ocean scientists.

Michael (Mike) Sissenwine from the National Marine Fisheries Service (NMFS) Laboratory in Woods Hole was the only government scientist named to the initial Steering Committee, but his appointment had an important influence on the future direction of GLOBEC, and Bill's ultimate management of it, for three reasons: (1) he was the primary advocate on the Steering Committee for US GLOBEC's first field program on Georges Bank; (2) as the Chair of the International Council for the Exploration of the Sea (ICES) Coordinating Committee on Recruitment Processes, he supported an international Cod and Climate Change program; and (3) he later became the NMFS Senior Scientist and led the successful effort to obtain NOAA funding to partner with the National Science Foundation (NSF) on US GLOBEC.

Other key members of the initial Steering Committee included Brian Rothschild, Charles (Pete) Peterson, and Thomas (Zack) Powell. The latter two took their turn as Chair during important periods in the evolution of US GLOBEC. Zack Powell was the initial leader of the Northeast Pacific Program. Eileen Hofmann, another initial member, later became the leader of the US GLOBEC Southern Ocean Program.

NSF and NOAA were ready to establish program leadership and commit substantial funding. Michael (Mike) Reeve, NSF Division Director of Ocean Sciences, and Mike Sissenwine, NMFS Senior Scientist, recognized that US GLOBEC required a credible hands-on scientist who would underpin the Program full-time and prepare a science plan for scientists, not for bureaucrats or politicians. In 1992, Bill Peterson was named the US GLOBEC Program Manager and Director of the Interagency Program Coordination Office, under the direction of Mike Sissenwine and Phillip (Phil) Taylor, NSF Program Manager for Biological Oceanography. Bill relocated from his supervisory scientist position at the recently created NOAA Center for Ocean Analysis and Prediction in Monterey, California to Silver Spring, Maryland and immediately took control of the planning effort, working with Eugene S. (Gene) Fritz (NOAA Coastal Ocean Program), Mark Eakin (NOAA Global Change Program), and, most importantly, the US GLOBEC Steering Committee.

The goal of US GLOBEC was to understand how physical processes influence the structure and dynamics of marine ecosystems and to predict the effects of climate change and variability on these systems (US GLOBEC, 1991). Previously NOAA supported a low-level Marine Ecosystem Program (MEP) as part of the NOAA Global Change Programs. However MEP was having difficulty gaining traction against the established physical science climate programs. When Bill became

**Table 1**  
Major US ocean research programs.

Program	Dates	Funding agencies	Global program	Scientific Goal
Tropical Ocean Global Atmosphere program (TOGA)	1985–1994	NOAA, NSF, NASA	World Climate Research Programme	Ocean and atmospheric variability in tropical ocean basins
Joint Global Ocean Flux Study (JGOFS)	1987–2003	NSF, NASA, NOAA, DOE, ONR	International Geosphere-Biosphere Programme	Global scale processes controlling fluxes of carbon and associated biogenic elements in the ocean
World Ocean Circulation Experiment (WOCE)	1990–2002	NSF, NASA, NOAA, DOE, ONR	World Climate Research Programme	Global survey of physical properties of the oceans
US GLOBEC	1991–2010	NSF, NOAA	International Geosphere-Biosphere Programme	Climate change impacts on the structure and dynamics of marine ecosystems and fishery production

program manager, US GLOBEC was in development conceptually, and planning was underway for modeling and field work. During his tenure, US GLOBEC greatly increased funding and launched extensive and long-term programs in three regions – the Northwest Atlantic (NWA), Northeast Pacific (NEP), and Southern Ocean (SO). A fourth regional study in the Arabian Sea was discussed but never funded.

Bill Peterson oversaw two critical steps in the transition of US GLOBEC into an operational program. The first was implementing a NWA field study based on scientific merit, not politics. This coincided with the collapse of the northern cod fishery, a huge economic and cultural force off eastern US and Canada, in part due to environmental change that was poorly observed and understood, and absent in both nations’ fishery management process. An important element of the NWA program’s success was reshaping its implementation plan from an academic research plan to one conveying the significance of these investigations to ocean resource management.

Bill and Franklin (Frank) Schwing, on detail to the NMFS Office of the Senior Scientist, worked closely with the US and Canadian ocean science community to prepare the GLOBEC Northwest Atlantic Implementation Plan (US GLOBEC, 1992). They were critical to incorporating fisheries management into an already solid scientific research program, a key addition to garner NMFS support. Bill and Frank Schwing led an extensive peer review of the Plan and worked with the research community to respond. The final NWA Implementation Plan articulated specific approaches, resources, and steps to assess ocean plankton populations and their interactions with ocean physical processes. It also emphasized the impacts of climate change on marine ecosystem dynamics in the NWA and their implications on long-term stock and fisheries management.

After the NWA Implementation Plan was adopted, the second critical step was the proposal request and review process, and aligning available NSF and NOAA funding. Bill worked with Mike Reeve and Phil Taylor at NSF, and Mike Sissenwine, Frank Schwing, and Mark Eakin at NOAA to issue joint funding announcements in 1992, and to oversee proposal peer review panels. Bill then led negotiations of a multi-year package of research awards among many academic and NOAA scientists.

US GLOBEC funded tens of millions of dollars of fisheries ecology research. Under the direction of Bill and other key program leaders, scientists shared their ideas and expertise in open and transparent planning. The planning and team building among academic and NOAA scientists was so strong that when budget glitches jeopardized the ability of US Federal scientists to carry out their part of the research plan, academic scientists voluntarily accepted reduced funding in favor of their government counterparts so that the Program would remain whole, albeit smaller.

Bill also coordinated US participation in International GLOBEC research in the North Atlantic and elsewhere. Initial planning for the Southern Ocean got underway. NSF and the Office of Naval Research (ONR) cooperation in ocean ecosystems science continued within the context of GLOBEC through the joint support of new technology development. Their first efforts developed a new long-term moored array and physical/bioacoustic sampling systems for assessing ocean plankton populations and their interactions with ocean physical processes, tools critical to GLOBEC’s operational success.

Endangered salmon stocks in the Pacific Northwest became a NOAA marine ecosystem science priority, and focused funding on the NEP Program. Bill and the Program’s agency leadership advocated for the NWA example of scientists selecting and planning the next US GLOBEC field program on scientific merit. The science community, with Bill’s oversight, was intimately involved in prioritizing and planning the NEP Program’s two regional foci in the California Current System and the Coastal Gulf of Alaska.

With the US GLOBEC Program firmly established, Bill returned to his first love, zooplankton and broader scale marine ecosystem research with NMFS. Even with his return to science, however, Bill continued to



provide strong and thoughtful leadership on regional ocean research. From his newly established lab in Newport, Oregon (part of the NMFS Northwest Fisheries Science Center, NWFSC), Bill advocated strongly for interdisciplinary California Current Ecosystem science. He helped launch the NEP Program by conducting his own excellent research under the US GLOBEC banner. Bill was prominent in the NEP program as a lead investigator and a member of the Executive Committee.

US GLOBEC was a component of the [US Global Change Research Program \(USGCRP\)](#). Although no longer program manager, Bill continued to provide national scientific leadership within the USGCRP, and specifically in its ecosystems dynamics research theme. Bill played a high-level role in developing national climate change science policy, and in drafting the nation's first Climate Change Science Plan ([US Global Change Research Program, 2003](#)). He represented NOAA on the USGCRP Ecosystem Interagency Working Group. In 2004, Bill was detailed back to Silver Spring to the NOAA Program Planning and Budgeting Office, under Mary Glackin. In this capacity Bill again worked with Frank Schwing to establish the NOAA Climate Office, NOAA's first completely cross-line office. The Office developed NOAA's policy for climate science, created an agency climate science initiative and budget plan, and set the foundation for the current NOAA Climate Program Office. It also demonstrated the great value and success of future cross-line "One NOAA" offices.

### 3. International scientific research programs and organizations

US GLOBEC set the standard for other nations in the GLOBEC International Program (1990–2010) and for planning future big science programs. GLOBEC International and other international science programs highlighted how marine ecosystems are impacted by global climate change and, specifically, the importance of secondary producers in the evolution of these systems. Bill Peterson recognized the importance of such multinational and international programs for understanding global ecological processes and for fostering the exchange of knowledge. Bill also understood the critical role of international research in managing trans-boundary stocks, high seas populations, and the resources of large marine ecosystems. He also realized that program outcomes and scientific conferences needed to result in peer-reviewed publications, closing the loop between conducting research and communicating its results both to the science community and to resource managers.

Bill was co-convenor with Daniel Lluch-Belda (CICIMAR-IPN, México), Jeffrey J. Polovina (NMFS), and Takashige Sugimoto (University of Tokyo, Japan) of the 2002 symposium, "Transitional Areas in the North Pacific Ocean" in La Paz, Mexico. The conference was organized by the North Pacific Marine Science Organization (PICES), Centro de Investigaciones Biológicas del Noroeste, SC (CIBNOR), and Centro Interdisciplinario de Ciencias Marinas del IPN (CICIMAR-IPN). Ninety-two scientists participated, and a special issue of *Journal of Oceanography* was published in 2003 ([McKinnell, 2003](#)). This symposium was an early effort to examine transitional areas marked by strong physical and ecological gradients where the impacts of climate change are expected to occur sooner and more dramatically. This symposium set the stage for a number of long-term multinational research efforts. Its seminal impact was noted years later when a second symposium was held in 2018 in La Paz, this one organized by PICES with Salvador Lluch-Cota (CIBNOR), the son of Daniel Lluch-Belda, as one of the conveners.

The 3rd International Symposium on Zooplankton Production, sponsored by ICES, PICES, and GLOBEC, was held in Gijón, Spain in 2003 with 333 scientists from 38 countries in attendance ([Fig. 2](#)). In addition to co-convening this conference with Roger Harris (GLOBEC), Tsutomu Ikeda (PICES), and Luis Valdes (ICES), Bill was Guest Editor of the issue on "The Role of Zooplankton in Global Ecosystem Dynamics: Comparative Studies from the World Oceans", which included 28 papers from symposium participants, in the *ICES Journal of Marine*

*Science* ([Valdes et al., 2004](#)). The symposium and subsequent publications highlighted the importance of international collaboration, integrated approaches to studying marine ecosystems, and long time series for monitoring climate impacts on zooplankton, all tenets that drove Bill's research throughout his career.

Recognizing the broad ecological impacts of recent shifts in conditions in the North Pacific, Bill co-convened the 2006 Seattle, Washington workshop "Poor Ocean Conditions in Summer 2005", which resulted in a special issue in *Geophysical Research Letters* (e.g., [Kosro et al., 2006](#), [Mackas et al., 2006](#)). Bill and So Kawaguchi (Australian Antarctic Division, Tasmania) were the organizers and conveners of Workshop W3 – "Krill research: current status and its future", at The 4th International Zooplankton Production Symposium, "Human and climate forcing of zooplankton populations", held in Hiroshima, Japan in 2007.

Bill returned to Gijón in 2008 to co-convene the First PICES/ICES/IOC Symposium on "Climate Change and the World's Oceans", which attracted about 400 scientists from 48 countries ([Fig. 3](#)). This continued the focus on interdisciplinary research to synthesize how climate change influences ocean ecosystems and society, themes near to Bill's heart. He also was a Guest Editor of the *ICES Journal of Marine Science* issue "Effects of Climate Change on the World's Oceans", which included 22 papers from symposium participants ([Valdes et al., 2009](#)). The success of this inaugural symposium resulted in three subsequent international conferences dedicated to the effects of climate change on the ocean and its ecosystems. It also set the stage for one of Bill's last professional duties as a Steering Committee Member for the 2017 ICES/PICES Symposium on "Drivers and Dynamics of Small Pelagic Fish" held in Victoria, BC, Canada.

In 2009 Bill Peterson, Angus Atkinson, Bettina Meyer, and Jaime Gómez-Gutiérrez were co-conveners for the Krill Workshop at the GLOBEC 3rd Open Science Meeting in Victoria, BC. The Workshop resulted in a 2010 Special Issue in *Deep-Sea Research II*, titled "Krill Biology and Ecology: Dedicated to Edward Brinton 1924–2010", which consisted of 18 scientific papers ([Kawaguchi and Peterson, 2010](#)). Bill also co-convened a series of annual Krill Workshops at PICES meetings (2009–2012).

In addition to helping to organize and lead a number of impactful international scientific conferences, Bill took on a number of key leadership roles in PICES. He co-chaired the PICES Regional Experiments Task Team (1999–2002) and Working Group 23, "Comparative Ecology of Krill in Coastal and Oceanic Waters around the Pacific Rim". He also was a member of the Executive Committee of the Climate Change and Carrying Capacity Program (2002–2011), the Biological Oceanography Committee (2010–2017), and the Review and Evaluation Committee for the Forecasting and Understanding Trends, Uncertainties and Responses of North Pacific Marine Ecosystems Scientific Program. In addition, Bill served on the ICES Working Group on Zooplankton Ecology (2010–2017).

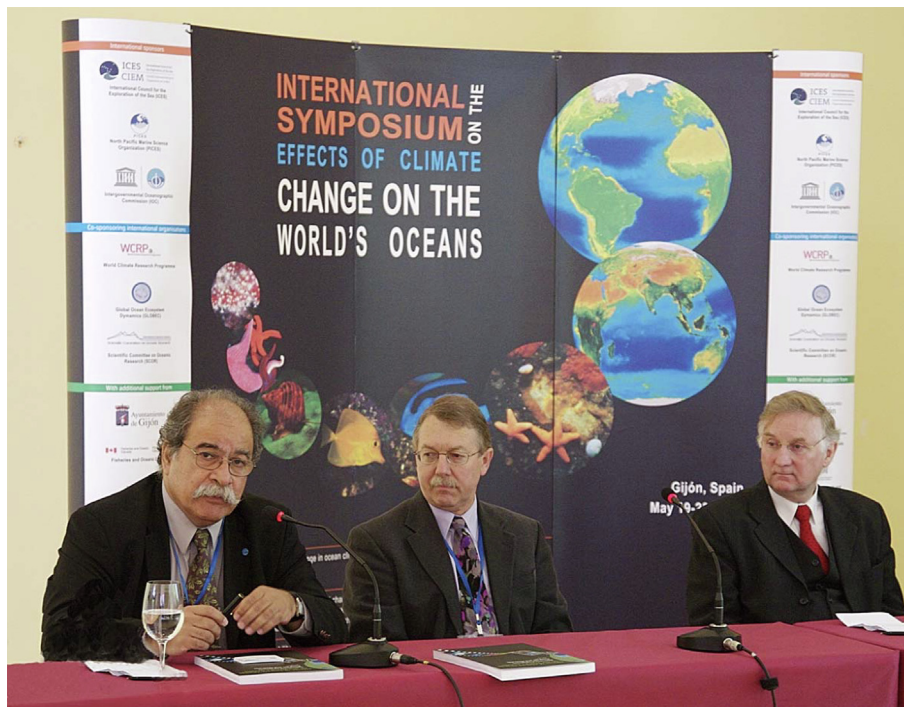
Bill Peterson provided leadership for multiple groundbreaking international scientific collaborations. Bill conducted research with scientists from around the North Pacific Basin (largely through PICES), as well as from South Africa, Namibia, Chile, Mexico, Sweden, and India. We highlight his collaborative work with US and Indian scientists as an example.

Together with Usha Varanasi and Vera Trainer of the NMFS NWFSC and the India Ministry of Earth Sciences, Bill participated in the inaugural workshop hosted by the Indian National Centre for Ocean Information Services (INCOIS) in 2013. From this workshop, scientists from NMFS and several Indian institutions developed a strategic planning document for research into marine fisheries and harmful algal blooms, leading to improvements in forecast systems for India's west coast fisheries and ecosystems.

In 2015, Bill participated in a workshop hosted by the Centre for Marine Living Resources and Ecology in Kochi, India to discuss methods for lipid analysis in zooplankton. This workshop included a cruise on



**Fig. 2.** Bill Peterson, Moto Ikeda, and David Mackas at “*The 3rd International Zooplankton Production Symposium on the role of zooplankton in global ecosystem dynamics: Comparative studies from the world oceans*” in Gijon, Spain in 2003. (Photo courtesy of PICES).



**Fig. 3.** The conveners (left to right) Patricio Bernal (Executive Secretary of IOC), William Peterson (PICES), and Joe Horwood (President of ICES) representing the three primary sponsors of the symposium on “*Effects of climate change on the world’s oceans*”, held from May 18–23, 2008, in Gijon, Spain (Photo courtesy of PICES).

the FORV Sagar Sampada to harmonize sampling techniques between India and the US (Fig. 4). The scientists were so engrossed in their work that they missed their appointment with the pilot boat, which led to an unexpected night aboard the ship. Bill, as designated chief scientist of the “expedition”, led the ensuing conversation well into the night at a gathering in his quarters. He subsequently hosted a young scientist from INCOIS as a PICES-sponsored intern for a month in his Newport lab. His colleagues in India remember Bill for his compassionate nature and his passion to impart his knowledge of marine and anadromous fisheries.

#### 4. Developing young investigators

Bill Peterson was passionate about working with and training students, technicians, and young researchers, and cultivating the next generation of ocean scientists through formal and more collegial approaches (Fig. 5). He supervised about 21 graduate students on a wide range of dissertation topics, mostly zooplankton ecology (Table 2). Nine post-doctoral researchers worked under Bill’s mentoring (Table 3). He also hosted and worked with nine scientists on extended research visits to his laboratory at Hatfield Marine Science Center in Newport, Oregon (Table 4).





Fig. 4. Bill Peterson with scientists from the Center for Marine Living Resources and Ecology, aboard the FORV Sagar Sampada offshore from Kochi, India. One of the goals of this NOAA-Ministry of Earth Sciences collaboration was to compare zooplankton sampling methods in India and the US. (Photo courtesy Vera Trainer).

#### 4.1. Oregon State University

After obtaining his PhD, and while applying for academic faculty positions, Bill was still conducting research and identifying and counting copepods and other zooplankton in Charles B. (Charlie) Miller's laboratory at Oregon State University (OSU). In January 1980 Charlie Miller, who had been Bill's PhD advisor, hired three young and

inexperienced technicians to go to sea on the Canadian Weatherships Quadra or Vancouver for multiple 49-day cruises over the next two years. None of the three new hires, Harold (Hal) Batchelder, Martha Clemons, or Richard Conway, had the necessary experience to sample zooplankton to depths of 2000 m, and only Hal Batchelder had even been to sea on research vessels. But all three were enthusiastic about the prospects of sampling at sea and learning to identify the plankton



Fig. 5. Bill Peterson with a number of his former students, technicians, and collaborators attending the Plankton Production Symposium March 2010 at Pucón, Chile. (Photo courtesy Jaime Gómez-Gutiérrez).

**Table 2**  
Graduate students advised by Bill Peterson.

Name and degree	Graduation year	Thesis/research project title
<b>Stony Brook University, New York</b>		
George McManus, M.S.	1981	Elimination of PCB residues by the copepod <i>Acartia tonsa</i> , and effects of PCB on fecundity, egg viability, and survival of nauplii
Hal Rose, M.S.	1981	Temporal and spatial variations of phytoplankton community composition and primary production in a nearshore zone
George Nardi, M.S.	1982	The queen conch fishery of the Turks and Caicos Islands
Seth Ausubel, M.S.	1983	Life history and feeding ecology of Atlantic mackerel in Long Island Sound
Harvey Simon, M.S.	1983	Management alternatives for the spiny lobster ( <i>Panulirus argus</i> ) fishery of the Turks & Caicos Islands, B.W.I.
Kimberly McKown, M.S.	1984	Age, growth and feeding ecology of sand lance ( <i>Ammodytes americanus</i> ) in Long Island Sound, NY
Doreen Montealeone, M.S.	1984	Year to year variations in abundance and feeding ecology of sand lance, <i>Ammodytes americanus</i> , larvae in Long Island Sound
Brian Beckman, M.S.	1985	Egg production by <i>Acartia tonsa</i> in Long Island Sound
Hans Dam, M.S.	1985	Copepod patch size in Long Island Sound: The role of current shear
Frances Horvath, M.S.	1985	An analysis of light, ichthyoplankton and benthic characteristics of Long Island Sound
Peter Tiselius (Fulbright Scholar and Nordic Council fellow)	1985	Life history and population dynamics of the chaetognath <i>Sagitta elegans</i> in central Long Island Sound
Diane Bellantoni, M.S.	1987	Temporal variability of egg production rates of <i>Acartia tonsa</i> Dana in Long Island Sound
Thomas Johnson, Ph.D.	1987	Growth and regulation of the population of <i>Parvocalanus crassirostris</i> (Copepoda: Calanoida) in Long Island Sound, New York
Dagoberto Arcos-Rojas, Ph.D.	1989	Seasonal and short time scale variability in copepod abundance and species composition in an upwelling area off Concepción coast, Chile
Hans Dam, Ph.D.	1989	The dynamics of copepod grazing in Long Island Sound
<b>University of Cape Town, Sudafrica</b>		
Colin Attwood, BSc Honours	1988	The effect of feeding history on egg production and lipid content in the copepod <i>Calanus australis</i>
Ingrid van der Riet, BSc Honours	1989	The effect of food concentration on ingestion rate by the copepod <i>Calanoides carinatus</i>
Jenny Ann Huggett, PhD	2003	Comparative ecology of the copepods <i>Calanoides carinatus</i> and <i>Calanus agulhensis</i> in the southern Benguela and Agulhas Bank upwelling ecosystems
<b>Oregon State University</b>		
Jaime Gómez-Gutiérrez, Ph.D.	2003	Comparative study of the population dynamic, secondary productivity, and reproductive ecology of the euphausiids <i>Euphausia pacifica</i> and <i>Thysanoessa spinifera</i> in the Oregon upwelling region
Julie Keister, Ph.D.	2008	Variability in mesoscale circulation and its effects on zooplankton distribution in the northern California Current
<b>Ocean University of China</b>		
Xiuning Du, Ph.D.	2012	Studies on phytoplankton seasonality, copepod egg production rate and euphausiid <i>Euphausia pacifica</i> grazing in the Oregon upwelling system

**Table 3**  
Post-doctoral fellows supervised by Bill Peterson.

Names	PhD Institution	Dates
Suzanne Painting	University of Cape Town	1987–1989
Patrick Ressler	Texas A&M University	2001–2002
Jay Peterson	University of Massachusetts, Boston	2005–2008
Hongsheng Bi	Louisiana State University	2005–2009
Linda O'Higgins	Galway University, Ireland	2007–2009
Hui Liu	University of Alaska, Fairbanks	2007–2009
Anita McCulloch	North Carolina State University	2010–2011
Mattias Johansson	Oregon State University	2010–2011
Xiuning Du	Ocean University of China, Qingdao	2013–2017

**Table 4**  
Scientists visiting the Peterson Laboratory at Hatfield Marine Science Center (Newport, Oregon) for extended periods for joint research.

Names	Home Institution	Years
Jaime Gómez-Gutiérrez	Centro Interdisciplinario de Ciencias Marinas, Mexico	1997
Jeanette Yen	Georgia Tech	2003
Andrew Hirst	British Antarctic Survey	2004
Motomitsu Takahashi	Seikai National Fisheries Research Institute, Japan	2007
Ramiro Riquelme-Bugueño	University of Concepcion, Chile	2010
Nelly Tremblay	Alfred-Wegner Research Institute, Germany	2011, 2012
Toru Kobari	Kagoshima University, Japan	2012
Michael Malick	Simon Fraser University, Canada	2012
Ryan Rykaczewski	University of South Carolina	2013

that were captured and preserved.

However Charlie Miller had previously arranged a one-year sabbatical leave, split between L'Observatoire Océanologique de Villefranche-sur-Mer (France) and Scripps Institution of Oceanography, during the first year of sampling, and would not be available to train the new technicians. Instead he asked Bill Peterson to instruct them in zooplankton taxonomy, and Bill took this on with an enthusiasm that quickly transferred to each of the three young ocean-going technicians. Hal Batchelder ultimately obtained a Ph.D. at OSU using zooplankton samples from the subarctic Pacific. He is now the PICES Deputy Executive Secretary.

#### 4.2. Stony Brook

In fall 1980 Bill left Oregon to assume an Assistant Professor position at the Marine Sciences Research Center (now the School of Marine and Atmospheric Sciences) of the State University of New York at Stony Brook (now Stony Brook University). He taught graduate-level courses in biological oceanography and zooplankton ecology (1980–1987), receiving a distinguished teaching award for the 1980–1981 academic year.

While at Stony Brook University, Bill established a sea-going program with modest funding from New York Sea Grant to investigate the plankton dynamics of Long Island Sound, with an emphasis on zooplankton and fish larvae. Virtually every student of Bill's participated in the weekly cruises that ran annually from February (the timing of the spring bloom) to December, sampling at a site in the central Sound near the station where Gordon A. Riley conducted his pioneering studies (e.g., Riley, 1963). Novel insights into plankton dynamics and tidal mixing, copepod fecundity and feeding, grazer control of primary



Fig. 6. Larry Hutchinson, Bill Peterson, Jenny Hugett, and Dr Sir Hans Verheye in Sea Point, South Africa in 1994. (Photo courtesy Jenny Hugett).

productivity, and feeding ecology of larval forage fish were obtained from those repeated cruises in the Sound.

An invitation from Dagoberto Arcos-Rojas, his former PhD student who had returned to Chile to finish his dissertation, led to NSF funding for Bill to study the high-frequency coupling of primary and secondary production in a coastal upwelling site off central Chile (Peterson et al., 1988). In coordination with Dagoberto Arcos-Rojas, Bill took his students at the time (Thomas Johnson, Diane Bellantoni, and Hans Dam) along with lab alumni George McManus and Peter Tiselius to the University of Concepción marine station in Dichato, Chile. The team dubbed the project ESCUDO (Ecological Studies of Coastal Upwelling off Dichato), in honor of the local beer they enjoyed during their stay in Chile.

Bill's most significant legacy from Stony Brook was the large cadre of graduate students he supervised and mentored, including 11 M.S. students, three Ph.D. students, and one visiting Fulbright student (Table 2), all of whom worked on a wide variety of topics on zooplankton and fisheries ecology. Collectively their theses from Stony Brook have been cited almost 1000 times.

About half of Bill's students from that time took jobs with the US Environmental Protection Agency, the City of New York, state conservation agencies, and the Port of Los Angeles. Diane Bellantoni became an environmental lawyer. Brian Beckman attained a PhD at the University of Washington and is now a research fish biologist at the NMFS NWFSC. Several others have continued their academic research careers.

Two of Bill's students at Stony Brook, George McManus (who later received his PhD at Stony Brook) and Hans Dam (later an AAAS fellow), are now professors at the University of Connecticut. Bill and Hans Dam collaborated on 11 publications (e.g., Dam and Peterson, 1988, 1991; Dam et al., 1994). Dagoberto Arcos-Rojas became the Director of the Institute of Fisheries Research in Concepción, Chile and later the founder of the Regional Center of Environmental Studies at the Catholic University of Concepción.

Peter Tiselius collaborated with Bill on zooplankton life history and population dynamics studies in a number of systems, investigating trophic and environmental effects on secondary production (Peterson

et al., 1988, 1991; Tiselius and Peterson, 1986). He is now a professor at the University of Gothenburg, Sweden, and an influential scientist on predator-prey interactions in plankton, physical-biological coupling, and food web dynamics in the pelagic environment.

#### 4.3. University of Cape Town

Bill was slated to leave Stony Brook University in 1987 after being denied tenure. At about this same time, he was invited to review the Fisheries Program in South Africa. They were so impressed with his work on the program review that they offered him a faculty position at the University of Cape Town and Sea Fisheries Research Institute in South Africa. Bill jumped at the opportunity to do research in a new coastal marine ecosystem and engage young scientists on another continent. His successful transition to South Africa, and how that experience became a springboard for Bill's career, serves as an example to young investigators navigating the tenure process, and the turns and moves they may encounter during their professional careers.

During his time in Cape Town (1987–1990) Bill supervised one PhD student and two B.Sc. Honors students (Table 2). He collaborated with post-doctoral fellows and scientists working at the (then) Sea Fisheries Research Institute and as part of the Benguela Ecology Programme (BEP) at the University of Cape Town. These included Suzanne Painting, Hans Verheye, and Larry Hutchings, all of whom were researching interannual variability in anchovy and sardine stocks on the Agulhas Bank linked to zooplankton abundance and species composition, with an emphasis on copepod ecology and secondary productivity. This work is summarized in seven peer-review publications that have been cited about 450 times (e.g., Peterson and Painting, 1990, Peterson et al., 1990, Verheye et al., 1994). Painting, an ecosystem scientist at the UK Centre for Environment Fisheries and Aquaculture Science since 2002, studies marine food webs and biogeochemical cycling in the North Sea, with relevance to legislative and policy drivers. Bill's impact extended well after his time in Cape Town. He was an advisor to Jenny Hugett on her 2003 dissertation, many years after Bill had departed South Africa (Fig. 6).





Fig. 7. Day shift on the Mesoscale survey on the R/V Wecoma in 2002. Left to right; Bill, Julie Keister, Anders Roestad (front), and three young volunteers. (Photo courtesy Jaime Gómez-Gutiérrez).

#### 4.4. Oregon State University

Bill and Mary (Neiger) Peterson married at an early age and had two sons, Seth and Paul. Mary was his regular traveling companion to scientific conferences and research trips, and an equal partner in Bill's career decisions and successes. In part due to raising a young family in a politically turbulent environment, they departed Cape Town in 1990 and Bill joined NOAA. After his stint as US GLOBEC Program Manager, he established a laboratory and research program within the NMFS NWFSC group at the Hatfield Marine Science Center (HMSC) in Newport, Oregon that focused on the same organisms and ecosystem he studied as a PhD student in the 1970s (Peterson, 1973; Peterson and Miller, 1975, 1977; Peterson et al., 1979). Bill also was an adjunct professor in the Oregon State University College of Earth, Ocean, and Atmospheric Sciences (CEOAS) from 1996 until 2017. In that capacity he advised and mentored several graduate students and post-doctoral researchers (Tables 2 and 3).

His research vision involved restarting a bi-weekly, year-around zooplankton sampling program along the Newport Hydrographic Line. The “NH Line” was established and occupied from 1961 to 1971 for a decade of physical oceanographic surveys (Huyer et al., 2007). Zooplankton was sampled monthly at 12 stations along the NH Line in 1970–1972 (Peterson and Miller, 1975; Gómez-Gutiérrez et al., 2005). The renewed surveys, which began in May 1996 with much help from Bill's first research assistant Cheryl A. Morgan, were conducted on small vessels, initially the 37' R/V Sacajawea and later the 54' R/V Elakha (“Sea Otter”). Bill arranged one-day cruises along the NH Line at two-week intervals throughout most of the year, often at monthly intervals during the winter when heavy storms prevented more frequent cruises.

The resulting long time series on the NH Line is a unique and invaluable record of plankton and oceanographic variability in the northeast Pacific, complementing environmental and zooplankton information from other California Current time series like the CalCOFI

Program, David Mackas' time series off the coast of British Columbia, Canada, and the IMECOCAL program along the west coast of Baja California, Mexico led by Bertha Lavaniegos (e.g., Mackas et al., 2006; Peterson et al., 2006).

In summer 1997, Bill welcomed Jaime Gómez-Gutiérrez, a Mexican krill biologist, to Newport to conduct secondary production experiments on eight copepod species collected from the NH Line (Gómez-Gutiérrez and Peterson, 1998) and from egg production estimations of nine copepod species collected in a June 1996 NOAA cruise on the R/V McArthur (Peterson et al., 2002). This led to his PhD research at CEOAS initially studying euphausiid community structure from the 1970–1972 NH Line samples (Gómez-Gutiérrez et al., 2005). Later, US GLOBEC funding supported their investigations of euphausiid egg production and ecology. Jaime Gómez-Gutiérrez was co-advised by Bill and Charlie Miller and co-authored 11 publications with Bill on egg production, early larval stage ecology, and parasites of euphausiids. He is now a professor at Centro Interdisciplinario de Ciencias Marinas-Instituto Politécnico Nacional (CICIMAR-IPN, La Paz, Mexico) studying the response of tropical and subtropical zooplankton species to climate change forcing off northwest Mexico and krill ecology, secondary production, and parasitology in several regions of the world.

The zooplankton research team at HMSC in 1998 consisted solely of Bill, Cheryl Morgan, and Jaime Gómez-Gutiérrez and lacked a steady funding source. However with support from NOAA and NSF, including the US GLOBEC NEP program, Bill was able to hire several young and highly motivated scientists, forming a diverse and talented team to investigate ocean variability and its impacts on the zooplankton fauna of the nearshore ecosystem off Oregon. Among the hard-working technicians were Julie E. Keister and Ryan C. Hooff (copepods), Leah R. Feinberg (a former student of Hans Dam at Connecticut) and C. Tracy Shaw (euphausiids), Jesse Lamb, Karen Hunter, Mitch Vance, Jennifer Menkel, Karen Hunter, and Jennifer L. Fisher (zooplankton), and Anders Røstad (nekton and zooplankton hydroacoustics).

Bill was a strong believer in the value of long ocean time series and going to sea regularly and frequently to collect those data. Everyone in the Peterson Lab spent substantial time on research vessels sampling ocean conditions and collecting zooplankton with towed nets for experimental work (Fig. 7). They archived samples for later identification and enumeration, and augmented the NH Line surveys with several extensive oceanographic cruises covering from Washington to the northern California coast. Bill would identify and count zooplankton from one sample late every afternoon—it became his Monday to Friday ritual, and often ran over into the weekends. His dedication to the data collection was passionate and impressive. Although his Lab team did much of the bi-weekly sampling, it wasn't uncommon for Bill to sleep in the back of his truck in the HMSC parking lot, waiting for the ship and its samples to return after midnight so he could help process and set up secondary production experiments with the live collections.

In return, the technicians and staff in the Peterson Lab were mentored to be critical thinkers and diligent researchers. Bill was extremely conscientious in educating, training, and supporting his team, while extending highly productive research into marine ecology, climate change, salmon ecology and production, and zooplankton ecophysiology. To Bill, everyone on his staff was a colleague. They routinely attended national and international scientific conferences to present their research, led- and co-authored numerous peer-reviewed papers, and assisted in preparing research proposals. Cheryl Morgan, Bill's long-term right hand in sampling and data analysis who is still working at HMSC on Columbia River salmon projects, is a co-author with Bill on at least 18 publications (e.g., Sorte et al., 2001; Peterson et al., 2002; Morgan et al., 2003; Miller et al., 2017). Leah Feinberg and Tracy Shaw, Bill's research assistants on euphausiid growth and egg production, co-authored 14 and 13 publications, respectively.

Under Bill's mentorship and with his encouragement, several of his technicians continued to advanced degree programs. Julie Keister, who was Bill's research assistant and second hire at HMSC, received a PhD with Bill and Timothy J. Cowles as co-major professors at CEOAS. She currently is an Associate Professor at the University of Washington School of Oceanography and continued to collaborate with Bill on studies of climate impacts on zooplankton long after her graduation, co-authoring ten publications and innumerable conference presentations with him (e.g., Keister et al., 2009, Keister et al., 2011, Di Lorenzo et al., 2013).

Anders Røstad, who was Bill's research assistant on hydroacoustic surveys from 2000 to 2002, received his PhD in 2006 from the University of Oslo and is now a Senior Research Scientist at King Abdullah University of Science and Technology, Red Sea Research Center, Saudi Arabia. Jesse Lamb attained his MS from CEOAS and works at the NOAA Ecosystem and Fishery-Oceanography Coordinate Investigations (EcoFOCI) as a zooplankton taxonomist investigating how climate change affects zooplankton ecology and the upper trophic levels supported by the zooplankton community.

With the expansion and maturation of the Peterson Lab staff, several post-doctoral researchers arrived (Table 3), bringing greater and broader expertise and international perspective to the research group and having the good fortune to collaborate with and learn from Bill. Patrick H. Ressler was a post-doctoral scientist with Rick Brodeur and Bill in the GLOBEC NEP program. His project focused on euphausiid distribution and mesoscale physical features off the west coast (Ressler et al., 2004). Patrick Ressler continued to work at the HMSC through March 2006 and stayed in touch in his research fisheries biologist position at the NMFS Alaska Fisheries Science Center.

Jay O. Peterson studied bio-physical interactions and the distribution of zooplankton in relation to the Columbia River plume (Peterson and Peterson, 2008, 2009) as part of the NSF-funded RISE (River Influences on Shelf Ecosystems) Project. He also helped to maintain the NH Line and regional ecosystem surveys, studying hypoxia (Peterson et al., 2013) and copepod and krill productivity. The NH Line long-term dataset and broader-scale surveys have provided a much better

understanding of regional ocean dynamics, including the distribution and severity of hypoxia. Jay Peterson is now a fisheries biologist with NOAA working on ways to better incorporate climate and environmental information into fisheries management.

Hongsheng Bi is an expert on statistical methods and worked with Bill to examine juvenile salmon distribution in the northern California Current System in relation to copepods and transport (Bi et al., 2007, 2008, Hao et al., 2012, Liu et al., 2015). Hongsheng Bi is an Associate Professor at the University of Maryland Center for Environmental Science.

Hui Liu met Bill at the 2006 Ocean Sciences meeting, which led to his research position with Bill at HMSC. It provided Hui Liu an opportunity to expand his research interests and led to papers on the phenology of subarctic copepods and the implications of climate change to forecasting salmon survival in the northern California Current System (Liu and Peterson, 2010; Liu et al., 2015). He now is an Associate Professor at Texas A&M University.

Linda O'Higgins, currently at National University of Ireland, Galway, investigated phytoplankton-zooplankton interactions, a novel subject to Bill, during her post-doctoral research position. Mattias Johannson introduced another topic to the Lab, investigating genetics of *Euphausia superba*, *Euphausia pacifica*, and *Thysanoessa raschi* (Johannson et al., 2012a,b). Anita McCulloch researched phytoplankton ecology. Xiuning Du, who Bill advised while she was working on her PhD at the Ocean University of China, studied phytoplankton community composition (Du et al., 2015) and phytoplankton-zooplankton interaction (Peterson and Du, 2015) as a post-doctoral researcher at HMSC, and continues to work there as a research scientist.

Not only graduate students and post-doctoral scientists benefitted from his mentoring. Bill supported one or two undergraduate interns each year (over 14 total) through various programs (e.g., NSF Research Experiences for Undergraduates, NOAA Hollings Undergraduate Scholarships), providing them an early and unique hands-on field and laboratory research experience (Fig. 8).

The Peterson Lab also hosted a number of young and mid-career investigators for joint research projects (Table 4), including many international researchers for training in zooplankton production, plankton ecology, or to analyze living or preserved samples from the NH Line.

Ramiro Riquelme-Bugeño conducted growth and molting rate experiments with euphausiids from Chile (Riquelme-Bugeño et al., 2016). Nelly Tremblay (a former MS student of Jaime Gómez-Gutiérrez at CICIMAR-IPN) did respiratory experiments on euphausiids as part of her PhD thesis from Universität Bremen - Alfred-Wegener Institute, Germany. Toru Kobari spent part of his sabbatical studying nucleic acid ratios in copepods and krill at the Peterson Lab (Kobari et al., 2017). Other visitors included Jeanette Yen working on flow fields around krill and pteropods, Motomitsu Takahashi examining growth of larval northern anchovy, Michael Malick studying climate-linked ecological pathways of salmon, and Ryan Rykaczewski investigating the effects of climate oscillations on the pelagic food chain.

## 5. Bill Peterson's legacy in ocean science

Bill Peterson was a thoughtful and productive scientist, as his lengthy and broad record of highly cited publications attests (Table S1). His research covered a range of marine ecology and fisheries topics, and increased our knowledge of ocean populations, how marine ecosystems function, and how they are shaped by climate change and environmental variability (Gómez-Gutiérrez et al., 2018). It also improved our ability to manage marine resources with greater certainty and on a longer time horizon. Bill's high scientific productivity was aided by his friendly personality, his open and collaborative spirit with fellow investigators, and the leadership he gave to his effective, hardworking staff.

Yet his influence on marine ecosystem research and management





Fig. 8. Bill explaining activities planned for the night shift to undergraduate students during a Mesoscale cruise on the R/V Wecoma in 2000. (Photo courtesy Jaime Gómez-Gutiérrez).

stretched well beyond his own research. Science was Bill's passion, but public service was his calling. Straddling the academic and government research communities, he melded extensive and productive research throughout his career with an appreciation of the importance of applying scientific information and knowledge to addressing societal problems and communicating it in clear non-technical forms for resource managers and the public. It also led him to recognize the need for "big science" programs that crossed government agency and national boundaries.

Bill Peterson's leadership in establishing and guiding highly influential national and international science programs resulted in some of his greatest contributions to science. Working with a dedicated group of scientists, managers, and administrators, Bill was instrumental in establishing US GLOBEC as an ongoing joint NSF-NOAA program that supported basic and applied interdisciplinary science for over a decade. It culminated in over 750 peer-reviewed publications, developed new sampling technologies and ecosystem modeling tools, trained a generation of young investigators, and transformed the management of domestic fish stocks.

The scientific methods, tools, and knowledge generated by US GLOBEC informed and advanced ecosystem-based management approaches now being implemented for fishery management in the US. The program also changed profoundly how we recognize and understand the impacts of global climate change and environmental variability on zooplankton, fish, and marine ecosystem structure and productivity. US GLOBEC also provided valuable lessons about institution building and cooperation when it comes to large scientific programs. Bill Peterson played a critical role at a critical time for US ocean science.

These lessons, as well as the interdisciplinary approach combining field sampling, technical development of new observing tools and advanced ecosystem modeling, shaped Bill's approach to his many international collaborations and has been adopted by a number of other national and multi-national programs. Colleagues across the globe

remember Bill as a passionate scientist always ready to learn from others and share his own experience and knowledge of marine ecosystems and fisheries.

Bill was always available to the media and a frequent contributor to print and broadcast science articles and features. Journalists preparing breaking news or in-depth stories related to salmon, ocean conditions, and climate change reached out to him, often based on a referral from one of his colleagues. Bill was a recurring source for numerous west coast regional and national newspapers and appeared on local, national, and international public radio and television. He found less-conventional ways of communicating science as well. Ardis deFrees, a 2016 intern from the Pacific Northwest School of Art, interpreted the Peterson Lab's research along the Newport Line through art. Her work is part of the permanent displays at the Hatfield Marine Science Center.

Bill Peterson was cherished among his former students who regarded him as "a great teacher, fun, humble, funny, and an inspiring mentor". He is remembered as a seagoing scientist who was "in the trenches" with his students. He had a big influence on them all. For many, Bill was more than a patient instructor and mentor; he was a great friend or a father figure. The greatest benefit of working with Bill was expanding their research vision and expertise into areas such as zooplankton ecology, salmon ecology, fisheries oceanography, and climate change. Bill's office door was always open and he encouraged everyone in his group to come by and talk about their work and recent findings.

In the view of his students and technicians, Bill's hallmark was that he led by example; "Bill was general and soldier at the same time". They "did not work for Bill, but rather with him." His position that "the students came first" surely contributed to the many professional accomplishments they later enjoyed. He especially loved to talk with students and early career scientists at scientific conferences, particularly during poster sessions. This was a more relaxed setting for discussing their research, which Bill relished.

Bill's tangible legacy includes the lab he established at HMSC. Kym



Jacobson (NMFS NWFSC) manages the lab and, together with Cheryl Morgan, Jennifer Fisher, and Samantha Zeman, continues to conduct innovative research on plankton dynamics and fisheries. They maintain the NH Line sampling program as an invaluable multi-decadal time series of physical and biological data that will stoke research on how ocean ecosystems respond to physical climate-scale variability for years to come.

Bill's more intangible mark on science is the network of scientists and colleagues he worked with, helped mentor, and developed. There is no better metric of his impact on science than the national and international programs and organizations he helped organize and lead, and the many young investigators he influenced. They continue to carry on Bill Peterson's legacy of conducting thoughtful and novel research that helps us understand marine ecosystems and practice more effective stewardship and conservation of their resources.

### Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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### Appendix A. Supplementary material

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.pocean.2019.102241>.

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